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Source and emplacement conditions of a directed blast deposit at Huarmi Imbabura volcano, Ecuador

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Imbabura (4620 meters above sea level) is a large strato-volcano in Northern Ecuador that experienced dominantly effusive eruptions during the Upper Pleistocene. However, a remarkably violent explosive eruption took place at ca 30 ka cal BP, with emplacement of a “directed blast” deposit to the southwest of the main edifice. The eruption started with a local debris avalanche event, and was followed by growth of the voluminous Huarmi Imbabura dome complex. At El Araque hill the blast layer rests directly upon the debris avalanche breccia, which points to sub-synchronous emplacement. A first goal of the present study is to decipher the characteristics of the blast layer: distribution, volume, aspect ratio, grainsize, and componentry. A second goal is to decipher the source conditions of the eruption: did it occur from a pre-blast dome or from a crypto-dome? What was the size of the vent, or the depth of the cryptodome? To investigate these issues, we conducted a detailed mapping of the blast deposit (scale 1:25.000), collected new thickness measurements at 35 sites, and obtained grainsize analyses of eight representative samples. We also conducted componentry analyses (seven clast types in the deposit, 300 grains per sub-sample) and density measurements of 100 juvenile clasts.

Our results show that the volume of the debris avalanche deposit is on the order of 0.4 - 0.5 km3. The concomitant pyroclastic density current (blast) had a maximum runout distance of about 10 km, spread over an area of >100 km2, and left a deposit whose bulk volume is on the order of 0.08 km3. This relatively thin and widespread deposit points to a high-energy transport dynamics. The grainsize analyses indicate that the blast deposit is coarse-grained, with a remarkably low amount of fine particles. Overall the deposit consists of about 88 vol% of juvenile material, and the non-juvenile clast fractions show complex patterns of enrichment and depletion correlated to componentry size, density and distance of deposition. Noticeably, the juvenile clast population displays a bimodal density distribution, which is a typical feature of many directed blast layers, with two density peaks at 1200 and 2600 kg/m3. The Dense-Rock-Equivalent (DRE) volume of the juvenile and non-juvenile fractions is estimated at 51 million m3 and 7 million m3, respectively. Along with results of componentry distribution patterns, these values suggest that the blast was produced by depressurization of a crypto-dome emplaced at shallow depth into Imbabura’s SW flank.

This is the first study that offers details on lateral componentry concentration in a blast deposit in the Andes, and it contributes to reassess the volcanic hazard in the area of the Imbabura Volcanic Complex. Additional work will focus on the role of volcano-tectonic interactions in triggering this directed blast eruption, as well as in controlling the development of other volcanic features in the area.