Structural heterogeneities beneath Taiwan

zhi wang[1]; Yoshio Fukao[2]

[1] IFRR of JAMSTEC; [2] IFREE/JAMSTEC

The Taiwan region is an important site for the processes associated with the subduction of the Eurasian lithosphere under the southern portion of Taiwan, and subduction of the Philippine Sea (PHS) slab beneath the northern part of the Ryukyu Trench. Processes associated with the subduction include mountain building, plate collision and arc magmatism. Crustal deformation and active seismicity are still underway due to the convergence of the PHS and Eurasian plates. In most parts of Taiwan, the convergent features are more complicated than those in other subduction zones along the Western Pacific island arc. Different tectonic models have been proposed to characterize the Taiwan Orogen based on different constraints and approaches, but the actual mechanism of the Taiwan Orogen remains a topic of wide debate. Whether or not and to what depth the Eurasian lithosphere has subducted beneath the Taiwan region is still unclear.

In the Taiwan subduction zone, local seismicity does not provide direct information on the Eurasian lithosphere because few earthquakes occurred deeper than 150 km. None of the proposed models has clearly explained all of the fundamental observations and none has been supported by the evidence derived from seismic velocity structures. Different models proposed thus far take different views on the structural heterogeneities under Taiwan. The proposed models such as arc-continent collision, skinned collision and crustal exhumation support the existence of a subducted Eurasian plate, whereas the arc-arc collision and lithosphere collision models prefer its absence. A global tomographic model showed that the Eurasian lithosphere subducted to a depth of 670 km under the southern portion of Taiwan. However, the evidence from the global model is less reliable because its resolution is not high enough to provide direct evidence for the detailed structural heterogeneities under Taiwan. Therefore, a high-resolution 3-D velocity structure under the region is crucial and necessary for a better understanding of the structural heterogeneities and dynamics in the crust and upper mantle.

To investigate the structural heterogeneities and their implications for mountain building, plate collision and tectonics beneath Taiwan, high-resolution 3-D P-wave velocity images at depths of 0-400 km were determined by simultaneously inverting a large number of arrival time data from local and teleseismic earthquakes. We used 227,258 absolute arrival times from 8,982 shallow and intermediate-depth earthquakes and 18,869 relative arrival time data collected from 3,179 teleseismic events. Our tomographic images provide direct geophysical evidence for a tectonic model proposed by previous studies and revealed some new features of structural heterogeneity related to the subducted Eurasian lithosphere. Low-velocity anomalies beneath the Kueishan volcano are revealed at depths of 0-65 km in North Taiwan, indicating its close relationship to the subducting process of the Philippine Sea slab. The Eurasian lithosphere is generally imaged as a high-velocity zone with a thickness of 65-80 km and it has subducted down to a maximum depth of 300 km under South Taiwan, whilst it is not visible beneath North Taiwan. Our results also indicate that the Philippine Sea slab descends northwestward from the Ryukyu Trench down to a depth of 200 km, showing agreement with the previous seismic, geochemical and geophysical studies. The plate convergence of the Eurasian plate varies from subduction beneath South Taiwan to collision with the Philippine Sea slab under North Taiwan. These features of the structural heterogeneities in the crust and upper mantle suggest that the mountain building process in the central region of Taiwan, arc magmatism and seismotectonics are mainly attributed to the subduction-collision configuration at the boundary between the Eurasian plate and the subducting Philippine Sea slab.