Origin of silicic magmas at Sumisu caldera volcano and crustal evolution in the Izu-Bonin arc

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The origin of rhyolite and dacite in oceanic arcs is a matter of considerable interest and debate. Tamura and Tatsumi (2002) suggested that rhyolites of the Izu-Bonin arc are partial melts of calc-alkaline andesite occurring at depth within the oceanic island-arc crust. Detailed petrography, mineral and bulk rock compositions, fractionation calculations of rocks from the Sumisu caldera volcano, Izu-Bonin arc, and new melting experiments of calc-alkaline andesite (Tanzawa tonalite) are presented. We conclude that large volumes of silicic magmas (dacites, rhyolites) at Sumisu were produced by 30-40 % partial melting of andesite protoliths, which segregated effectively from residues within the crust. The rare Sumisu andesites have features consistent with en-mass remobilization of compositionally similar andesite protoliths. Coeval basalt magmas played a subordinate role in producing the andesites, and the heat required for this melting was likely supplied by the rise of subjacent basaltic magmas. Sumisu has a relatively narrow temperature range (900-1100 degree C) associated with a large compositional variation (56-74 wt % SiO2). Partial melting and effective melt-segregation, and remobilization of andesite magma body could make compositional gap within the large compositional variations in such a narrow temperature difference.

Such silicic volcanism is also closely related to crustal evolution of oceanic arcs. A detailed structural study of the Izu-Bonin arc at 32.25 degree N (Suyehiro et al., 1996) revealed that the middle crust, characterized by a P-wave velocity of ˜6 km/s, constitutes ˜25% of the crustal volume. Similar results have been found at other latitudes along the Izu-Bonin-Mariana (IBM) arc (Nishizawa et al., 2003). The 6 km/s velocity zone is a distinctive feature of continental crust and indicates abundant modal quartz, such as Tanzawa tonalite. This implies that mantle melting along convergent plate boundaries in oceanic arcs can produce continental crust, but it does not constrain its age, or whether the composition of these granitic rocks are similar to those found on the continents. Furthermore, recent studies of along-arc crustal structures show a clear correlation between the average seismic velocity of arc crust and the chemistry of the Quaternary volcanoes that have been constructed upon it (Kodaira et al., 2005). Surprisingly, the Izu-Bonin arc crust, which has a complex 50-million-year history, is compositionally related to the Quaternary volcanoes. Moreover, basaltic volcanoes stand on the lower velocity (or more continental like) crust than silicic volcanoes (Kodaira et al., 2005). Thus the origin of arc magmas and their chemical variations are directly linked to the origin and evolution of the plutonic and volcanic arc crust.

References

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