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Izu-Bonin-Mariana forearc crust as a modern ophiolite analogue

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Recent geological and geophysical surveys in the Izu-Bonin-Mariana (IBM) fore-arc have revealed the occurrence on the seafloor of oceanic crust generated in the initial stages of subduction and embryonic island arc formation. The observed forearc section is composed of (from bottom to top): (1) mantle peridotite, (2) gabbroic rocks, (3) a sheeted dyke complex, (4) basaltic pillow lavas, (5) boninites and magnesian andesites, and (6) tholeiites and calc-alkaline arc lavas.

The oldest magmatism after subduction initiation generated forearc basalts (FAB) between 52 and 48 Ma, and then boninitic and calc-alkaline lavas that collectively make up the extrusive sequence of the forearc oceanic crust. The change from FAB magmatism to flux melting and boninitic volcanism took 2-4 m.y., and the change to flux melting in counter-flowing mantle and “normal” arc magmatism took 7-8 m.y. This evolution from subduction initiation to true subduction occurred nearly simultaneously along the entire length of the IBM subduction system.

One important characteristic feature of the common forearc stratigraphy in the IBM forearc is the association of sheeted dykes with basaltic pillow lavas, which strongly implies that the eruption of FAB was associated with seafloor spreading. This is supported by the seismic velocity structure of the Bonin Ridge area (Kodaira et al., 2010), showing it to have a thin ocean-ridge-like crust (< 10km). It appears that the FAB was produced by sea-floor spreading associated with subduction initiation along the length of the IBM forearc.

A potential location of subduction nucleation along the Mesozoic-aged crust has been found along the margins of the West Philippine Basin. One possible scenario for subduction initiation at the IBM arc was that it was induced by overthrusting of the Mesozoic arc and backarc or forearc terranes bounding the east side of the Asian Plate over the Pacific Plate, followed by failure of the Pacific plate lithosphere and subduction initiation. Alternatively, subduction could have begun spontaneously, facilitated by the density contrast between the arc-bearing Mesozoic Asian crust and the old oceanic Pacific crust to its west.

This volcanic stratigraphy and their time-progressive development in the IBM system are analogous to those documented from suprasubduction (SSZ) ophiolites. Most SSZ ophiolites are on-land fragments of forearc oceanic crust, produced at subduction initiation and during the early stages of island arc development (Dilek and Furnes, 2009, 2011). Similarities between the oceanic lithosphere of both forearc settings and SSZ ophiolites also extend to the upper mantle units, which are composed of extremely depleted peridotites.