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RESEARCH ARTICLE

New insights into eruption source parameters of the 1600 CE Huaynaputina Plinian eruption, Peru

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Abstract

In the Central Andes, large Plinian eruptions (Volcanic Explosivity Index ≥ 5) occur at a relatively high frequency, i.e. average one every 2000 to 4000 years over the past 50,000 years in Peru. Such recurring explosive activity represents a significant challenge for regions typically hosting several million people (e.g. Southern Peru, Western Bolivia and Northern Chile). With VEI 6, the 1600 CE Huaynaputina eruption is considered the largest historical eruption in South America. We have re-examined the first Plinian phase of this eruption in order to better assess critical eruption source parameters (i.e. erupted volume, plume height, mass eruption rate, eruption duration).The revised bulk volume of the tephra-fall deposit associated with the Plinian phase is approximately 13–14 km^3, almost twice the previous estimate (7–8 km^3 within the 1 cm isopach) based on methods including power law, Weibull function and Bayesian linear regression. Tephra was dispersed by strong winds to the WNW as far as 400 km on Peruvian territory and then in the Pacific Ocean. Seven villages were buried, killing ~ 1500 people. The revised plume height estimate, 32.2 ± 2.5 km, is consistent with the early estimations. As a result, the Huaynaputina 1600 CE first eruption phase lies in the upper part of the Plinian field close to the ultra-Plinian transition, making this event one of the largest in the past millennium which coincides with results from recent studies on palaeoclimatic impacts.

Keywords Tephra-fall deposit · Plume height · Erupted volume · Mass Eruption Rate

Introduction

The study of tephra-fall deposits is fundamental to modern volcanology as they preserve important information about eruption dynamics (e.g. Cas and Wright 1987; Sigurdsson et al. 2015; Bonadonna et al. 2016). Physical characteristics of the deposits such as thickness, grain size, componentry and density are used to estimate critical eruption source parameters (ESPs), e.g. erupted volume (e.g. Pyle 1989; Bonadonna and Houghton 2005; Bonadonna and Costa 2012), plume height (e.g. Carey and Sparks 1986; Burden et al. 2011; Rossi et al. 2019) and mass eruption rate (e.g. Mastin et al. 2009; Wilson and Walker 1987; Degruyter and Bonadonna 2012). Determination of ESPs is essential both for the assessment of volcanic hazards, as they are used as input parameters for tephra dispersal models, and for the characterisation and classification of eruptions. The term "Plinian" describes "explosive eruptions characterised by a quasi-steady, hours-long, high speed discharge into the atmosphere of a high-temperature, multiphase mixture (gas, solid and liquid particles), forming a buoyant vertical column that reaches heights of tens of kilometres" (Cioni et al. 2015). Historical Plinian eruptions include Vesuvius (Italy) in 79, Hatepe (New Zealand) in 186, Ilopango (El Salvador) in 535, Baekdu (China/North Korea) in 946, Samalas (Indonesia) in 1257, Huaynaputina (Peru) in 1600, Tambora (Indonesia) in 1815, Krakatoa (Indonesia) in 1883, Santa María (Guatemala) in 1902, Novarupta (USA) in 1912 and Pinatubo (Philippines) in 1991 (Sigurdsson et al.

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