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The Tutupaca volcanic complex (Southern Peru): Eruptive chronology and successive destabilization of a dacitic dome complex

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ABSTRACT

Several processes have been proposed as triggering mechanisms for the large sector collapses that affect most volcanoes, and which may occur several times in the volcano's lifetime. Here we present and discuss the case of Tutupaca volcano, located in southern Peru and part of the Central Volcanic Zone of the Andes. Tutupaca is composed of an old, hydrothermally altered and highly eroded Basal edifice, as well as younger twin peaks located in the northern part of the complex (the Western and Eastern Tutupaca). The youngest Eastern edifice of Tutupaca is composed of at least seven coalescing lava domes and associated deposits, including block-and-ash flow and debris avalanche deposits. We identified two debris avalanche deposits. An older unit (Azufre debris avalanche deposit) was channeled in the valleys located to the E and SE of the basal volcano, reaching up to 3.5 km from its source region. Four cosmogenic nuclide exposure dates (^{10}Be/feldspar) were obtained from boulders of this debris avalanche deposit and ranged between 6.0 ± 0.7 and 7.8 ± 1.5 ka. The younger unit (Paipatja deposit) was associated with the sector collapse of the edifice reconstructed just after the first debris avalanche (domes IV to VIII). The sector collapse produced a debris avalanche deposit that outcrops immediately to the NE of the amphitheater and was associated with a large pyroclastic density current deposit that was previously dated by radiocarbon at 218 ± 14 a BP (Samaniego et al., 2015). Both debris avalanche deposits have two contrasting sub-units: (1) the main subunit, hereafter called hydrothermal-altered debris avalanche deposit, is a whitish-yellow volcanic breccia with heterolithic and heterometric blocks, which originated from the Basal edifice, and (2) a dome-rich debris avalanche deposit, composed by non-altered dome blocks from Eastern Tutupaca. In proximal areas, the dome-rich unit overlaps the hydrothermally-altered unit while in distal areas, these two units are mixed forming a hummocky and/or ridged topography. In addition to the similarity of both debris avalanches, we propose that the triggering mechanism for these debris avalanches was similar. The dacitic dome growth, coupled with a substrate of older, hydrothermally-altered rock, induced the destabilization of the edifice, producing the debris avalanches and the related pyroclastic density currents.

1. Introduction

Reconstructing the eruptive chronology of potentially active volcanoes represents the first step of any volcanic hazard initiative. During the last two decades, the eruptive chronology of some Peruvian volcanoes has been studied in detail. These studies include some of the most active volcanoes of this part of the Andes, such as El Misti (Thouret et al., 2001), Ubinas (Thouret et al., 2005), Ampato-Sabancaya (Samaniego et al., 2016), and Yucamane (Rivera et al., 2020). In addition, previous work has been focused on some key eruptions that showed an importance by their size and their eruptive dynamics. This is the case of the large, 2 ka BP explosive eruption of El Misti volcano (Volcanic Explosive Index, VEI 5, Harpel et al., 2011; Cobeñas et al., 2012), and the 1600 CE explosive eruption of Huaynaputina volcano, which is considered the

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