Magma conditions recorded in eruption products of paleo- to modern Mount Pinatubo, Philippines

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Abstract

Older eruption products of Mount Pinatubo were examined together with those of 1991 to evaluate change in the conditions of magma reservoirs. Samples in this study comprise chiefly dacites from modern Pinatubo (1991 AD, 500 BP, 3400 BP, 5100 BP and 35000 BP), the Pleistocene ancestral volcano (~1.1 Ma) and paleo-Pinatubo. The paleo-Pinatubo eruption products, from Dizon Mine, are late Tertiary to early Pliocene in age (>2.5–2.7 Ma). The primary mineralogy remains the same, highlighting Qz +Pl +Hbl +Cum +Mag +Ilm ±Bt. This equilibrium assemblage attests the temperature of the magma reservoirs at ~800°C and H_2O-rich conditions (up to ~6.5 wt%).

Whole-rock composition data (including basalt fragments) show a typical calc-alkaline differentiation trend: decreasing FeO_{total} (9.30–3.97 wt%) and relatively constant Al_2O_3 (avg. 16.8 wt%) with increasing SiO_2 (54.3–64.8 wt%). Although there is no systematic relationship between SiO_2 values and eruptive age, the contents in older dacites are slightly lower than that of 1991 (avg. 63.1 vs. 64.5 wt%). Overall, the data show a good fractional crystallization trend, highlighting increasing incompatible elements (e.g. K_2O = 0.68–1.61 wt%) with increasing SiO_2. Furthermore, trace element data are similar among all eruption products, including strong depletion in Nb, Ta and Ti; elevated U, Pb, Cs, and Sr; and high Ba/La ratios (avg. 27.4). Chondrite-normalized REEs show a negatively-sloped pattern ($(La/Yb)_N$ = ~6.6), with weakly positive Eu/Eu* (~1.07). Sr/Y ratios (18.2–53.6) and Y contents (avg. 15.9 ppm), in conjunction with the above data, indicate a typical island arc signature.

Co-existing pairs of unexsolved magnetite-ülvospinel$_{(ss)}$ and ilmenite-hematite$_{(ss)}$ grains yield magmatic temperatures ranging 788–825°C and fO_2 of FMQ +3.0 to +3.1. This is consistent with the presence of Cum rims on Hbl phenocrysts in dacite. The conditions for the past eruption products are identical to those for the shallow (~5 km) magma reservoir of the 1991 eruption products. These data strongly suggest that magmatic conditions below Mount Pinatubo have remained relatively unchanged since the Pliocene; however, the timespan examined in this study is far longer than what is required for the solidification of H_2O-rich crustal magma reservoirs. Accordingly, our findings suggest a steady-state supply of oxidized melt in a spatially-focused manner, which may in part be explained by an overall compressional regime created by the subduction of the extinct South China Sea ridge system.

Keywords: Mount Pinatubo, arc volcanism, oxygen fugacity, geothermometry