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

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Basalt-basaltic andesite ($<$55 wt % SiO_2) and dacite-rhyolite (66-74 wt % SiO_2) are predominant eruptive products in Sumisu caldera volcano, Izu-Bonin arc, Japan. The most-magnesian basalt (8.5 % MgO), as well as some of the other basalts, contain low Zr (20-25 ppm), which cannot yield basalts containing higher Zr (29-40 ppm) through fractionation and/or assimilation. On the other hand, we recognised that high- and low-Zr basalts have differing phenocryst assemblages, distinct phenocryst chemistries of olivine, plagioclase and pyroxene, different depletion of REE (rare earth element) patterns, and differing fluid mobile-element/immobile-element ratios. Estimated primary olivine compositions are more magnesian ($>Fo_{91}$) and thus more depleted in low-Zr basalts compared to those in high-Zr basalts ($<Fo_{89}$). Low-Zr basalts contain up to 11 vol % augite, but many high-Zr basalts are free of augite, which appears only in their evolved stage. Hydrous basalts crystallize olivine followed by augite and plagioclase, producing the former assemblage. Moreover, the low-Zr basalts have higher U/Th values than the high-Zr basalts. We suggest that both dry and wet primary basalts existed in the Sumisu magmatic system, each having different trace element concentrations and mineral chemistry and assemblages. The lower content of Zr and light REE and magnesian primary olivines in the wet basalt could therefore have resulted from a higher degree of partial melting ($\sim$20 %) of a hydrous source mantle compared to $\sim$10 % melting of a dry source mantle. Interestingly, Sr, Nd and Pb isotopes between these wet and dry basalts are similar and are limited in range. These lines of evidence indicate that a mantle diapir model might be applicable to satisfy the configuration of such a mantle source region beneath a single volcanic system such as Sumisu.