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Volcanic gas emissions and degassing dynamics at Ubinas and Sabancaya volcanoes; implications for the volatile budget of the central volcanic zone

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ABSTRACT

Emission of volcanic gas is thought to be the dominant process by which volatiles transit from the deep earth to the atmosphere. Volcanic gas emissions, remain poorly constrained, and volcanoes of Peru are entirely absent from the current global dataset. In Peru, Sabancaya and Ubinas volcanoes are by far the largest sources of volcanic gas. Here, we report the first measurements of the compositions and fluxes of volcanic gases emitted from these volcanoes. The measurements were acquired in November 2015. We determined an average SO_2 flux of 15.3 ± 2.3 kg s^{-1} (1325-ton day^{-1}) at Sabancaya and of 11.4 ± 3.9 kg s^{-1} (988-ton day^{-1}) at Ubinas using scanning ultraviolet spectroscopy and dual UV camera systems. In-situ Multi-GAS analyses yield molar proportions of H_2O, CO_2, SO_2, H_2S and H_2 gases of 73, 15, 10 1.15 and 0.15 mol% at Sabancaya and of 96, 2.2, 1.2 and 0.05 mol% for H_2O, CO_2, SO_2 and H_2S at Ubinas. Together, these data imply cumulative fluxes for both volcanoes of 282, 30, 27, 1.2 and 0.01 kg s^{-1} of H_2O, CO_2, SO_2, H_2S and H_2 respectively. Sabancaya and Ubinas volcanoes together contribute about 60% of the total CO_2 emissions from the Central Volcanic zone, and dominate by far the total revised volatile budget of the entire Central Volcanic Zone of the Andes.

1. Introduction

Whilst volcanic SO_2 emissions can be measured from space at all strongly outgassing volcanoes (e.g., Carn et al., 2017), emissions of other gases still rely on ground-based measurements. Such measurements have only been performed on a fraction of all outgassing subaerial volcanoes (e.g., Burton et al., 2013). In order to determine the contribution of volcanic gases to the atmosphere and to quantify Earth's deep volatile cycle, a much larger number of measurements need to be performed. The total volcanic volatile flux is dominated by persistent degassing (Shinohara, 2013). Although impressive and punctually important, explosive eruptions typically contribute fifteen times less volatiles than persistent degassing does (Shinohara, 2008), such that total volatile flux is dominated by only a handful of persistently degassing volcanoes. Based on volcanoes with quantified emissions, ten volcanoes emit 67% of the estimated total volatile flux from subduction zones (Shinohara, 2013), while five volcanoes are thought to be responsible for 80% of the global CO_2 flux from subaerial volcanoes (Burton et al., 2013). Identifying and accurately measuring strongly emitting volcanoes is hence of paramount importance for an accurate global estimate to be achieved. High quality gas measurements however tend to be

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