Marine active-source seismic studies in the Japan Trench: a seismogenic zone in an ocean-continent collision zone

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JAMSTEC has been carrying out large-scale active-source seismic studies in the Japan Trench, where the 2011 Tohoku-Oki earthquake (Mw=9.0) occurred along the plate boundary fault zone in the subduction zone (i.e., an ocean-continent collision zone). A striking observation from the 2011 Tohoku-Oki earthquake was a huge coseismic slip (> 50 m) reaching the shallow portion of the subduction zone which had been considered to be an aseismic or creeping zone. Besides, a clear separation of source locations between high- and low-frequency seismic energy radiation was reported (e.g., a source region of low-frequency seismic energy with a large slip in the shallow part and a source region of high-frequency seismic energy in the deeper part).

In order to examine structural characters controlling such complicated slip behavior along the plate-boundary fault, we have been acquiring active-source seismic data along profiles covering the ocean basin – the trench axis – the subduction zone. For the data acquisition, we used JAMSTEC's research vessel Kairei which has a 6000 m-long 444 ch. streamer cable and 7,800 cu. inch air-gun array. We also use densely deployed (2 – 6 km interval) OBS for a wide-angle seismic survey. A newly developed ultra-deep OBS, which can be deployed more than 9,000 m, was a quite useful instrument to acquired seismic data in the trench axis where the maximum water depth is more than 8,000 m in the Japan Trench. To obtain an overall structural character of the rupture zone, we processed seismic reflection data acquired along ~ 200 km-long profiles covering the large slip zone. Data quality along the profiles are excellent. The subducted oceanic crust can be traced down to 25 km deep, which correspond to the deepest part of the large coseismic slip zone. The resultant seismic images are characterized as a low-velocity frontal prism, a reflective zone above the subducted oceanic plate and subducted horst-and-graben structures (Fig. 1). It should be noted that the low-velocity frontal prism structure is only observed in the central and the northern part of the Japan Trench where the large coseismic slips to the trench axis are observed.

In addition to the overall structural images, we also obtained high-resolution seismic images around the trench axis. From the high-resolution seismic profiles which densely cover the trench region, we found a localized thin sediment patch (~ 50 km wide) in the trench axis at around 39.5°N. Comparing the seismic section and core samples from deep sea drilling at the outer rise and the trench axis shows that the pelagic clay layer, which observed along the plate boundary fault in the large slip region during the 2011 Tohoku-Oki earthquake, is likely missing in the thin sediment patch. The thin sediment patch in the trench axis seems to be well correlated with the northern end of the large slip zone along the trench axis.

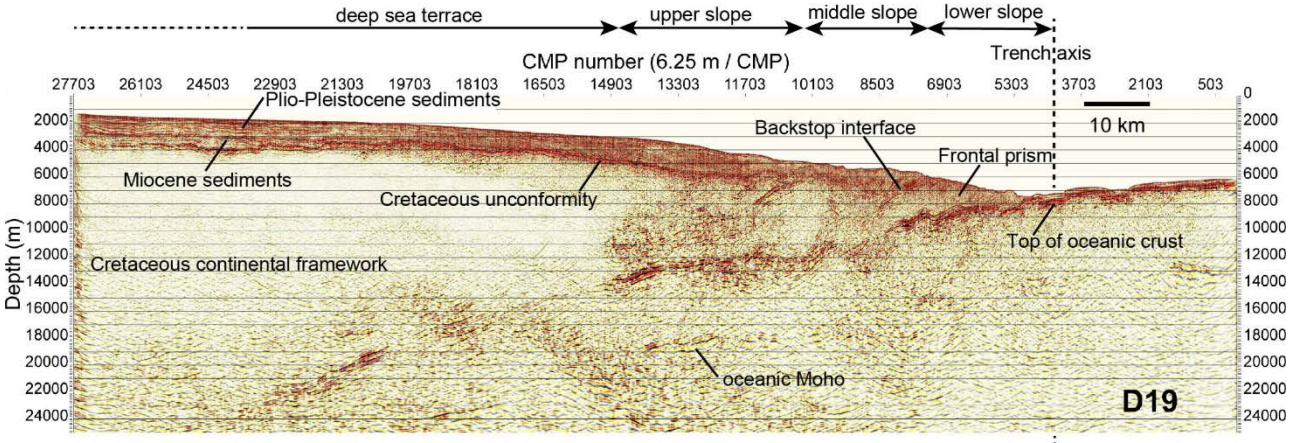

Fig.1 Prestack depth migrated section in the central Japan Trench. In each panel, the vertical dotted line indicates the location of the trench axis (Kodaira et al. 2017).

References

Kodaira, S., Nakamura, Y., Yamamoto, Y., Obana, K., Fujie, G., No, T., Kaiho, Y., Sato. T. & Miura, S. (2017). Depth-varying structural characters in the rupture zone of the 2011 Tohoku-oki earthquake. Geosphere, 13(5), 1408-1424