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New radiometric and petrological constraints on the evolution of the Pichincha volcanic complex (Ecuador)

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Abstract

Fieldwork, radiometric ($^{40}Ar/^{39}Ar$ and ^{14}C) ages and whole-rock geochemistry allow a reconstruction of eruptive stages at the active, mainly dacitic, Pichincha Volcanic Complex (PVC), whose eruptions have repeatedly threatened Quito, most recently from 1999 to 2001. After the emplacement of basal lavas dated at ~1100 to 900 ka, the eruptive activity of the old Rucu Pichincha volcano lasted from ~850 ka to ~150 ka before present (BP) and resulted in a 15 × 20 km-wide edifice, which comprises three main building stages: (1) A lower stratocone (Lower Rucu, ~160 km^3 in volume) developed from ~850 to 600 ka; (2) This edifice was capped by a steeper-sided and less voluminous cone (the Upper Rucu, 40–50 km^3), the history of which started 450–430 ka ago and ended around 250 ka with a sector collapse; (3) A smaller (8–10 km^3) but more explosive edifice grew in the avalanche amphitheatre and ended Rucu Pichincha's history about 150 ka ago. The Guagua Pichincha volcano (GGP) was developed from 60 ka on the western flank of Rucu with four growth stages separated by major catastrophic events. (1) From ~60 to 47 ka, a basal effusive stratocone developed, terminating with a large ash-and-pumice flow event. (2) This basal volcano was followed by a long-lasting dome building stage and related explosive episodes, the latter occurring between 28–30 and 22–23 ka. These first two stages formed the main GGP (~30 km^3), a large part of which was removed by a major collapse 11 ka BP. (3) Sustained explosive activity and viscous lava extrusions gave rise to a new edifice, Toaza (4–5 km^3 in volume), which in turn collapsed around 4 ka BP. (4) The ensuing amphitheatre was partly filled by the ~1-km^3 Cristal dome, which is the historically active centre of the Pichincha complex. The average output rate for the whole PVC is 0.29 km^3/ka. Nevertheless, the chronostratigraphic resolution we obtained for Lower Rucu Pichincha and for the two main edifices of Guagua Pichincha (main GGP and Toaza), leads to eruptive rates of 0.60–0.65 km^3/ka during these construction stages. These output rates are compared to those of other mainly dacitic volcanoes from continental arcs. Our study also supports an overall SiO_2 and large-ion lithophile elements enrichment as the PVC develops. In particular, distinctive geochemical signatures indicate the involvement of a new magma batch at the transition between Rucu and Guagua. At the GGP, the same phenomenon occurs at each major collapse event marking the onset of the ensuing magmatic stage. Since the 11-ka-BP collapse event, this magmatic behaviour has led to increasingly explosive activity. Four explosive cycles of between 100 and 200 years long have taken place at the Cristal dome in the past 3.7 ka, and repose intervals between these cycles have tended to decrease with time. As a consequence, we suggest that the 1999–2001 eruptive period may have initiated a new eruptive cycle that might pose a future hazard to Quito (~2 million inhabitants).

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