HUAYNAPUTINA VOLCANO, SOUTHERN PERU, AD 1600: ERUPTION PHASES AND MECHANISMS

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The largest explosive eruption in the Andes over the past five centuries at Huaynaputina volcano encompassed seven eruptive phases: 1) plinian fallout, 2) ashfall from a dwindling column, 3) ignimbrite-forming with (4) interspersed phreatomagmatic eruptions, 5) crystal-rich ashfall, 6) ash flows, and 7) late ashfall.
The plinian fallout with a bulk volume of ~7 km^3 was deposited over an area 100,000 km ^{2} from 19 February pm to 20 February am. From a sustained plinian column 27 - 35 km high that lasted 13 to 19 hours, the volumetric eruption rate is computed in the range of 6 x 10^4 to 1 x 10^5 m^3/s and the mass eruption rate 1.2 to 1.7 x 10^8 kg/s. The onset and high discharge of the plinian eruption was probably fueled by the disruption of a hydrothermal system as shown by the amount of hydrothermally altered fragments in the pumice fallout.
Following the plinian shutdown, a dwindling column sent ash fall and pyroclastic surges on proximal-to-medial slopes during the second phase. During the third phase, nonwelded pumice-rich pyroclastic flows were channeled in the Río Tambo valley and tributaries. The flows produced vigorous columns over the proximal-to-medial ridges: winds winnowing the columns dispersed a co-ignimbrite ash over an area ~360,000 km^2. The third phase tapped a magma batch richer in silica and crystals than the plinian magma from a layered magma chamber.
Accretionary lapilli-bearing base-surge deposits interbedded with ignimbrites indicate phreatomagmatic interactions; the magma discharge decreased, owing to erosion of the plinian vent and opening of subsequent vents. Dacitic domes that grew in the vent area probably after the plinian phase were torn apart: two youthful vents formed when the unusually crystal-rich magma of unit 5 was tapped toward the end of the eruption. The crystal-rich magma resulted, either from a process of hyperfragmentation at depth in the layered magma chamber, or from strong degassing and cooling processes that induced a rapid crystallization just after the plinian phase. Ash flows that segregated from the crystal-rich magma deposited lag breccia near the vent and small-volume ash-flow deposits in proximal catchments. The preserved deposits point toward thin flows, probably subcritical but able to surmount ridges ~1,400 m high as far as 20 km from the vent. Air entrainment in flows moving over a series of ridges and valleys likely enhanced turbulence. Although the total 6.7-9.2 km^3 DRE volume of AD 1600 erupted tephra did not involve caldera collapse, ring-fractures cut through the vents and the floor of the amphitheater, suggesting the onset of a funnel-type caldera collapse.