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Geological setting and failure mechanisms of the 1998 Casita volcano landslide, Nicaragua

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A flank collapse occurred at the Casita volcano in Nicaragua on 30 October 1998 during Hurricane Mitch. The collapse transformed into a disastrous lahar that completely buried two small towns 6 km downstream (killing about 2500 people), destroyed small settlements and disrupted the Pan American Highway.
Based on the knowledge acquired during previous investigations with additional unpublished field data and observations, this study provides a comprehensive review of all previous studies (published and unpublished) on the 1998 Casita lahar and new insights into the initial flank collapse and the current stability. The knowledge on pre- and post-failure geometry, geology, lithology, tectonics and stratigraphy of the scarp area is improved and a summary of available geotechnical data is provided. Lithological characteristics that were significant in the initial flank collapse and failure mechanism were identified. The location of the failure surface was more precisely defined and the number and sequence of stages in the initial failure presented in previous studies have been confirmed. Slope stability analyses were carried out using limit-equilibrium methods.
Geological interpretations, analysis of digital elevation models and geotechnical back-analyses confirmed that the flank collapse took place in three stages involving both the northern and southern areas of the scarp and occurred continuously during a time interval of seconds to a few minutes. In the first stage, failure initiated in a highly fractured and altered volcanic breccia in the northern area of the scarp which released a volume of 260 000 m3. The flow that developed from this failure removed colluvium deposits at the toe of the slope in the southern part in not more than 40 seconds. This rapid removal of the colluvium triggered a second stage which comprised 640 000 m3 and consisted in the failure of the southern part of the scarp by the sliding of a fractured volcanic breccia over a unit of clay-rich pyroclastic deposits. The third and final stage consisted in a failure of the remaining breccia and the overlying fractured lavas in the northern area and involved a volume of 690 000 m3.
The fact that future events can affect some remaining settlements and the segment of the Pan American Highway, between Chinandega and León, motivated an analysis of the stability of the remaining slope using parameters calibrated in the back-analyses of the 1998 flank failure. The results indicated that the remaining slope is stable as long as groundwater levels in the northern and southern area are deeper than 65 m and 90 m respectively (relative to the points of maximum elevation on the analyzed section) and the colluvium deposits in the southern area are not removed from the toe of the slope.