Are arc basalts dry, wet, or both? Evidence from Sumisu caldera, Izu-Bonin arc, Japan

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The northern Izu-Bonin arc consists of 11 Quaternary volcanoes and eight Quaternary submarine caldera volcanoes. Sumisu caldera (31.5 N, 140 E), is one of these caldera volcanoes and has been studied and sampled during the R/V Natsushima NT02-10 cruise in Sept.-October 2002. After Hakone volcano Sumisu is the second-largest caldera along the Izu-Bonin volcanic arc. We collected more than seventy rock samples from the area, both from pre-caldera Sumisu island, the post-caldera central cones, caldera walls, and the caldera floor. The ROV Dolphin 3K and the manned submersible Shinkai 2000 were used for sea-floor sampling. Both basalt-basaltic andesite (less than 55 wt % SiO2) and dacite-rhyolite (66-74 wt % SiO2) are clearly predominant eruptive products, but rocks having SiO2 contents of 60-66 wt % are absent. Basalts (50-53 wt % SiO2) from Sumisu caldera and Sumisu island contain 4~8.5 wt % MgO; variations of major and trace element compositions are relatively large in the basalt-basalt intervals. They ubiquitously bear plagioclase phenocrysts and some contain more than 4 % olivine and augite, but others are free of olivine and/or augite phenocrysts. Many parent-daughter sets within the basalts were examined by least squares mass-balance calculations using phenocryst phases. It is suggested that fractionation alone of phenocryst phases from the most magnesian basalt (8.5 % MgO) cannot explain even the major element variations of the daughter basalts. These discrepancies, however, disappear if the parent basalts were to assimilate small amounts of rhyolite, together with fractional crystallization (AFC). Unfortunately, however, incompatible trace element concentrations, such as Zr and Ba, are not always compatible with these AFC models. The most-magnesian basalt, as well as some of the other basalts, contain low Zr (20-30 ppm), which cannot yield basalts containing much higher Zr (30-40 ppm) through fractionation and/or assimilation. On the other hand, we recognised that high- and low-Zr basalts have different mineral assemblages; low-Zr basalts contain up to 5 vol % augite phenocrysts, but most high-Zr basalts are free of augite phenocrysts. Thus, the former and the latter assemblages are OL + CPX + PL and OL + PL, respectively. H2O will retard crystallization of plagioclase. Hydrous basalts will crystallize olivine followed by augite and plagioclase, producing the former assemblage, but plagioclase will appear on the liquidus just after olivine in the dry basalts, yielding the latter assemblage without augite. We suggest that there existed dry and wet primary basalts in the Sumisu magmatic system, each having different trace element concentrations and mineral assemblages, which would have been caused by differences of water content in the source mantle and basaltic melt. The lower content of Zr in the wet basalt could then have resulted from higher degree of partial melting of a hydrous source mantle.