

Large volcanic debris avalanches in Ecuador

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Since the Mount St. Helens eruption in 1980, the study of volcanic debris avalanches has been a major topic in volcanology worldwide. Ecuador has a high concentration of volcanoes and many have been affected by giant landslides with a characteristic scar in the source area and a thick debris avalanche deposit at the foot of the volcano. In this work we present the first catalog of large ($>0.1 \text{ km}^3$) volcanic debris avalanches in Ecuador based on the compilation of bibliographic references and the analysis of the most recent digital elevation models in a geographic information system. This catalog is analyzed in order to obtain statistics on the number of events, their size, frequency, and direction. Other metrics, such as deposit areas and run-out distances, are not analyzed because of a lack of information. Accordingly, we record 46 events at 32 volcanoes, of which 39 have a partially preserved landslide scar and 35 have a partially preserved debris avalanche deposit. Although most of the landslide scar have been modified by volcanic activity or erosion processes, their size can be estimated using their apparent dimensions (length, width, depth, area) and comparing with well known structures. The volume of the lateral collapses is highly variable with a range that extends from $0.1\text{-}0.2 \text{ km}^3$ for the 12-14 ka Chimborazo event to $12\text{-}20 \text{ km}^3$ for the Pleistocene Sangay event. In general this hazard has an extremely low frequency, with an average interval of ~ 9000 years over the last 300 ky for the whole volcanic arc. However, this interval drops below 3000 years over the last 50 ky, which probably indicates a bias in the database and suggests a debris avalanche yearly probability of at least $0.03\text{-}0.04\%$ in Ecuador. Our analysis of the direction of the landslides show that the edifice substratum slope and local tectonic faults are the main controlling factors. In conclusion we find that, even if numerous volcanic debris avalanches have been recognized in Ecuador, their study and reconstruction is largely incomplete leading to a lack of awareness and a deficient hazard assessment.