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Lateral structural variation within the overlying plate and its correlation to the Tonankai earthquake

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Destructive interplate earthquakes have repeatedly occurred every 100-150 years beneath the Kumano-nada, off the Kii peninsula owing to the subduction of the Philippine Sea plate beneath the southwest Japan arc. The last great interplate earthquakes in this seismogenic subduction zone was the 1944 Tonankai earthquakes and a number of coseismic slip distribution models have been proposed by seismic and tsunami waveform analysis. These slip distribution models show significant lateral variations along the trough axis.

In 2006 and 2007, we conducted extensive wide-angle seismic refraction and reflection surveys in the rupture zone of the 1944 Tonankai earthquake in order to reveal the detailed crustal structure, focusing on the lateral variation along the trough axis. We designed two along-trough seismic survey lines, about 250km long, to cover the entire rupture zone of the 1944 Tonankai earthquakes. Along these lines, we deployed a number of OBSs (Ocean Bottom Seismometers) with a spacing of 5km and fired an airgun array with a total volume of 200L at every 0.2km.

The quality of the obtained wide-angle seismic record section is substantially good and we observed remarkable regional variation in the amplitude of refraction and reflection phases. For example, in some record sections, we can trace seismic signals up to the offset of more than 100 km, but in other sections, the airgun signals become dim at the offset of less than 30km. Such regional variation in the amplitude indicates the lateral variation of the seismic attenuation structure. Therefore, we developed seismic attenuation models in addition to the usual seismic velocity structure models. Our modeling approach was the following.

First, we developed P-wave velocity structure models by the first arrival tomography. Then, structure boundaries were imaged by the traveltime mapping method. Finally, we projected observed amplitude of first arrivals onto the corresponding raypaths; in the projected image, raypaths of non-attenuated first arrivals are illuminated and we can estimate the seismic attenuation structure.

In the P-wave velocity structure models and traveltime mapping images, we found a height on the subducting Philippine plate at the eastern end of the Kumano basin (south-east off Shima peninsula). In the western area (i.e. Kumano Basin), the sedimentary layer is much thicker than that in the eastern area. However, the seismic attenuation is laterally homogeneous around the height. Instead, the seismic attenuation changes significantly at the center of the Kumano Basin. In the western half of the Kumano Basin, all the first arrivals diving into the basement attenuate heavily, but first arrivals do not attenuate in the eastern half of the Kumano Basin. This is well correlated with the coseismic displacement models derived from seismic waveform analysis, in which coseismic displacement is small in the western half of the Kumano Basin and large in the eastern half of the Kumano Basin. This suggests the possibility that the lateral variation of the seismic attenuation just above the plate boundary affects the lateral variation of the interplate coupling.

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