Forearc slope deformation and oceanic plate subduction of the southern Kuril Trench convergent plate margin

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The Kuril Trench convergent plate margin is known as one of the non-accretionary convergent plate margins, where several large earthquakes have occurred. The southern Kuril Trench is characterized by subduction of the Pacific plate beneath the North American plate. Subducting Pacific plate is deformed by normal faults, and horst and graben structure is developed.

In this study, we used multi-channel seismic reflection (MCS) data across the southern Kuril Trench collected during R/V Hakuho-maru KH-92-3 cruise, off Nemuro area. The MCS data were acquired using a 24-channel streamer of 1200 m length and 37 l airgun seismic source. The seismic source was fired every 50 m. Our MCS data processing included common mid-point (CMP) sorting, deconvolution, velocity analysis, band-pass filtering, normal move-out (NMO) correction, CMP stacking, and Kirchhoff time migration. Seismic velocities were analyzed every 2.5 km using full CMP gathers. To obtain improved velocity models, we used a recent instantaneous phase velocity analysis technique (Tsuji et al., 2007, Island Arc, 16, 361-373).

Normal fault deformations form horst and graben structure in the incoming Pacific plate. These incoming plate deformations are also observed other trenches in the western Pacific. Here, we classified the forearc slope into three parts, lower, middle and upper slope on the basis of their bathymetric feature.

Forearc deformation is clearly imaged in the MCS profile across the southern Kuril Trench, particularly in the upper forearc slope. Development of a sedimentary basin with normal fault deformations can be recognized there. These deformations indicate subsidence of the basin. The deformed basin includes two unconformities, which appear as high-amplitude reflectors. The unconformities suggest that the basin has subsided intermittently. Normal faults in the basin reach to the seafloor, which suggest the fault deformations are active at present. Recent seismic events distributed around the upper slope near our MCS line. Moreover, these seismic events mainly occurred at the depth of 30-40 km, and some events occurred shallower than 10 km. These depths are consistent with plate boundary depth and basement of the deformed sedimentary basin, respectively. To explain these structural features and seismicity, possible interpretation is mass removal at the base of overriding plate caused by basal erosion. In this case, downward mass transfer at the base of overriding plate with subducting plate occurs, and forearc subsidence is induced to compensate the mass removal as brittle deformations.

In contrast, lower and middle forearc slopes do not have significant sedimentary sequence and/or normal fault deformations. This area is characterized by low seismicity. In our MCS profile, high-amplitude and low-frequency reflection from the subducted oceanic plate is imaged beneath the lower forearc slope. Several reflectors have reverse polarity there. These features of reflectors suggest the presence of fluid along the plate boundary, which is proposed on the basis of wide-angle seismic reflection study (Nakanishi et al., 2004, JGR, 109, doi:10.1029/2003JB002574).