

The 1707 AD eruption of Fuji Volcano, Japan: Magmatic Processes and Timescales

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Fuji Volcano, one of the most hazardous volcanoes in Japan, has erupted primarily basaltic magmas throughout its history. However, the most recent eruption in 1707 AD produced a chemically zoned deposit with compositions ranging from basalt to dacite. This eruption was one of the largest (0.7 km^3 d.r.e.) and most explosive eruptions in Fuji's history, and related tephra deposits a few centimeters in thickness reached as far as Tokyo, approximately 100 km from the vent [1-3]. Prior studies have proposed a variety of processes to explain the chemical variations in this deposit, including liquid immiscibility [4], magma mixing involving magmas from discrete magma chambers [2], and fractional crystallization with minor crustal assimilation and basaltic magma injection [5]. In order to further constrain the timescales of magma evolution leading to the 1707 eruption, we have evaluated a suite of samples from throughout the 1707 AD deposit for ^{238}U - ^{230}Th - ^{226}Ra and Ba systematics. Major and trace element variations, as well as constant Sr, Nd and Pb isotopes throughout the Fuji 1707 AD deposit are consistent with fractional crystallization of plagioclase, pyroxene, olivine and magnetite, and minor apatite as the dominant process leading to chemical variations. U-series disequilibria data show that all samples are U-enriched, consistent with derivation from a mantle wedge that has been fluxed by hydrous slab fluids [6; this study]. Essentially constant $^{230}\text{Th}/^{232}\text{Th}$, but decreasing $^{238}\text{U}/^{232}\text{Th}$ with increasing SiO_2 and $^{230}\text{Th}/^{238}\text{U}$ close to radioactive equilibrium in the most evolved samples could be explained by assimilation of old, low U/Th crust with a $^{230}\text{Th}/^{232}\text{Th}$ ratio similar to the Fuji basalts. However, Os isotope variations indicate that the most evolved samples have been affected by less than 0.2 percent crustal assimilation, which should have an insignificant effect on the U-Th disequilibria. Fractionation of apatite during magma differentiation can alternatively explain the variations in $^{238}\text{U}/^{232}\text{Th}$. The constant $^{230}\text{Th}/^{232}\text{Th}$ requires this fractionation to take place over a timescale of less than 10 ka. However, activity ratios of $^{226}\text{Ra}/^{230}\text{Th}$ greater than 1 in all samples [6; this study] indicate that magma fractionation timescales may be substantially shorter. Decreasing $^{226}\text{Ra}/^{230}\text{Th}$ with increasing SiO_2 can be explained by instantaneous or continuous fractionation models, and indicate timescales of magma fractionation from parental basalts to dacite on the order of 10^3 years. References: [1] Miyaji (1984), Bull. Volcanol. Soc. Japan 29, 17-30. [2] Yoshimoto et al. (2004), Proc. Japan Acad., Ser. B 80, 103-106. [3] Miyaji et al. (2011), JVGR 207, 113-129. [4] Kawamoto (1992), Int. Geological Congress Abs. 29, 558. [5] Watanabe et al. (2006), JVGR 206, 1-19. [6] Kurihara et al. (2008), Radioisotopes 57, 471-483.