Differentiation rates and geochemical characterization of parental magmas for The Piton des Neiges Volcano (Réunion Island, Indian Ocean)

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A high-resolution K/Ar geochronological and geochemical study has been performed on the terminal activity of the now extinct central shield volcano of the Réunion hot spot (Indian ocean) : the Piton des Neiges. This ultimate stage of activity which lasted over about 300 kyr (from 350 ka to 25 ka), is characterized by the outpouring of differentiated products ranging from plagioclase-phyric basalts to quartz-trachytes and comendites. The high time-resolution of the chronostratigraphy allows two distinct and simultaneous geochemical evolution trends to be recognized. Based on brown amphiboles study, a two superimposed magma chamber model is proposed to account for the whole geochemical evolution of the Piton des Neiges volcano with a deep one (5-6 kbar) and a shallower one (2-3 kbar). Differentiation rates for magmas in the shallow reservoir are comprised between 0.4 and 1.3 wt.% SiO_2/ka. Such rapid differentiation occurred four times in the final history of the Piton des Neiges volcano. The parental magmas are Si-undersaturated with normative nepheline comprised between 0.8 and 4.8 wt.%.

Gradients in silicic bodies caused by mixing rather than chamber differentiation

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One widely accepted paradigm for compositional zoning in silicic eruptions is that such heterogeneity reflects vertical gradients in the source-magma reservoir developed gradually through in situ differentiation. Although the pattern of chemical and phenocryst variation in some eruptions may support magmatic gradients in the source reservoir at the time of eruption, evidence for protracted chamber differentiation is generally equivocal. In many instances the observed zonation is as readily explained by mixing during chamber replenishment just prior to eruption. Here we show that integration of textural and whole-rock geochemical signatures with mineral-scale isotopic variations in the rhyolite of Taylor Creek, New Mexico, can be used to identify and track the involvement of recharge in magma evolution and eruptive activity.

At Taylor Creek, a group of 20 high-silica rhyolite lava domes and flows totalling ~ 55 km^3 in volume erupted in a period of 100,000 years or less at 27.9 Ma. For domes and flows showing time-related trace-element trends, phenocryst modal distributions vary systematically with relative age. Early erupted lava has moderate to high crystal contents (20-36 vol. %). Late erupted lava is relatively crystal poor (< 20 vol. %). Within these dome clusters, high-$^{87}Sr/^{86}Sr$, incompatible-element-poor lava is invariably first erupted.

Mineral-scale isotope variations indicate the rhyolite formed by mixing of relatively low-$^{87}Sr/^{86}Sr$ rhyolitic liquid into stagnant, partially solidified high-$^{87}Sr/^{86}Sr$ magma previously intruded into, and contaminated by, Proterozoic granitic crust. Reinjection appears to have occurred prior to and during growth of the lava-dome field and may have triggered eruptions by slight reheating and/or addition of volatiles to resident magma. Mixing calculations suggest that addition of 10 to 90 % replenished liquid to resident magma can account for the entire compositional spectrum of Taylor Creek lava. Time variations in lava compositions and size distributions of phenocrysts indicate, however, that serial eruptions progressively tapped off most of the hybrid magma formed by mixing of contaminated resident magma with replenishment liquids prior to final dome emplacement. These observations link growth of the lava-dome field to reinjection events and are consistent with waning of eruptive activity following cessation of replenishment.