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Mineral compositions and thermobarometry of basalts and boninites recovered during IODP Expedition 352 to the Bonin forearc

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Abstract

Central aims of IODP Expedition 352 were to delineate and characterize the magmatic stratigraphy in the Bonin forearc to define key magmatic processes associated with subduction initiation and their potential links to ophiolites. Expedition 352 penetrated 1.2 km of magmatic basement at four sites and recovered three principal lithologies: tholeiitic forearc basalt (FAB), high-Mg andesite, and boninite, with subordinate andesite. Boninites are subdivided into basaltic, low-Si, and high-Si varieties. The purpose of this study is to determine conditions of crystal growth and differentiation for Expedition 352 lavas and compare and contrast these conditions with those recorded in lavas from mid-ocean ridges, forearcs, and ophiolites. Cr# (cationic Cr/Cr+Al) vs. TiO_2 relations in spinel and clinopyroxene demonstrate a trend of source depletion with time for the Expedition 352 forearc basalt to boninite sequence that is similar to sequences in the Oman and other suprasubduction zone ophiolites. Clinopyroxene thermobarometry results indicate that FAB crystallized at temperatures (1142–1190 °C) within the range of MORB (1133–1240 °C). When taking into consideration liquid lines of descent of boninite, orthopyroxene barometry and olivine thermometry of Expedition 352 boninites demonstrate that they crystallized at temperatures marginally lower than those of FAB, between ~1119 and ~1202 °C and at relatively lower pressure (~0.2–0.4 vs. 0.5–4.6 kbar for FAB). Elevated temperatures of boninite orthopyroxene (~1214 °C for low-Si boninite and 1231–1264 °C for high-Si boninite) may suggest latent heat produced by the rapid crystallization of orthopyroxene. The lower pressure of crystallization of the boninite may be explained by their lower density and hence higher ascent rate, and shorter distance of travel from place of magma formation to site of crystallization, which allowed the more buoyant and faster ascending boninites to rise to shallower levels before crystallizing, thus preserving their high temperatures.

Keywords: International Ocean Discovery Program (IODP), JOIDES Resolution, Expedition 352, Izu-Bonin-Mariana Fore Arc, forearc basalt, boninite, ophiolite, Sites U1439, U1440, U1441, U1442; New Advances in Subduction Zone Magma Genesis