



Geomorphological evolution of volcanic fluvial channels: Eighteen years of morphological monitoring of the upper stretch of the Tenenepanco Gorge, Popocatepetl volcano, Mexico

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During volcanic eruptions a significant volume of material accumulates on the slopes and pre-existing gorges of the stratovolcanoes. This abundance of loose and unconsolidated material is very likely to be mobilized by rapid flows or lahars generated by sudden heavy rain or melting snow and ice. Thus, volcanic gorges are affected by complex cycles of incision, filling and widening, altering the equilibrium of river systems due to the major changes that lahars cause in channel morphology.

These geomorphological dynamics characterize the gorges located on the north flank of the Popocatepetl volcano (19°02' N, 98°62' W, 5424 m). This volcano, located in the centre of the Trans-Mexican Volcanic Belt, began its most recent eruptive period in December 1994, when a glacier partially covered the northern slope. Since then, the interaction of volcanic and glacier activity triggered the formation of lahars in the gorges, causing significant morphological changes in the channel (especially in April 1995, July 1997 and January 2001). The most recent major eruption at Popocatepetl took place on 19 July 2003, and since then a series of smaller eruptions has reduced the glacier to near extinction.

The aim of this study is to assess the morphological response of the Tenenepanco channel over an 18-year period, from 1995-2013, where two main scenarios can be observed: a) the period from 1995 to 2001 of volcanic activity and glacier retreat with the formation of flows and b) the period from 2002 to 2013 of relative volcanic calm, the almost complete extinction of the glacier, and the formation of secondary lahars associated with heavy rainfall.

Monitoring of the gorge has consisted in the elaboration of 14 geomorphological maps during field studies (November 14, 1995, December 5, 1997, February 7, 1998, October 6, 2001, November 14, 1995, December 5, 1997, February 7, 1998, October 6, 2001, Julio 16, 2002, February 11, 2004, September 8, 2004, February 5, 2006, November 2, 2008, February 5, 2008, November 5, 2009, November 5, 2010, November 9, 2011, November 6, 2013). An additional map (May-1989) was made based on photo-interpretation of aerial photographs taken during that period. A set of 13 morphological units were recognized in each of the maps. Subsequently, the maps were georeferenced using a 2010 orthophoto and the image of Google Earth from 2013. In a second step the 15 maps were digitized and the topology created in a CAD environment (Bentley Microstation V8i). Finally a spatial analysis was carried out in a GIS (ESRI ArcMap 10) in order to study the morphological variations of the channel gorge.

The preliminary results show that during the initial period (1995-2001) channel evolution is more variable, with episodes in which the bottom of the gorge is eroded with multiple channels alternating with others where there is only a single channel. These moments presumably coincide with volcanic activity which provides abundant material that fills the smaller gullies and concentrates the lahars in a single channel. However, the secondary flows in the 2002-2013 period tend to merge into one wide channel that drops in depth, creating pseudo-terraces.

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