Characterizing the last explosive gasps of the Piton des Neiges (La Réunion Island) over the last 200 ka

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The most recent activity of Piton des Neiges (La Réunion) is characterized by explosive behavior and relatively evolved magma compositions. These eruptions occurred roughly over the past 200 thousand years producing thick pyroclastic deposits, lava domes and block and ash flow deposits. We here present a detailed petrologic and geochronologic characterization of these deposits providing insights into the timing of explosive eruptions and pre-eruption magma storage conditions.

The early phase of explosive activity is characterized by up to 15 m-thick pyroclastic deposits found on the southeastern and western flanks of Piton des Neiges. These deposits have been regarded as individual discrete eruptions that occurred between 220 and 110 ka. Our detailed petrographical and geochemical study on juvenile fragments and the main mineral phases indicate that all deposits share similar geochemical fingerprints. High-precision single crystal 40Ar/39Ar dates on 70 alkali feldspars from 6 samples reveal significant dispersion but the youngest population of dated crystals from each sample yield overlapping weighted mean dates around 200 ka, supporting their geochemical correlation. The wide spread in 40Ar/39Ar dates of up to 88 kyrs prior to eruption, uncommon for alkali feldspar in volcanic rocks, argues for the presence of excess and/or inherited argon in those crystals. Together, our findings suggest that the early pyroclastic deposits are the product of a Plinian-type eruption that covered a large area of the island around 200 ka. The eruption was fed by a long-lived magma reservoir that produced differentiated magmas in response to lower recharge fluxes after the main active center migrated to the currently active Piton de la Fournaise. A wide range of mineral compositions and the strong disequilibrium between crystals and the trachytic groundmass is an indication of the pronounced heterogeneity of the magmatic reservoir following a deep recharge event that triggered the eruption.

The younger eruptive episode of Piton des Neiges occurred between 70 and 30 ka with dome-forming lavas of trachytic to rhyolitic composition that collapsed into pyroclastic density currents resulting in block and ash flow deposits found closer to the current summit. This eruptive style, infrequent in this geotectonic setting, has not yet been well recognized for Piton des Neiges.
Pristine zircon crystals, found in a sample from a block and ash deposit, were dated with a total of 192 LA-ICP-MS spot analyses using the U-Th disequilibrium method, and constitute the first zircon geochronology study for this volcano. The results yield a well-defined isochron with a date of 44.80 ± 1.32 ka (2 S.E., MSWD = 1.2). Single crystal $^{40}\text{Ar}/^{39}\text{Ar}$ dates on alkali feldspars show a similar dispersion as for the older eruptive phase, but the youngest dates overlap with the zircon U-Th date, providing robust estimates of the eruption age.

This detailed characterization of the youngest eruptive episode of Piton des Neiges documents its explosive potential during the past 200 thousand years and has significant implications regarding the current view of Piton des Neiges as an extinct volcano.