Difference in erupted magma volume inferred from the crustal density structures of the Izu-Bonin-Mariana arc and the northeast Honshu arc

*Kenta Mishiro[1], Yoshiyuki Tatsumi[2], Katsuya Kaneko[1]

1. Graduate School of Science, Kobe University, 2. Kobe Ocean-Bottom Exploration Center

Volcanic activities in the Izu-Bonin-Mariana (IBM) arc and the northeast Honshu arc are caused by subduction of the Pacific plate. Because these arcs are similar features (e.g., subduction rates and linear density of active volcanoes), it is inferred that magma generation rates in both the arcs are similar. Nevertheless, erupted magma volume at the IBM arc (10.22 km^3/km) is much larger than that at the northeast Honshu arc (1.80 km^3/km). Moreover, major composition of magma erupted at the IBM arc is basaltic while that at the northeast Honshu arc is andesitic. In this study, we try to explain these differences between the two arcs on the basis of crustal structures of the two arcs.

The IBM arc is the juvenile oceanic arc and the crustal thickness is about 25 km. Inferred from P-wave velocity, the rhyolitic crust is located at 0-5 km depth, the andesitic crust is located at 5-11 km depth and the basaltic crust is located at 11-25 km depth in the IBM arc (Takahashi et al., 2008). The northeast Honshu arc is the mature continental arc and the crustal thickness is about 35 km. Inferred from P-wave velocity, the rhyolitic crust is located at 0-5 km depth, the andesitic crust is located at 5-25 km depth and the basaltic crust is located at 25-35 km depth in the northeast Honshu arc (Iwasaki et al., 2001).

Mineral assemblages, P-wave velocity structure and density structure of these crusts are estimated by using Perple_X (Connolly, 2005). First, we estimate compositional structures of the crusts which reproduce observed P-wave velocity structure of the crusts (Takahashi et al., 2008; Iwasaki et al., 2001), then evaluate density structures of the crusts. The estimated density structure of the IBM arc is about 2800 kg/m^3 in the middle crust and 3100-3200 kg/m^3 in the lower crust while that of the northeast Honshu arc is about 2750-2900 kg/m^3 in the middle crust and 3150-3200 kg/m^3 in the lower crust.

An ascending magma forms a magma chamber at a level with neutral buoyancy. Assuming that the ascending magma is a mantle-derived primary basalt magma with 1.65 wt% H_2O and 20 % crystals by crystallization, the density comparison between the crusts and the ascending magma indicate that the depth of the magma chamber is less than 5 km for the IBM arc and 14-21 km for the northeast Honshu arc.

For eruption of the magma in the chamber, the magma needs water saturation by crystallization and foaming. Because the magma chambers at the IBM arc is shallower and has lower water solubility than at the northeast Honshu arc. Based on experimental results by Williams and McBirney (1979), the magma is saturated in water by about 50 % differentiation for the IBM arc while about 80 % for the northeast Honshu arc, suggesting that eruptable magmas are 50 % and 20 % of the ascending magma for the IBM and the northeast Honshu arcs, respectively. In addition, the magma by 50 % differentiation is basaltic while by 80 % differentiation is andesitic (Tatsumi and Suzuki, 2009). Namely, these simultaneously explain the two differences between the IBM and the northeast Honshu arcs, the erupted magma volume and composition.

We conclude that the crustal density structure is one of important factors governing volcanic activity in arcs.

Keywords: erupted magma volume, crustal structure, IBM arc, northeast Honshu arc

