Seismic attenuation profiling for imaging geological structures and faults in incoming oceanic crust in the Nankai Trough

*Tetsuro Tsuru[1], Jin-Oh Park[2], Tetsuo No[3], Yukari Kido[3], Kazuo Nakahigashi[1]

1. Tokyo University of Marine Science and Technology, 2. Atmosphere and Ocean Research Institute, The University of Tokyo, 3. Japan Agency for Marine-Earth Science and Technology

We tested seismic attenuation properties as indicators of lateral variation in geological structures and detection of faults within poorly-reflective incoming oceanic crust in the Nankai Trough. Seismic reflection surveys are often conducted to investigate not only geological structures but also development of faults in sedimentary basins, because the past activities of faults are recorded as offsets of geological formations at their locations. However, it is almost impossible to specify the existence of faults within oceanic crust because seismic reflections are inherently invisible there. Seismic attenuation profiling was, therefore, applied to image faults and investigate their activities within the oceanic crust seaward from the trough axis of Nankai Trough.

The Nankai Trough is located at the northern margin of the Philippine Sea Plate subducting below the Eurasian Plate, where large earthquakes with Mw > 8 have occurred with a recurrence interval of 100 to 200 years. Many seismic reflection studies have been carried out in the landward slope of the Nankai Trough to reveal the geologic structures and the fault properties of this seismogenic plate boundary. However, only a few seismic reflection studies have been conducted to investigate geological structures and intracrustal faults within the incoming oceanic crust, because it is very difficult to observe seismic reflections. Therefore, alternative methods to the conventional seismic reflection methods are required.

In 2005, high resolution seismic reflection survey was conducted by R/V Kairei of Japan Agency for Marine-Earth Science and Technology (JAMSTEC) on a seismic line NT501H, which was designed along the axis of the Nankai Trough, southwest Japan. Through the surveys, a total of ca 552 km of high-resolution seismic reflection data were collected with two GI-Guns (a total of 12 liter) and a 5100 m streamer cable. Shot interval, receiver interval and CDP interval are 50 m, 25 m and 12.5 m, respectively. The GI-Guns and the streamer cable were towed at 5 m and 8 m depths, respectively. Those towing depths are shallower than ones of conventional Kairei seismic reflection survey (10 and 15m), providing broader frequency bandwidth due to higher ghost-notch frequencies. The broader frequency bandwidth has advantage in estimation of seismic attenuation in frequency domain, such as spectral ratio method.

We applied seismic attenuation profiling (SAP) that maps seismic attenuation property instead of seismic reflectivity to image geological structures and possibly-developing faults in the incoming oceanic crust. Spectral ratio method was used to calculate seismic attenuation from multichannel seismic reflection data, because the method is one of the most general methods to estimate Q. In the present study, average Q was calculated only for depths of the oceanic crust as well as the uppermost mantle, to avoid influences from sediments and see spatial variation in attenuation property within the igneous oceanic crust.

©2018. Japan Geoscience Union. All Right Reserved.

As a result, oceanic crust altered by late-coming volcanisms as well as damaged by intraplate earthquakes was imaged as extremely high-attenuation property, which was clearly distinguished from normal oceanic crust. By using a composite profile of seismic reflection and seismic attenuation, many faults were observed in the sedimentary unit on the seismic reflection profile, whereas possible lower segments of the faults were imaged as high-attenuation stripes in the oceanic crust on the seismic attenuation profile. Thus, the effectiveness of SAP method to structural and fault imaging within poorly reflective oceanic crust was successfully demonstrated.

Keywords: Seismic attenuation, Oceanic crust, fault

©2018. Japan Geoscience Union. All Right Reserved.