ORIGIN OF CHEMICAL ZONATION IN THE 1707 ERUPTION OF FUJI VOLCANO, JAPAN: THE ROLE OF CRUSTAL ASSIMILATION

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Most large, explosive volcanic eruptions produce chemically zoned volcanic deposits, reflecting chemical zonation in the magma chamber. Magmas gradually become highly silicic and volatile-rich towards the top, becoming potentially explosive. The processes leading to chemically zoned magma chambers are not fully understood; however, fractional crystallization, magma mixing, and crustal assimilation have been recognized as potentially important processes for generating such zonations.

Although the eruptive history of Fuji Volcano in Japan has been predominantly basaltic, the 1707 eruption was explosive and resulted in a chemically zoned volcanic deposit. Previous studies have suggested that liquid immiscibility caused the zonation in the magma chamber (Kawamoto, 1992). However, the petrogenetic processes that formed the observed 1707 deposit are still being debated. Our investigations are aimed to further constrain the petrogenetic processes and better understand the 1707 chemically zoned magmatic system.

Major and trace elements, and Sr, Nd, and Pb isotopic studies indicate that closed-system fractional crystallization of the observed mineral assemblage can explain the 1707 chemically zoned volcanic deposit (Watanabe and Widom, 2003). The restricted range in Sr and Nd isotope signatures limits potential crustal contamination to less than 0.2%, if the assimilated crust is similar to typical Japanese upper crust. However, petrographic examination of plagioclase and olivine phenocrysts has revealed disequilibrium textures, which suggests that open-system processes such as crustal contamination might have taken place.

In order to assess the role of crustal contamination in the development of the 1707 chemically zoned magma chamber, Os isotopes measurements have been made. Os isotopes are sensitive to crustal assimilation due to the extreme difference in $^{187}Os/^{188}Os$ ratios between the mantle and the crust; $^{187}Os/^{188}Os$ is higher in the crust than in the mantle by approximately one order of magnitude. Therefore, even minor amounts of crustal assimilation can be detected. More evolved eruptive products would be expected to show elevated $^{187}Os/^{188}Os$ signatures, if they were subjected to crustal contamination.

Measured $^{187}Os/^{188}Os$ ratios in the 1707 basalts range from 0.165 - 0.174. These values are slightly higher than mantle-derived basalts from mid-ocean ridges and ocean islands (0.13-0.15); however, they fall within the range of other arc basalts and sub-arc mantle xenoliths (0.13-0.17; Widom et al, 2003). In contrast, Fuji 1707 andesites and dacites showed significantly elevated $^{187}Os/^{188}Os$ ratios, ranging from 0.26 – 0.39. These high $^{187}Os/^{188}Os$ ratios indicate that crustal assimilation played a significant role in the development of the magmatic system prior to the 1707 eruption of Fuji Volcano.

References:

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