Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SCG10-P05 Room:Convention Hall Time:May 22 18:15-19:30

Magmatic accretion and backarc opening controlling crustal structure of the Izu-Ogasawara-Mariana island arc

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has carried out seismic surveys using a multi-channel reflection streamer system and ocean bottom seismographs (OBSs) since 2002. Through these surveys, we obtained a lot of velocity structures and reflective images across and along the arc. The arc crust has strong variation in the crustal thickness and is composed of an upper crust with a P-wave velocity (Vp) of 4.5-6.0 km/s, a continental middle crust with Vp of 6.0-6.5 km/s, a lower crust with Vp of 6.5-7.5 km/s and with much proportion, and mantle with lower Vp of less than 8 km/s beneath the arc. In the lower crust, two layers are distributed, one is a thin upper layer with Vp of 6.5-6.8 km/s and the other is thick lower layer with Vp of 7.0-7.5 km/s. The characteristics of the velocity structure of this region are thick crust with much volume of a layer with Vp of 6.0-6.8 km/s and broad distribution of high Vp lower crusts. The former has developed lower crust adding the thick middle crust. Although the crustal thickness along the volcanic front is not homogeneous but various, the rough thicknesses are 20-25 km, 10-15 km and 15-20 km at the northern, central and southern arcs. The change of the crustal thickness is mainly brought by the middle crust. Such variation of the crustal structure can be seen around the rear arc and forearc regions, and we confirmed three rows of the thick crustal chain like the volcanic front. The thickest crusts, however, distribute beneath not the volcanic front but initial rifting region. The Sumisu rift in the northern arc and the northern tip of the Mariana Trough has thickest crust and the origin is thick lower crust with high Vp of over 7 km/s. Inside of the crust is also heterogeneity. In particular, pairs of thick middle crust and thin upper part of the lower crust or thin middle crust and thick upper part of the lower crust are identified. The thick upper part of the lower crust was detected beneath the rhyolite volcanoes. On the other hand, the middle crust beneath the forearc region is thinner than that of the volcanic front. This suggests that the variation of the crustal composition depends on the situation of crustal differentiation and degree of the crustal evolution. The latter distributes broadly at eastern half of the Shikoku Basin, between the rear arc and the volcanic front and between the volcanic front and a row in the thick arc crusts in the forearc region. Over the high velocity lower crust, many normal faults are identified on the reflection records. Areas with normal faults are in backarc side like the Sumisu rift, and front side of the volcanic front also has half graben with normal faults. The central arc has much volume of the high velocity lower crust between the rear arc and forearc regions except a part of the volcanic front. And the twice timing that these normal faults were activated was recorded on the basement. The degree of the backarc opening and the crustal thickening by magmatic accretion at a bottom of the crust control the arc structures, which are the crustal thickness, the crustal compositions of the middle crust plus the upper part of the lower crust and the proportion of the high velocity lower crust. At the eastern end of the arc, it is possible that a part of the old oceanic crust is distributed. The Ogasawara ridge has complicated and asymmetry structure and has thin crust locally. Inside the crust, there are no clear layers with high acoustic impedance and its velocity distribution shows strong heterogeneity. This suggests that initial subduction and the accompanied subsidence occurred in relative short period.

Keywords: Izu-Ogasawara-Mariana arc, velocity structure, crustal evolution, backarc opening, ocean bottom seismographs, MCS