Seismic attenuation profiling for imaging active faults within poorly reflective oceanic crust in Nankai Trough

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We tested applicability of seismic attenuation profiling (SAP) method as an indicator to understand present fault activity within poorly-reflective incoming oceanic crust in the Nankai Trough. Seismic reflection surveys are usually conducted to investigate fault activities in sedimentary basins, where faults can be specified by offsets of seismic reflections from formation boundaries. However, it is almost impossible to analyze the activities 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 the northern margin of the subducting Philippine Sea Plate, where large earthquakes with Mw > 8 have occurred with a recurrence interval of 100 to 200 years. Seismic reflection studies have been carried out in order to figure out geologic structures of the seismogenic plate boundary and splay faults. On the other hand, only a few seismic reflection studies have been applied to investigate intracrustal faults within the incoming oceanic crust, because it is very difficult to observe seismic reflections.

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.

In order to visualize fault activities in the incoming oceanic crust, we applied SAP that maps seismic attenuation property instead of seismic reflectivity. 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, in order to avoid influences from sediments and see spatial variation in attenuation property within the igneous oceanic crust. Based on amplitude decay curve analysis, the method is applicable to approximately 10 km depth below the sediments.

Combining the seismic reflection profile and the seismic attenuation profile enables us to understand a whole picture of fault activity. The former clearly shows active and fossil faults in the sedimentary layers. The latter shows active faults within the igneous oceanic crust as high-attenuation anomalies, which extend immediately beneath the active faults that were specified by the seismic reflections. On the other hand, the fossil fault zone was discriminated as low-attenuation zone from the active fault zone, within the oceanic crust.

Keywords: seismic attenuation, fault, oceanic crust

