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Contrasting origin of two clay-rich debris flows at Cayambe Volcanic Complex, Ecuador

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Abstract

We investigate the sedimentological and mineralogical properties of a debris flow deposit west of Cayambe Volcanic Complex, an ice-clad edifice in Ecuador. The deposit exhibits a matrix facies containing up to 16 wt% of clays. However, the stratigraphic relationship of the deposit with respect to the Canguahua Formation, a widespread indurated volcaniclastic material in the Ecuadorian inter-Andean Valley, and the deposit alteration mineralogy differ depending on location. Thus, two different deposits are identified. The Río Granobles debris flow deposit (~1 km3) is characterised by the alteration mineral assemblage smectite + jarosite, and sulphur isotopic analyses point to a supergene hydrothermal alteration environment. This deposit probably derives from a debris avalanche initiated before 14–21 ka by collapse of a hydrothermally altered rock mass from the volcano summit. In contrast, the alteration mineralogy of the second debris flow deposit, which may itself comprise more than one unit, is dominated by halloysite + smectite and relates to a shallower and more recent (<13 ky) mass movement of high-altitude (>3200 m) volcanic soils. Our study reinforces the significance of hydrothermal alteration in weakening volcano flanks and in favouring rapid transformation of a volcanic debris avalanche into a clay-rich debris flow. It also demonstrates that mineralogical analysis provides crucial information for resolving the origin of a debris flow deposit in volcanic terrains. Finally, we posit that slope instability, promoted by ongoing subglacial hydrothermal alteration, remains a significant hazard at Cayambe Volcanic Complex.

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