The evolution of chemically zoned trachyte deposits: Fogo Volcano, São Miguel, Azores

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Fogo Volcano is an active stratovolcano with a summit caldera, located on São Miguel, Azores. Fogo summit eruptions typically involve volatile-rich trachytic magmas that give rise to explosive eruptions. Within the past 5,000 years, Fogo has been the source of two chemically zoned deposits: Fogo A (4.6 ka) and 1563AD. Here we compare the petrogenetic processes leading to the two eruptions, and evaluate whether they could result from one continuously evolving magma body.

In order to constrain the petrogenetic processes that formed the Fogo 1563AD deposit, a major and trace element and Sr-Nd-Pb isotope study has been done. Thirteen samples collected from throughout the Fogo 1563AD deposit fall within a limited range in SiO_2 (63.5 to 65 wt%), but exhibit large trace element variations with Ba and Sr showing 4-fold decreases (~200-50 ppm and ~60-15 ppm, respectively) and Zr an ~1.7-fold increase (~1200-2000 ppm) with increasing SiO_2. Chondrite-normalized REE patterns display enrichment from least to most evolved trachyte with an increasing negative Eu anomaly. The major and trace element variations are consistent with ~60% fractionation of sanidine, augite, biotite, magnetite and apatite, consistent with the observed phenocryst assemblage, and similar to the Fogo A deposit.

Open system processes (assimilation of syenite wall rock) have been recognized in the Fogo A deposit, but they do not play a major role in the formation of the Fogo 1563AD deposit. Sr, Nd and Pb isotopes are essentially constant throughout the deposit, with $^{87}Sr/^{86}Sr = 0.70500\pm2$, $^{143}Nd/^{144}Nd = 0.51272\pm1$, $^{206}Pb/^{204}Pb = 19.94\pm2$, $^{207}Pb/^{204}Pb = 15.71\pm2$ and $^{208}Pb/^{204}Pb = 40.06\pm4$. The lack of variation in $^{87}Sr/^{86}Sr$ rules out significant assimilation of hydrothermally altered wallrock.

Although existence of a single, evolving trachytic magma body beneath Fogo has been proposed by Storey (1981), our data suggest that multiple batches of magma and more complex petrogenetic processes may have been involved in the evolution of Fogo Volcano.

LA-ICPMS studies of microscale trace element variations in zoned minimum-melt magma systems

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Single-eruption rhyolitic and phonolitic pyroclastic sequences are often vertically compositionally zoned in trace elements, but not in major elements. This observation has usually been explained by the fact that liquids that approximate to one of the two minima in Petrogeny's Residua system undergo crystallization-differentiation (or are produced by partial melting) without experiencing significant changes in major element composition, but trace element concentrations are not so constrained. It is also recognized that trace phenocryst phases (e.g. zircon, titanite, chevkinite, allanite, phosphates) play a dominant role in governing the behavior of many trace elements, especially REE and HFSE. The advent of routine, rapid, cheap, accurate and precise *in situ* microanalysis of trace elements by LA-ICPMS therefore offers considerable potential for furthering our knowledge of these systems.

We present LA-ICPMS trace element analyses of glassy bubble walls inside pumice clasts, together with data from accompanying phenocryst phases, from a zoned alkaline system at the phonolitic minimum (Diego Hernandez Fm., Las Cañadas caldera, Tenerife), and a zoned high-silica rhyolite system at the granite minimum (Bandelier Tuff, Valles caldera, New Mexico). In both cases, single pumice clasts exhibit internal variations in trace element contents of glass. At Las Cañadas, almost the entire compositional range within a deposit may be found within a single pumice clast, and the zonation is the product of intimate mingling of independently-derived minimum liquids, rather than continuous fractionation at the minimum.

At Valles, the relationships are more complex, with glass compositional trends on element-element diagrams steeply angled with respect to those defined by whole-pumice variations for elements (REE, Y, Zr, Hf) that are strongly sequestered into trace phases. However, glass data mimic whole pumices for elements such as Rb that weakly partition into major phases (alkali feldpar). This is interpreted as the result of preferential dissolution of trace phases associated with thermal rejuvenation of a stagnant, crystal-rich rhyolitic magma prior to eruption; the ultimate origin of the most evolved liquid nonetheless remains enigmatic.