

Fundamental structure model of island arcs and subducted plates in and around Japan -II

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The eastern margin of the Asian continent is under complicated tectonic environment, dominated by subduction and collision of the Pacific (PAC), Philippine Sea (PHS) and Eurasia (EU) plates. Crustal activities in and around the Japanese Islands, which have a wider range spatial extent with different time scale, are dominated by strong interplate interactions. The 2011 Tohoku earthquake (M=9.0) produced a large amount of coseismic and post-seismic crustal deformations and remarkable changes in seismic activity in broader region of easternmost Asia, providing good opportunities to study response of trench-arc system due to a mega thrust earthquake on the plate boundary. Quantitative understanding for such phenomena requires to develop fundamental structure models including plate boundaries and crust and uppermantle structures from the fore- to back-arc provinces. This paper presents results of our research aiming to construct key items for fundamental structure models for island arcs, namely, (1) topography, (2) plate geometry, (3) fault models, (4) the Moho and brittle-ductile transition zone, (5) the lithosphere-asthenosphere boundary, and (6) petrological/ rheological models.

Our modelling area is set 12°-54° N and 118°-164° E to cover almost the entire part of Japanese Islands together with Kuril, Ryukyu and Izu-Bonin trenches. Geometry of the subducted Pacific and PHS plates are modelled through the two steps. In the first step, we constructed “base” models, which have rather smooth surfaces in our whole model area, from earthquake catalogues provided by JMA, USGS and ISC. As the second step, regional plate configuration with shorter wave-length (<50-100 km) is constrained particularly in the vicinity of Japan from recent results by seismic tomography, RF analysis and active source experiment. Our analysis indicates that the plate boundaries in the regional models are systematically shallower than those from the base models in a depth range of 10-50 km. This probably indicates that the regional models represent the structural boundary of the subducted plate, while the base models its mechanical boundary. In the Kanto area, the geometry of the PHS plate is very complicated due to the existence of the triple junction and the collision of Izu-Bonin arc to the EU plate. We defined the plate geometry of the PHS plate from results of active seismic experiments and seismic tomography studies as well as natural earthquake observation (Sato et al., 2005; Nakajima & Hasegawa, 2007; Hirose et al., 2008a,b, Nakajima et al., 2009, Sato, 2009, Uchida et al., 2010). The northern margin of the PHS plate under the NE Japan arc west of the Japan trench is based on the result by Uchida et al. (2010), which is almost consistent with the southern end of aftershock distribution and major aftershock fault of the 2011 Tohoku earthquake.

So far, detailed Moho structure was presented by several authors (Zhao et al., 1994; Shiomi et al., 2009; Katsumata, 2010; Igarashi et al., 2011; Matsubara et al., 2016). We intend to combine these results with global crust model (crust 1.1, Laske et al. 2013), to generate Moho depth models for EU, PHS and PAC plate in our model region. We are newly developing software packages necessary for this work. As an example, the Moho model by Katsumata (2010) beneath the Japanese islands is extended to the surrounding region using crust 1.1 model. For the PAC and PHS plates, the Moho depths beneath the subducted oceanic crust are assumed from our plate boundary model, which are merged to those beneath the oceanic basin. These models are still tentative, and should be revised by incorporating structural information from active source experiments.

Keywords: island arc, plate boundary, Moho, fundamental structure, active margin, subduction zone