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Diversity of silicic crust in the IBM arc and Izu collision zone: constraints from zircon and whole-rock geochemistry

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The Izu-Bonin-Mariana (IBM) arc system is an intra-oceanic arc, where silicic to intermediate middle crust is being generated through subduction zone magmatism. A characteristic tectonic feature is that the IBM arc has been colliding end-on with the Honshu arc at the Izu collision zone (ICZ) for the past 15 million years. As a result of this collision, voluminous granitic rocks are exposed in the ICZ (ICZ granitoids), previously interpreted to represent an exposed deep crustal section of the IBM arc. The collective understanding of silicic crust formation in modern intra-oceanic arcs and their successive modification during arc-arc collision is important, as they may be the modern analogue for continental crust formation during the early Earth history.

Despite their importance, the granitic rocks in the IBM arc and ICZ have not been well characterized geochronologically and geochemically to understand their petrogenesis. In this study, comprehensive zircon U-Pb and Lu-Hf isotopic compositions, together with whole-rock major/trace element and Sr-Nd-Pb isotopic compositions, were acquired for granitic rocks from the IBM arc and ICZ.

The zircon ages obtained from the IBM arc granitoids range from ca. 50 Ma to <1 Ma, showing that silicic crust formation in IBM arc was initiated at the earliest stage of arc magmatism and has continued to the present. Episodic Eocene crustal formation is suggested from the zircon ages of the granitic rocks exposed in the IBM forearc and Kyushu-Palau Ridge, possessing distinctive Pb, Hf, and Nd isotopic compositions from other volcanic rocks erupted in the history of the IBM arc. These results suggest that the Eocene silicic crust is derived from a distinctive proto-IBM crust. Furthermore, the IBM middle crust layer displays geochemical and petrological across-arc variation that range from granodiorite to tonalite composition not consistent with the previously believed monolithologic layer of tonalitic rocks.

Zircon dating of the ICZ granitoids reveals that all of these plutons were syncollisional, formed after the onset of IBM arc collision with the Honshu arc. This implies voluminous and rapid granitic magma formation during the arc-arc collision. ICZ granitoids show marked influence of the mature sediments from the Honshu arc during their syncollisional magma formation, which is most compellingly documented by whole-rock Pb isotope, as well as the zircon and whole-rock Th/Nb ratios. The ICZ granitoids show clear spatial distribution in terms of ages and geochemistry, with respect to the E-W Tonoki-Aikawa Tectonic Line (TATL). The plutons north of TATL are older (ca. 16 to ca. 13 Ma) and enriched in incompatible elements, whereas plutons south of TATL are younger (ca. 9 to ca. 4 Ma) and depleted in these elements. These geochemical spatial variations among the ICZ granitoids may reflect the compositional diversity that existed in the primary IBM lower crust that sourced these granitic magmas.