Spatial variations in the crustal thickness of the oceanic Pacific plate and its implication to subduction zone processes

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Subduction of the oceanic plate causes various processes in the plate subduction zone including interplate and intraplate earthquakes and arc volcanism. The nature of the subducting oceanic plate, as the subduction inputs, is thought to be one key control on the spatial variations in these various processes in subduction zones. However, the oceanic plate structure had not been well studied and conventionally been considered to be nearly uniform other than near LIPs and large seamounts.

Since 2009, to reveal the nature of the subduction inputs to the northeastern part of Japan Island arc, we have conducted extensive controlled-source seismic surveys in the northwestern part of the oceanic Pacific plate. In order for the oceanic plate to subduct beneath the continental plate from the oceanic trench, the oceanic plate must bend downward in the outer trench area, causing plate bending-related normal faulting. As the bend faulting is expected to change the nature of the oceanic plate by fracturing and water penetration through the normal faults, the impact of bend faulting on the oceanic plate structure and its spatial variations is considered to be related to spatial variations in various processes in subduction zones. Therefore, the primary aim of our seismic survey was initially revealing the structural impacts caused by bending faults prior to subduction and our survey area covered the area from the trench to 500 km from the trench, where plate bending is not expected to affect the oceanic plate structure.

As expected, we have confirmed systematic structural evolution of the incoming oceanic plate due to bend faulting prior to subduction. In addition, owing to the wide coverage of our seismic survey, we observed large scale variations in the oceanic plate structure that we had not expected before, the thickness variations in the oceanic crust. The crustal thickness in this region is typically 6.5 km. For example, in the outer trench area of the Kuril and the northern Japan Trench where the seafloor depth shows relatively shallower than the surrounding area, we observed thicker oceanic crust than surrounding area. On the other hand, we observed a significantly thin oceanic crust in the deepest oceanic basin in our survey area, located at the southern end of the Nosappu fracture zone. In short, our observation shows the seafloor depth is closely related to the thickness of the oceanic crust, implying that a simple isostatic equilibrium can mostly explain the seafloor depth variations.

One intriguing observation is the crustal thickness variations along the Japan Trench. Our observation suggests the Pacific plate has relatively thick oceanic crust in the northern Japan Trench but thin oceanic crust in the southern Japan Trench, suggesting the more buoyant oceanic plate is subducting into the northern Japan Trench. In this presentation, we will map the crustal thickness of the oceanic Pacific plate estimated by all our controlled-source seismic survey data obtained since 2009 and discuss its potential relations to the subduction zone process.

Keywords: oceanic crust, crustal thickness, seismic survey, Japan Trench, Pacific plate

