Non-linear explosion tremor at Sangay, Volcano, Ecuador

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Abstract

Sangay (5230 m), the southernmost active volcano of the Andean Northern Volcanic Zone (NVZ), sits ∼130 km above a >32-Ma-old slab, close to a major tear that separates two distinct subducting oceanic crusts. Southwards, Quaternary volcanism is absent along a 1600-km-long segment of the Andes. Three successive edifices of decreasing volume have formed the Sangay volcanic complex during the last 500 ka. Two former cones (Sangay I and II) have been largely destroyed by sector collapses that resulted in large debris avalanches that flowed out upon the Amazon plain. Sangay III, being constructed within the last avalanche amphitheater, has been active at least since 14 ka BP. Only the largest eruptions with unusually high Plinian columns are likely to represent a major hazard for the inhabited areas located 30 to 100 km west of the volcano. However, given the volcano's relief and unbuttressed eastern side, a future collapse must be considered, that would seriously affect an area of present-day colonization in the Amazon plain, ∼30 km east of the summit. Andesites greatly predominate at Sangay, there being few dacites and basalts. In order to explain the unusual characteristics of the Sangay suite—highest content of incompatible elements (except Y and HREE) of any NVZ suite, low Y and HREE values in the andesites and dacites, and high Nb/La of the only basalt found—a preliminary five-step model is proposed: (1) an enriched mantle (in comparison with an MORB source), or maybe a variably enriched mantle, at the site of the Sangay, prior to Quaternary volcanism; (2) metasomatism of this mantle by important volumes of slab-derived fluids enriched in soluble incompatible elements, due to the subduction of major oceanic fracture zones; (3) partial melting of this metasomatized mantle and generation of primitive basaltic melts with Nb/La values typical of the NVZ, which are parental to the entire Sangay suite but apparently never reach the surface and subordinate production of high Nb/La basaltic melts, maybe by lower degrees of melting at the periphery of the main site of magma formation, that only infrequently reach the surface; (4) AFC processes at the base of a 50-km-thick crust, where parental melts pond and fractionate while assimilating remelts of similar basaltic material previously underplated, producing andesites with low Y and HREE contents, due to garnet stability at this depth; (5) low-pressure fractionation and mixing processes higher in the crust. Both an enriched mantle under Sangay prior to volcanism and an important slab-derived input of fluids enriched in soluble incompatible elements, two parameters certainly related to the unique setting of the volcano at the southern termination of the NVZ, apparently account for the exceptionally high contents of incompatible elements of the Sangay suite. In addition, the low Cr/Ni values of the entire suite—another unique characteristic of the NVZ—also requires unusual fractionation processes involving Cr-spinel and/or clinopyroxene, either in the upper mantle or at the base of the crust.

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