



Mass movement hazard at Irazu Volcano (Costa Rica): the Rio Reventado debris avalanche case study

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Irazu Volcano is a composite stratovolcano (3432 m a.s.l.) located in the Cordillera Central of Costa Rica, about 25 km E of San José and 14 km NNE of Cartago. It is part of the Irazu-Turrialba Massif (ITM). The summit consists of an E-W oriented ridge, along which the volcanic activity has migrated westward and formed several independent vents. The edifice as a whole is a very complex structure, being characterised by several craters and parasitic cones on its flanks. The active crater, presently occupied by a lake, lies on the eastern side of the ridge, where all historic activity has occurred. Since 1723 several Vulcanian and Strombolian events have occurred, the last of which began in 1963 and ended in 1965. This activity has produced hydrothermalized breccias (phreatic opening phase) followed by scoria falls and surges whose deposits crop out close to the vent. Both contemporaneously and subsequently to these volcanic episodes several lahars occurred, mainly along the Rio Reventado valley, causing 20 fatalities and severe economic losses at the periphery of Cartago.

Mass movements are relatively common at the ITM and, as evidenced by extensive fieldwork, have often interested large portions of the southern flank of Irazu. In particular, two debris avalanche deposits, known as the Rio Birris and Rio Reventado (RRDA), have been identified, with the latter dated at 6 Ka. The RRDA deposit extends over more than 35 km², starting from close to the summit (3300 m a.s.l.) and extending down to the Reventazon River basin (1200 m a.s.l.). According to the present-day distribution of the deposit, the debris avalanche split into two main branches due to the topography of the slope. The deposit is whitish-grey in colour, is massive and

has a hetero-lithologic texture; the fabric is matrix-supported with particles ranging from lapilli to coarse blocks set in a sand-silt matrix with a relatively low clay content (<10%). The matrix is characterized by strong hydrothermal alteration, indicating the likely entrainment of deep portions of a previously existing parasitic cone in the collapse. The estimated volume of the RRDA is 1-2 km³ with a H/L ratio of 0.12, values very similar to those recorded at Mt. St. Helens in 1980. The source area is a 2.5 km wide horseshoe-shaped structure that opens to SW towards Cartago, about 1 km from the summit crater. As evidence of concurrent volcanic activity seem to be missing, the RRDA was likely triggered by an exogenous event (e.g. high-magnitude seismic shocks) that facilitated the failure of the pervasively hydrothermally-altered material.

The recurrence of relatively recent mass movements such as those of Rio Birris and Rio Reventado indicate that the Irazu edifice has likely developed a cyclic structural instability. Present-day hazards are therefore related to these instabilities. During the eruptive periods, characterized by the thick accumulations of ash on the slopes, this instability leads to the triggering of numerous debris flows, which, due to the presence steep channel banks of loose material of the Rio Reventado, probably represent the major hazard for the city of Cartago. To delineate the inundation areas of potential debris flows, modelling was performed with a GIS-based application (FLO-2D).