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ScienceDirect
Journal of Volcanology and Geothermal Research 173 (2008) 185–195
Journal of volcanology and geothermal research
www.elsevier.com/locate/jvolgeores

Morphological and statistical characterisation of recent mafic volcanism on Tenerife (Canary Islands, Spain)

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Received 16 May 2007; accepted 29 December 2007
Available online 20 February 2008

Abstract

Tenerife is the largest island of the Canarian Archipelago and presents a complex volcanic history. The construction of a mafic shield and a phonolitic composite volcano represent the main features of the volcanic evolution of the island. Both volcanic complexes are still active, the first through two main rift zones and the second through the Teide–Pico Viejo central complex. Up to 297 mafic monogenetic volcanoes can be recognised on Tenerife, most of them corresponding to scoria cones that can been grouped into five geographical volcanic fields characterised by similar volcanological features. The large number of these edifices, compared to the other existing morphological volcano-types, indicates that they represent the most common eruptive events occurring during Tenerife's recent geological past and, therefore, the type with the shortest recurrence period and the most likely to occur in the near future. In this paper, the most frequent mafic monogenetic volcano is defined by means of the statistical analysis of its main volcano-morphological features (cone height, cone width ratio, crater width, crater depth, etc.). We have applied a simple methodology of our own design, based on statistical correlations and modal intervals of the morphological and morphometric parameters best defining the volcanoes' morphology. The most frequently identified mafic monogenetic volcano corresponds to a scoria cone with Strombolian to violent Strombolian dynamics, ≤ 100 high, and <0.01 km^3 in volume, covering an area of <0.2 km^2. By defining this most common mafic volcano or volcano-type we may provide key information on the nature of a potential volcanic event on Tenerife in the future.

Keywords: volcanic geomorphology; morphometric; scoria cones; Tenerife

1. Introduction

Mafic monogenetic volcanoes constitute the most common eruptive forms produced by subaerial volcanism (Wood, 1980a; Vespermann and Schmincke, 2000; Walker, 2000). 297 mafic monogenetic cones are still well preserved on Tenerife, and represent the most common eruptive activity occurring on the island during the last 1 Ma (Fig. 1). The large number of these elements has encouraged us to establish a systematic methodology to describe and classify the possible common features of the scoria cones and to establish the general characteristics of the eruptions responsible for their formation.

Although morphometry has been used since the 70′s to analyse mafic monogenetic volcanoes, it has not been fully developed until recently. Many authors point out that scoria cones constitute simple and ideal morphologies to which one may apply morphometric techniques and develop statistical studies (Dohrenwend et al., 1986; Hooper, 1995; Hooper and Sheridan, 1998; Carn, 2000; Corazzato and Tibaldi, 2006).

Two approaches can be distinguished in the development of the morphometric analysis of subaerial mafic monogenetic volcanoes. Studies carried out before the 80′s were mainly descriptive and qualitative. However, since 1980 they have become more quantitative and have different objectives including: 1) reconstruction of magma-feeding fractures (Settle, 1979; Pasquaré et al., 1988; Tibaldi et al., 1989; Tibaldi, 1995;

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doi:10.1016/j.jvolgeores.2007.12.046

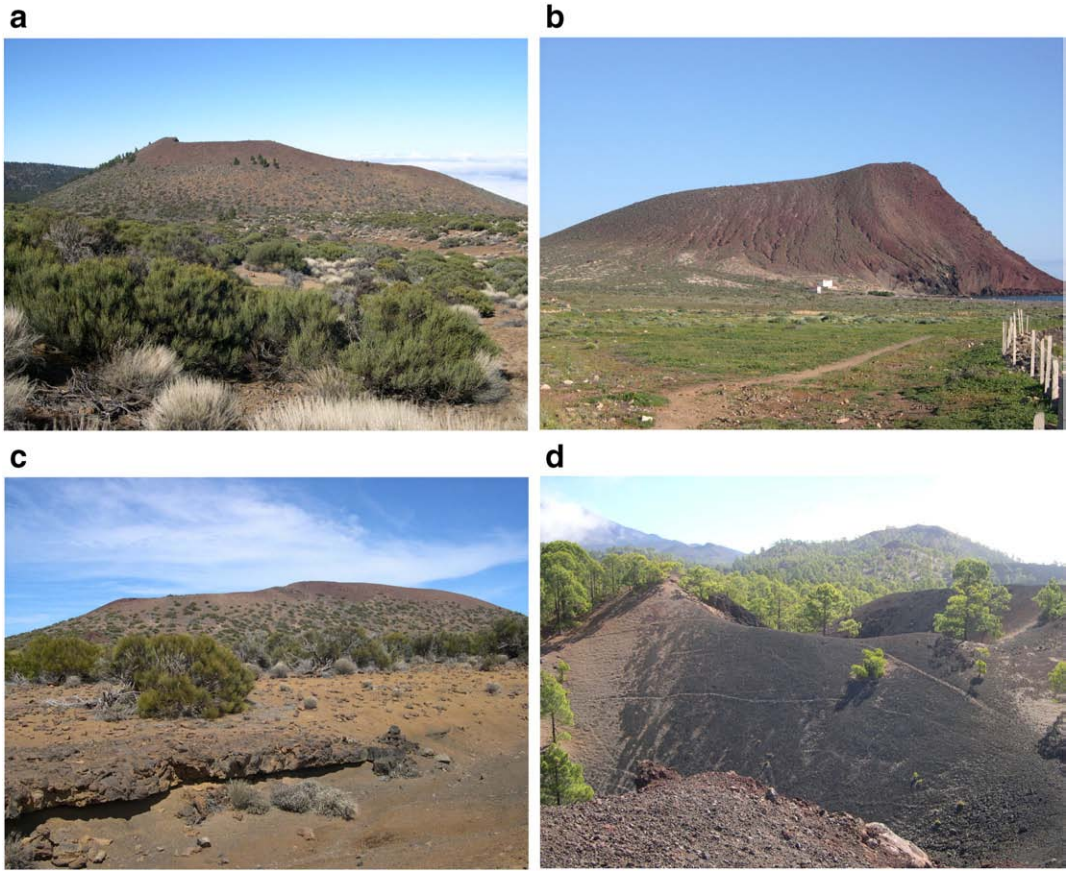

Fig. 1. Scoria cone morphologies from Tenerife appearing in different volcanic fields (VF): a) Montaña Guamasa (Pedro Gil VF), b) Montaña Roja (San Lorenzo–Galletas VF), c) El Cerrillar (Pedro Gil VF) and d) Boca Cangrejo (Bilma VF).

Corazzato and Tibaldi, 2006); 2) morphological definition of the scoria cones (Porter, 1972; Wood; 1980a; Hasenaka and Carmichael, 1985a, b; Tibaldi et al., 1989; Márquez et al., 1999); 3) establishment of correlations between volcanoes' evolution and their relative age (Wood, 1980b; Martín del Pozzo, 1982; Hooper, 1995; Hooper and Sheridan, 1998); 4) cone erosion estimates (Dohrenwend et al., 1986; Karátson, 1996); 5) determination of the chronospatial evolution (Romero, 2003); and 6) determination of the volcano size (Dóniz et al., 2006). In general, morphometric techniques applied to the study of monogenetic volcanoes allow the establishment of quantitative comparisons between scoria cones from different volcanic regions.

Dóniz (2004) studied the distribution of scoria cones on Tenerife and their morphological and morphometric characteristics. Mafic monogenetic volcanoes are the most abundant volcanic edifices on the island and also represent the most probable future eruptive type (Carracedo et al., 2007). For this reason it is important to apply statistical methods to characterise this kind of volcanism, and also to define the most common volcano edifice or volcano-type, which could be used as a standard model for future studies on hazard assessment and risks associated with the phenomena.

The main aim of this work, therefore, is to define the most frequent volcano-type among the mafic monogenetic scoria cones on Tenerife for each of the volcanic fields identified on the island, as well as to characterise the main differences between them. This volcano-type will represent the most common type of eruptive activity related to mafic magmas on Tenerife and will allow the statistical determination of any deviations from the normal behaviour that have occurred during its most recent volcanological history. In order to determine the most common monogenetic volcano, we use a self-designed methodology based on the compilation of 17 morphological and morphometric parameters, both qualitative (shape, location, type of crater, etc.) and quantitative (cone height, cone diameter, crater perimeter, cone slope, etc.). These parameters have been selected between more than 30 indexes from Pearson correlations (Pearson, 1896) and grouped into modal intervals.

2. Geological and geomorphological setting

Tenerife is the largest (2034 km^2) and highest (3718 m a.s.l.) of the Canary Islands. It has been built up over several long-lasting submarine and subaerial constructive episodes (see Ancochea et al., 1990) (Fig. 2). The oldest subaerial volcanic rocks (Old Mafic Series) are to be found in the Massifs of Anaga (NE), Teno (NW) and Roque del Conde (S), with ages ranging from 12 Ma to 4 Ma (Ancochea et al., 1990). These massifs represent the subaerial remains of the main stages of shield volcanism (Ancochea et al., 1990; Thirlwall et al., 2000) and were built by Strombolian and Hawaiian-type mafic eruptions mainly fed from fissure vents. These old volcanic massifs are