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Volcanic geomorphological classification of the cinder cones of Tenerife (Canary Islands, Spain)

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ABSTRACT

This paper proposes a method to establish a morphological classification of Tenerife's cinder cones on the basis of a dual analysis of qualitative (existence, geometry and disposition of craters) and quantitative morphometric parameters (major and minor diameters and cone elongation, major and minor diameters and crater elongation). The result obtained is a morphological classification of the cinder cones of Tenerife, which can be sub-divided into four types: ring-shaped-cones, horseshoe-shaped-volcanoes, multiple volcanoes and volcanoes without crater. In Tenerife there is a clear dominance of horseshoe-shaped volcanoes (69.0%) over ring-shaped cones (13.1%), volcanoes without craters (11.4%) and multiple volcanoes (6.4%). The classification presented in this paper is characterized by its simplicity which makes it possible to include all morphological types of volcanoes found in Tenerife. This fact also renders our classification a useful tool to apply in other, both insular and continental volcanic areas to eventually analyze and systematize the study of eruptive edifices with similar traits.

1. Introduction

The general characteristics of monogenetic volcanoes have been analyzed in several works (Wood, 1980a,b; Cas and Wright, 1987; Ollier, 1988; Romero, 1991, 1992; Francis, 1993; Poblete, 1995; Cárdenas, 1996; Connor and Conway, 2000; Vespermann and Schminke, 2000; Dóniz-Páez, 2004; Favalli et al., 2009; Bemis et al., 2011; Fornaciai et al., 2012; Grosse et al., 2012; Kereszturi and Németh, 2012; Becerra-Ramirez, 2013). The studies about the morphology of monogenetic volcanoes have undergone considerable improvement in recent decades (Di Traglia et al., 2014). Monogenetic volcanoes are the most common volcanoes on Earth (Wood, 1980a) and appear shaping volcanic fields in different tectonic contexts. These volcanic fields comprise small volcanoes such as cinder or scoria cones, maars, tuff cones, tuff rings, small shield volcanoes and lava domes (Connor and Conway, 2000). These volcanic structures are dominantly mafic in composition and characterized by the short duration of their eruptions, from several days to a few years (Németh, 2010). Monogentic mafic volcanoes usually appear on the flanks of composite-stratovolcanoes, like in Etna or Teide, large shield volcanoes, such as Kilauea, or in volcanic rifts, as in Cumbre Vieja volcano (Connor and Conway, 2000; Geyer and Martí, 2010). Conventionally, the authors have documented five types of monogenetic volcanoes (lava spatter cones, scoria or cinder cones, maar or maar-diatremes, tuff rings and tuff cones). This classification is primarily based on the morphological aspects and dominant eruption styles of these volcanoes (Tort and Finizola, 2005; Gomez, 2012; Kereszturi and Németh, 2012; Di Traglia et al., 2014).

Rittmann (1963) classifies monogenetic volcanoes such as cinder cones that release a little amount of basaltic products (lapilli, scoria, bombs, spatter, lavas) (<1 km^3) at high temperature (1000–1200 °C). The resulting volcanic forms are morphologically homogeneous volcanoes (Rittmann, 1963; Macdonald, 1972), which are small, and produce equally small in volume eruptive products, and therefore, they are considered to be simple. Current research shows that they can be fairly big, and/or have erupted through a longer time span, and/or followed some irregular eruptive path (Kereszturi and Németh, 2012; Kereszturi et al., 2013b). These various phenomena resulted and are reflected in their morphology, this then being far more complex than just a simple cone with a crater. The shapes of monogenetic volcanoes are the result of complex evolutions (eruptive activity, structural setting and erosion processes) (Di Traglia et al., 2014). In this sense Romero (1991), Dóniz-Páez (2004) and Becerra-Ramirez (2013) show the geomorphological and structural complexity of cinder or scoria cones.

The cinder cones are formed by near-vent accumulation of tephra that is characterized by various degrees of agglutination or welding (Vespermann and Schminke, 2000; Valentine et al., 2007). The cinder, spatter and lava cones are normally associated with mafic magma, but in Tenerife these volcanoes include olivine basalts, olivine-pyroxenic basalts and alkaline basalts with olivine (Barrera et al., 1988). The cinder

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cones generally constitute elongated edifices, evidenced by both the number of craters along a fracture and the elongation (Cas and Wright, 1987; Francis, 1993; Romero et al., 2000; Dóniz-Páez et al., 2008). Cone elongation represents in turn the distortion factors of the morphology of the volcano, and the former is obtained by dividing the cone major diameter by the cone minor diameter (Romero et al., 2000; Dóniz-Páez et al., 2008). In Tenerife the cones have 1 to 20 craters and the average elongation index is 1.47 with a maximum of 2.03. These volcanoes are constructed from fractures opened in steep slope areas (>10°) (Corazzato and Tibaldi, 2006; Tibaldi and Lagmay, 2006; Favalli et al., 2009; Fornaciai et al., 2012), but in Tenerife the slope where the volcanoes are located is not greater than 25° (Dóniz-Páez, 2011). In general, the morphology of the cinder cones corresponds to a truncated cone (Macdonald, 1972; Cas and Wright, 1987; Francis, 1993). Nevertheless, cinder cones are simple because most of them erupted through a limited period of time (days to years). These volcanoes are associated with explosive fragmentation of low viscosity magmas, among other distinctive traits.

The cinder cones have been categorized using different morphological classifications (Thuoret, 1999). Traditionally, these classifications (morphogenetic or morphological) only refer to two main morphological categories, namely, ring-shaped cones and horseshoe volcanoes

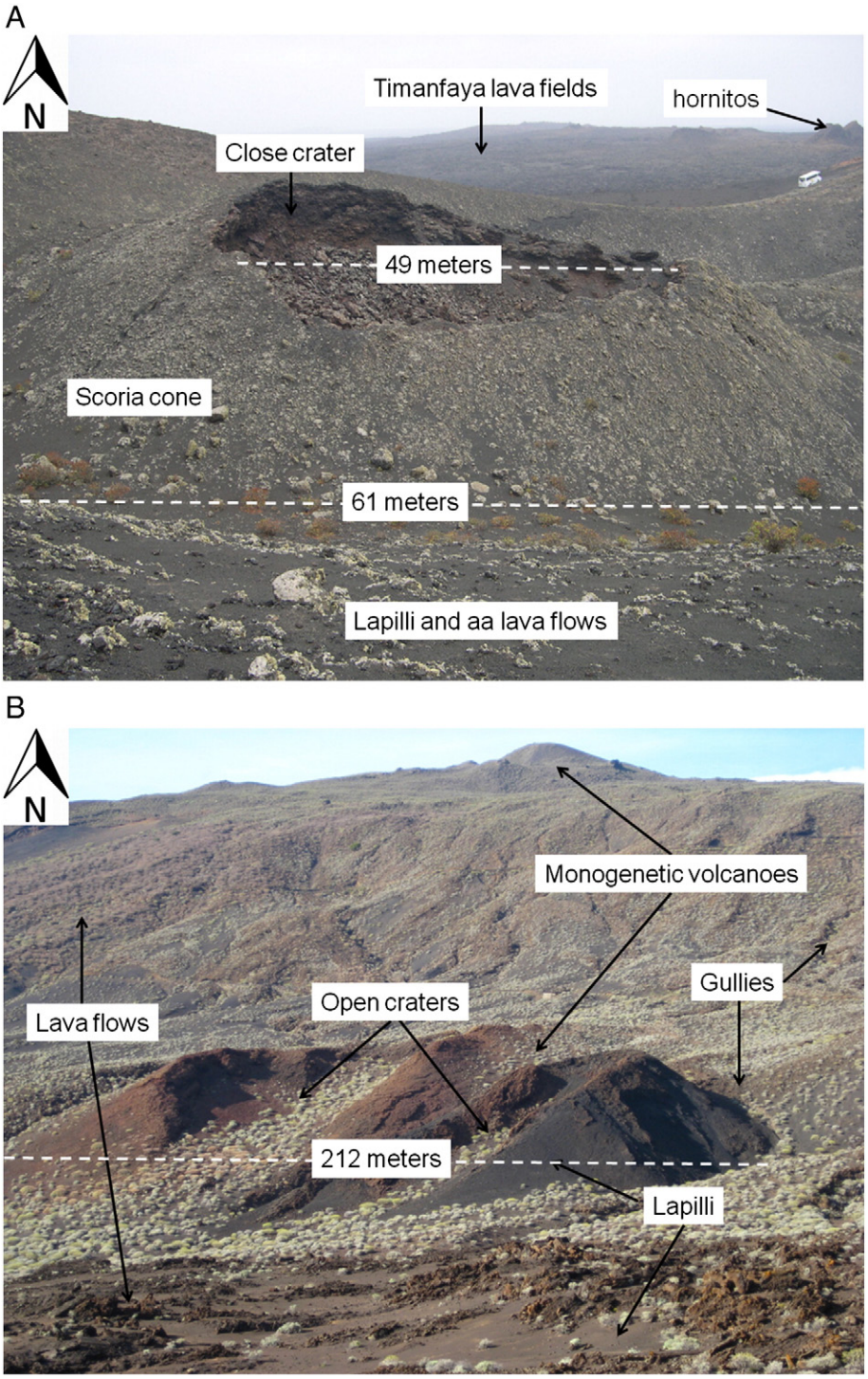

Fig. 1. A ring-shaped cinder cone in Lanzarote (Canary) (left) and horseshoe volcanoes in El Hierro (Canary) (right).