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Control of the geomorphic evolution of an active crater: Popocatpetl (Mexico) 1994-2003.

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Volcanic activity often causes intense and successive geomorphic changes to occur inside a crater. In terms of hazard mitigation, it is important to understand the cause of these changes whether they be exterior lava spills, sequences of explosions or massive glacier melt. Access to an active crater, however, is very difficult and dangerous, so analytical approaches involving remote study must substitute actual fieldwork. Several studies done at Popocatepetl volcano during its most recent eruptive phase that began in December 1994, use remote techniques and are described in Cruz-Reyna *et al.* (1998), Wright *et al.* (2002), Martín-Del Pozo *et al.* (2003), Tanarro *et al.* (2005), Matiella et al. (2008), and Zamorano *et al.* (1996,1998), among others. The compendium of results reveals that recent volcanic activity on Popocatépetl is characterized by successive dome growth and destruction inside the crater. Macias and Siebe (2005) even suggest that the walls of the crater may no longer withstand future dome growth.

The purpose of this study is to understand the morphologic evolution of the interior of the crater during the most active period of the present eruptive phase on Popocatepetl from 1994 to 2003. The methodology is based on photogrammetry techniques that have been used successfully at volcanic sites by Donnadieu *et al.* (2003), and on a GIS to organize information, draft maps and 3-D images, and to calculate spatial variations in landforms (Procter *et al.*, 2006; Schilling *et al.*, 2006). Traditional aerial photo interpretation was used for 22 triplets selected from a collection of photos taken by the Mexican Highway and Transport Secretariat, from 1982 to 2003, and enabled us to draft geomorphic maps of the interior of the crater. The photos and maps were rectified and georeferenced with ArcGis software, and then the maps were digitized. The areas containing morphologic units associated with a date (exterior crater walls, colluvial ramps and recent volcanic complex features such as craters, cones and domes) were uploaded to a temporal database. Next, we linked the morphologic description of the craters and the surface variations occupied by each of the landforms with the volcanic activity. Topographic restitution for 7 of the 22 pairs of selected aerial photos was performed and the Digital Elevations Models (DEMs) for each date were imported to ArcGis to analyze the variations in elevation at the base of the crater and changes on the slopes. Finally, we calculated the free space inside the crater for each date.

The results from the data processing showed a sequence of transformations in the crater, each of which was identified with a specific type and intensity of volcanic activity. In the pre-eruptive stage prior to 1994, the growth of the outer walls and the colluvial ramp of the crater (90% of the crater) was attributed primarily to non-volcanic activity. The period from 1994 to June 1999, was marked by dome growth and destruction, which expanded the surface area of the complex (34.5% in April 1998), but reduced the colluvial ramp and the wall. Explosions ejected material from inside the crater, increasing its width and depth (48m). Free space occupied 17.3×10^6 m^3 in June1999, but after an interval of relative calm, dome growth resumed in 2000. Larger forms were produced and were not immediately destroyed, so the dome complex increased to 45.219 m^2 by September 2001. This chain of events marked by the overlapping of domes and materials, gave the recent volcanic complex an intricate morphology. During this time, the depth of the crater in February 2003 was 66 m with 11.2×10^6 m^3 of free space. The July-August 2003 photograms reveal a morphology of craters created by a succession of phreatomagmatic explosions that inhibited the formation of lava bodies. Judging from descriptions by volcanologists in February 2004 (Macias and Siebe, 2005), the amount of material ejected from the crater by these explosions was not substantial.

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