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Invited review article

Petro-geochemical constraints on the source and evolution of magmas at El Misti volcano (Peru)

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ABSTRACT

El Misti volcano, a large and hazardous edifice of the Andean Central Volcanic Zone (CVZ) of southern Peru, consists of four main growth stages. Misti 1 (>112 ka) is an old stratovolcano partly concealed by two younger stratocones (Misti 2, 112–40 ka; Misti 3, 38–11 ka), capped in turn by a recent summit cone (Misti 4, <11 ka). In order to gain insights into magma composition controls on eruptive behaviour through time at El Misti, we have conducted a petrological and geochemical study of selected rock samples from the main growth stages of the volcano. Whole rock compositions range from andesite to rhyolite and belong to a medium to high-K calk-alkaline magmatic suite. El Misti samples are characterised by high large-ion lithophile elements, but low concentrations of high field strength elements, and heavy rare earth elements, consistent with a subduction zone setting. The $^{87}Sr/^{86}Sr$ (0.70715–0.70882) and $^{143}Nd/^{144}Nd$ (0.511983–0.512277) isotope ratios suggest that magma composition is significantly affected by contamination and/or assimilation processes during their evolution, likely due to the presence of thick (65–70 km) continental crust beneath the CVZ in southern Peru. Geochemical evidence indicates that magmatic evolution is mostly controlled by Assimilation–Fractional Crystallisation (AFC) mechanisms. Modelling reveals a mass-assimilated/mass-fractionated ratio (ρ) ≤ 2.2, which suggests an assimilated crust fraction below 14 wt.% on average. Our isotopic data clearly identify the Proterozoic "Charcani gneiss" basement as the main contaminant. Both contamination and assimilation processes peaked at ~30 wt.%, during the Misti 3 stage when rhyolites were generated. We ascribe the general depletion in HREE and Y and elevated La/Yb and Sr/Y ratios in El Misti samples to the enrichment of the mantle wedge source of the parental magmas by a felsic melt of adakitic composition and hydrous fluids. Our work highlights that El Misti's magmatic system has remained relatively homogeneous since at least 0.12 Ma, with a marked influence of the contaminating crust in the Late Pleistocene Misti 3 stage, which resulted in highly explosive eruptions. Andesitic-dacitic compositions are dominant in the Holocene and historical Misti 4 stage, and are expected for future volcanic events at El Misti.

Contents

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