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RESEARCH ARTICLE

# Probing the hidden magmatic evolution of El Misti volcano (Peru) with the Pb isotope composition of fumaroles

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## Abstract

This work proposes a new method to probe the hidden magmatic evolution of quiescent Andean volcanoes from the Pb isotope composition of gases. The method is based on an assimilation-fractional crystallisation-degassing model linking the Pb isotope composition of gases with the $SiO_2$ content of their magmatic source. The model is applied to El Misti volcano that threatens Arequipa, the second most densely populated city of Peru. Gas condensates and Pb-rich solid deposits (PbS, $PbCl_2$, $PbSO_4$) collected in 2018 in the bottom of El Misti crater at 260–150°C fumarole vents were used to reconstruct the mean composition of degassing magmas (60.8–61.8 wt% $SiO_2$). These compositions are slightly more evolved than the lavas from the last AD 1440–1470 eruption, suggesting either the secular differentiation of the main magma reservoir, or the contribution of more evolved magmas to volcanic gases. On the other hand, the slight but significant difference between the instantaneous composition recorded in gas condensates and the time-integrated composition recorded in solid deposits points to the degassing of less evolved magmas over the last decades. This trend is ascribed to a recent recharge of El Misti reservoir with hot mafic magmas, in agreement with the evolution of fumarolic deposit mineralogy in the last half a century. The Pb isotope composition of gas appears to be a promising tool for probing the hidden magmatic evolution of quiescent volcanoes where assimilation-fractional crystallisation operates.

**Keywords** El Misti volcano · Assimilation-fractional crystallisation · Magmatic gases · Fumaroles · Sublimates · Pb isotopes

## Introduction

El Misti stratovolcano threatens the city of Arequipa, the second most densely populated city of Peru (>1.1 million inhabitants, INEI 2018) that is continuously growing at its foot (Fig. 1). Over the last 50 000 years, the volcano has shown a cyclic activity, with Plinian eruptions every 2000 to 4000 years and smaller to moderate explosive eruptions every 500 to 1500 years, on average (Thouret et al. 2001). The lavas produced since 0.12Ma are andesitic to dacitic in composition, with rare rhyolites and no marked evolution through time (Rivera et al. 2017). This relative homogeneity contrasts with the mineral evidence for regular recharge and mixing, which led Ruprecht and Wörner (2007) to suggest that magma recharge events are more frequent in comparison to the eruption frequencies, and that El Misti reservoir evolves most of the time cryptically. Since the last major eruption (AD 1440–1470), El Misti crater has showed a persistent but fluctuating degassing activity (Thouret et al. 2001; Moussallam et al. 2017). Over the last decades, the temperature of gases has varied between 125 and 310°C (Hantke and Parodi 1966; Birnie and Hall 1974; Thouret et al. 2001, and observations from Observatorio Vulcanológico del Ingemmet (OVI) and Instituto Geofísico del Perú (IGP)). The gases sampled in 2015 showed a dominant magmatic signature with little evidence for interaction with rocks and hydrothermal fluids (Moussallam et al. 2017), which

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