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Control of dome evolution during the last eruptive period of Popocatépetl volcano (Mexico) and hazard prevention.

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Following 50 years of calm, Popocatepetl (19º03' NW; 98º35' W; 5424 m) resumed activity in December 1994. Great quantities of pyroclasts were ejected during the most significant eruptive episodes occurring in April 1995, July 1997, December 2000 and January 2001. The majority of these episodes were explosive events associated with a pattern of gradual and successive dome building followed by dome destruction caused by the explosions. The hot rock melted the glacier and increased the supply of the solid fraction in a process that triggered the formation of powerful lahars that channeled through several proglacial gorges. The largest lahars occurred in 1997 and 2001, and extended to more than 12 km beyond the crater.

These flows pose a threat to neighboring populations, which warrants the need for controlled studies. To understand the dynamics of these formations it is necessary to quantify material such as the pyroclasts ejected during periods of volcanic activity and massive emissions. Our study examines the changes that took place in the crater's morphology and volume during the most recent eruptive period (1994-2003) and relates the volcanic activity to the generation of lahars. The relationship between laharic events and the evolution of the crater domes is the focus of several studies (Tanarro, Zamonaro and Palacios; 2004 and 2005).

Since the start of the current volcanic crisis, there has been no direct access to the crater, so aerial photographs provided by the Secretariat of Communication and Transport (SCT) of the Mexican government were used to trace the evolution of the crater and its formations. Twenty photograms with clear resolution and minimal distortion were chosen. The images dated November 1982 and May 1989 were taken prior to the present eruptive phase, while the remaining 18 represent other dates selected according to availability, quality, distortion...: November 17, 1997; April 13, 1998; June 8, 1998; December 2 1998, January 2, 1999; June 20, 1999; October 14, 1999; November 4, 2000; January 20, 2001; March 15, 2001; April 6, 2001; August 20, 2001; June 17, 2002; September 17, 2002; December 2002, February 13, 2003; July 21, 2003; and August 25, 2003.

The photograms were georeferenced to facilitate the analysis of the crater's morphological variations and to calculate the surface area occupied by each formation. Using conventional photo interpretation, each photogram was analyzed and detailed maps of the crater were produced. The next step was to correct the images' geometric distortion so that the map series could be compared to images that differed in scale and degree of distortion. This was accomplished by using 13 UTM control points associated with easily recognizable locations on an orthophoto published by the INEGI (1982), scale 1:20,000. The x-y coordinates were rectified using ArcGis georeferencing software and the third order polynominal function made it possible to complete the geometric rectification with an average median standard deviation from 3-5 meters.

We were also able to develop DEMs from a series of photograms that were exceptionally clear (November 17, 1997; December 2, 1998; June 20, 1999; November 4, 2000; March 15, 2001; June 17, 2002; December 2002; and February 13, 2003). Restitution (analytical and digital) of the scanned images with 21 micra resolution produced results within a 2 meter margin of error.

Correction to a scale of 1:5,000 with 10 m equidistant contour lines was used to create TINs and DEMs in raster format, which allowed us to determine changes in the volume of the crater area for pairs of consecutive dates. Several software programs were used to calculate the variations in volume: *InRoads* and *SelectCAD (INTERGRAPH)* for the TINs; *TCP-IT* for *AutoCad* with contour gridding, TIN and transversal profile differences; and *ArcGis* from DEMs in raster format.

These corrections made it possible to determine the morphology and volume of the crater domes and to calculate the mass destroyed by a specific event. With this information readily available, we were able to quantify a significant factor in the formation of lahars: the volume of pyroclasts deposited in relation to the volume of melted ice.

1 REFERENCES

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