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Abstract: The 1991 eruption of Mount Pinatubo, Philippines, released over ~20 Mt of SO2 into the atmosphere. The dacitic eruption products contain anhydrite phenocrysts, reflecting high fO2 conditions (~NNO+1.6). The pre-eruptive conditions of the magma are evaluated based on several geothermometers, including Fe-Ti oxide equilibrium, zircon saturation and Ti-in-zircon.

Fe-Ti oxides are low in Ti, with average X(Ilm)=0.12 and X(Ulv)=0.53. Average equilibrium temperatures of 830°C and 730°C are obtained using the models of Ghiorso and Gualda (2013) and Andersen et al. (1993), respectively.

Zircon saturation temperature was calculated from the compositions of bulk rock (avg. 111 ppm Zr) and matrix glass (avg. 90.3 ppm Zr) using the models of Gervasoni et al. (2016), Boehnke et al. (2013) and Watson and Harrison (1983). Bulk rock and matrix glass yield 500, 667, 738°C and 525, 681, 741°C, respectively.

Zircon contains low Ti (2.4–7.9 ppm) that shows no correlation with REE, Y, U and Th contents, indicating a non-crystallographic control on Ti substitution. Use of melt aTiO2=0.6, which is commonly assumed for felsic rocks, yield an average crystallization temperature of 676°C. True aTiO2 is evaluated using the compositions of Fe-Ti oxides and matrix glass. Oxides give aTiO2=0.30 (Teq=830°C) and 0.88 (Teq=730°C), whereas matrix glass yield aTiO2 of 0.34 (melt T=830°C) and 1.04 (melt T=730°C). Using aTiO2=0.3 and 0.88, zircon crystallization T of 740°C and 640°C, respectively, are obtained.

The above data suggest that the pre-eruptive dacitic magma at ~10 km depth was cooler than previously assumed. Cummingtonite started to crystallize over hornblende below 780°C (Tmax) and the magma progressively cooled to below ~740°C. Hereafter, two possible petrogenetic sequences are proposed. (1) Zircon began to nucleate and crystallize from a low aTiO2 (~0.30) melt at a saturation temperature of ~740°C. Injection of hot mafic magma several weeks before the eruption heated the dacitic magma to greater than 800°C, locally re-equilibrating the Fe-Ti oxides. (2) Alternatively, zircon started to crystallize at much lower temperatures of ~640°C from a high aTiO2 (~0.88) melt, possibly due to supersaturation of the melt or liquidus depression. This work demonstrates that multiple mineral geothermometers can be used to reveal the evolution of a magma chamber.

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