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Chemostratigraphy of Subduction Initiation: Boninite and Forearc Basalt from IODP Expedition 352

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The Izu-Bonin forearc has been the focus of several recent IODP (International Ocean Discovery Program) expeditions studying the geophysical, petrologic, and chemical response to subduction initiation and its potential relationship to ophiolite genesis. IODP Expedition 352 cored four holes in the Izu-Bonin forearc near Chichi Jima in order to document the petrologic and chemical evolution of nascent subduction zones.

Holes U1440 and U1441, drilled closest to the trench, sampled forearc basalt (FAB). U1439 and U1442, drilled stratigraphically up-section and farther from the trench, sampled boninite, high-Mg andesite, and basalt. FAB are characterized by MORB-like compositions, with relatively constant Ti, Zr, and Ti/Zr. In general, more primitive FAB are found in the lower part of the section. In detail, FAB have lower Na, Ti, P, and Zr, lower Ti/V ratios, and are LREE-depleted relative to MORB. Best fit models for the least evolved FAB and a depleted MORB mantle (DMM) source require extraction of $\sim$1% melt in the garnet lherzolite field and 19% melt extraction in the spinel lherzolite field (relative to 8-10% melt of DMM to produce MORB).

Three types of boninite were found: high silica boninite (HSB), low silica boninite (LSB), and basaltic boninite (BB), as well as high Mg andesites (HMA). HSB, the youngest unit in both U1439 and U1442, is underlain by LSB-BB-HMA lavas, which often occur in mixed magma zones with evolved boninite and basalt. Boninites are distinguished by co-variations in SiO_2-MgO and TiO_2-MgO, and by Ti/Zr ratios, which increase from HSB through LSB to BB. HSB, LSB and BB define parallel trends in TiO_2-MgO space: a low Ti trend represented by LSB and BB, and a lower Ti trend represented by HSB. All of the boninite suite rocks are slightly LREE-rich relative to MORB. LSB and BB have flat REE patterns relative to primitive mantle, whereas HSB are slightly LREE-rich. These trends require distinct source compositions in HSB relative to LSB/BB. The decrease in Ti/Zr from BB to HSB suggests a slab melt component. Melting models (non-modal, fractional) for boninites require additional partial melting of a residual source more depleted than DMM, and mixing with less depleted melts. The data require a heterogeneous source during subduction initiation, tapping progressively more refractory mantle through time, and showing progressive enrichment in slab components.