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Evolution of the 2015 Cotopaxi eruption revealed by combined geochemical & seismic observations

S. Hidalgo[1], J. Battaglia[2], S. Arellano[3], D. Sierra[1], B. Bernard[1], R. Parra[4], F. Dinger[5, 6], C. Barrington[7], P. Samaniego[2]

[1]Instituto Geofísico – Escuela Politécnica Nacional, Quito, Ecuador

[2]Université Clermont Auvergne, CNRS, IRD, OPGC, Laboratoire Magmas et Volcans, Clermont-Ferrand, France

[3]Department of Space, Earth and Environment – Chalmers University of Technology, Göteborg, Sweden

[4]Instituto de Simulación Computacional, Colegio de Ciencias e Ingenierías - Universidad San Francisco de Quito, Quito, Ecuador

[5]Max-Planck Institut for Chemistry, Mainz, Germany

[6]Institute for Environmental Physics, University of Heidelberg, Germany

[7]Earth Observatory of Singapore, Nanyang Technological University, Singapore

The integrated use of several geophysical, geochemical and petrological data sets helps scientist from volcanic observatories to better monitor volcanic unrests and to make more robust eruption forecasts by obtaining an holistic interpretation of volcanic systems. Between April and November 2015, Cotopaxi volcano located in central Ecuador, showed a low magnitude eruption. This volcano displays typically one moderate to large eruption per century with the last deadly eruption in 1877. Due to its eruptive frequency, this volcano was the first to have a monitoring system installed since 1976 by the Instituto Geofísico. The monitoring network evolved through time and nowadays it includes at least 57 instruments providing different data in real time. Thanks to the complete monitoring network installed on the volcano at the time of unrest and thanks to the rapid and continuous sampling of the eruptive products throughout the eruptive period, we were able to obtain the total mass of emitted ash, gas emission and gas geochemistry, as well as seismic and petrologic data. We use these data to decipher the origin and temporal evolution of this eruption. Seismic amplitudes and the identification of families of similar seismic events reveal temporal changes in volcanic processes. SO_2 and BrO were measured in the plume by permanent DOAS stations throughout the eruption and indicate a shallow magmatic source, with SO_2 varying from 300 t/d to 24,000 t/d and, BrO/SO_2 ranging from 5 to 10 x 10^{-5}. SO_2/HCl (5.8 ± 4.8 and 6.6 ± 3.0) and CO_2/SO_2 (0.6 to 2.1) were measured only during field campaigns, but display also typically magmatic values. Bulk ash and glass chemistry indicate a homogenous andesitic (SiO_2 wt.% = 56.94 ± 0.25) magma having undergone extensive S-exsolution and degassing during ascent. These data lead us to interpret this eruption as a magma intrusion and ascent to shallow levels. The intrusion progressively interacted with the hydrothermal system, boiled off water, and produced hydromagmatic explosions, which took place on August 14th. A small volume of this magma continued to fragment and produced episodic ash emissions until it was sufficiently degassed and rheologically stiff. Based on the 470 kt of measured SO_2 we estimate that ~65.3 x 10^6 m^3 of magma were required to supply the emitted gases. This volume exceeds the volume of erupted juvenile material by a factor of 50. This result emphasizes the importance of careful monitoring of Cotopaxi to identify the intrusion of a new batch of magma, which could rejuvenate the non-erupted material.