Spatial variations in incoming oceanic plate and its implications for subduction zone processes along the Japan Trench

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Since 2009, to reveal the nature of the incoming oceanic plate in the western part of the Kuril Trench and the northern half of the Japan Trench, we have conducted extensive controlled-source seismic experiments at the northwestern margin of the oceanic Pacific plate. Like the other subduction trenches around the world, we have confirmed that the seismic velocities within the oceanic crust and the topmost mantle gradually reduce toward the trench owing to plate bending-related faulting near the trench. Previously, other than areas where bend faulting and fracture zones are observed, the northwestern part of the oceanic Pacific plate was generally considered to be laterally homogeneous. However, seismic velocity models and seismic reflection profiles we obtained show lateral variations within the crust and the topmost mantle which cannot be explained by the bending of the oceanic plate. Observations including seismic structure, seafloor topography, and gravity anomalies are summarized as the following. (1) In the area within 300 km from the trench axis, the crustal thickness is about 7 km. This area roughly corresponds to the Hokkaido rise, which is a topographic high clearly observed on the bathymetry data. (2) In the eastern and southern area of the Hokkaido rise, the crustal thickness is about 6 km, significantly thinner than the crustal thickness beneath the Hokkaido rise. (3) The water depth of the thin-crust area is deeper than the water depth expected by the plate age. (4) The gravity anomalies are basically consistent with the spatial variations in the crustal thickness. These observations indicate that the Hokkaido rise, conventionally considered as the topographic high caused by plate bending, has different nature from the surrounding area.

In 2017 and 2018, we conducted additional seismic experiment at the trench-outer rise areas of the southern Japan Trench off Fukushima. Unlike the northern part of the Japan trench, a large seamount chain exists on the incoming plate off Fukushima, but the water depth other than the seamounts are basically deeper than the northern area. The maximum water depth at the trench axis is significantly deeper in the southern Japan Trench than in the northern Japan Trench and the western Kuril Trench. We applied traveltime inversion to the OBS-airgun data and obtained a P-wave velocity structure model along the survey line. The Vp model clearly shows the reduction in Vp near the trench axis which can be explained by bend faulting. The crust is remarkably thick beneath a large seamount, but except for the seamount, the crustal thickness seems to be a little thinner than the northern Japan Trench area, which is consistent with the gravity anomalies. These observation implies that the thickness of the crust show regional variations along the Japan Trench and the Kuril Trench, which is well correlated with the seafloor topographic high called the Hokkaido rise. As the plate bending prior to subduction cannot explain the thickening of the oceanic crust, we infer that the crustal thickness beneath the Hokkaido rise is originally thicker than the other areas, suggesting the nature of the incoming oceanic plate, the thickness and the weight, is different between the northern and the southern Japan Trench. In this presentation, we will show Vp models on the oceanic Pacific plate in the western part of the Kuril Trench and northern and southern Japan Trench, and discuss the variations in the crustal thickness and implication for the subduction zone.

Keywords: incoming oceanic plate, seismic structure, crustal thickness

