Morphometric analisys of cinder cones on Tenerife (Canary Islands, Spain): results and applications

F. J. Dóniz Páez

Iriarte University College in Tourism, University of La Laguna, Paseo Santo Tomás s/n, E-38400, Puerto de la Cruz. Tenerife. e-mail: jdoniz@ull.es

ABSTRACT

This paper applies morphometric to the cinder cones of Tenerife. The technical morphometric allows to establish simple models of morphology, and size to the most frequent volcanoes of Tenerife´s mafic volcanism. The obtained classifications allow to distinguish four morphological types of scoria cones and three size groups, which is also extended to other volcanic regions.

Key words: Volcanic geomorphology, Cinder or scoria cones, Morphometric, Tenerife.

INTRODUCTION

Basaltic monogenetic volcanoes constitute the most common eruptive forms produced by subaerial eruptions (Wood, 1980). The scoria cones are formed by an accumulation of normal (proximal) to inverse (distal) graded welded and/or nonwelded volcaniclastic deposits with symmetrical, fluidal and irregular shapes and different sizes (lapilli, bombs, blocks, scoria, spatter, ash, etc.), xenoliths and intercalated lava flows. These pyroclastics appear in layers of variable thickness (from several cms up to 1 m) (Dóniz et al., 2008). 297 scoria cones are still well preserved on Tenerife, and represent the most common eruptive activity occurred on the island during the last 1 Ma. The high number of these elements has led us to establish a systematic methodology to describe and classify the cinder cones and to establish their general characteristics.
The cinder cones constitute simple and ideal morphologies to apply morphometric techniques and to develop statistical studies (Dóniz, 2004). The main aim of this paper is to study scoria cones through a morphometric analysis to eventually obtain simple morphological models, the size, and the most frequent volcano.

STUDY AREA

Tenerife constitutes the largest (2034 km^2) and highest (3718 m a.s.l.) of the Canary Islands. It has been built up as a result of the accumulation of different volcanic materials (mafic, felsic and intermediate) in a large period of time. The basaltic volcanism is responsible for the formation of hundreds of monogenetic volcanoes, characterized by effusive and explosive strombolian activity. The scoria cones generally constitute elongated edifices, evidenced by both the number of craters (1 to 20-30 eruptive vents), and the elongation (cones show indexes of 2.03, that is, elongated elliptical), whose general morphology corresponds to a truncated cone. These volcanoes are constructed from fractures opened in steep slope areas (about 25º) (Dóniz et al., 2008).The materials of these eruptions cover most of the previous topographic relief, and form several volcanic fields (Figure 1) (Dóniz, 2005).

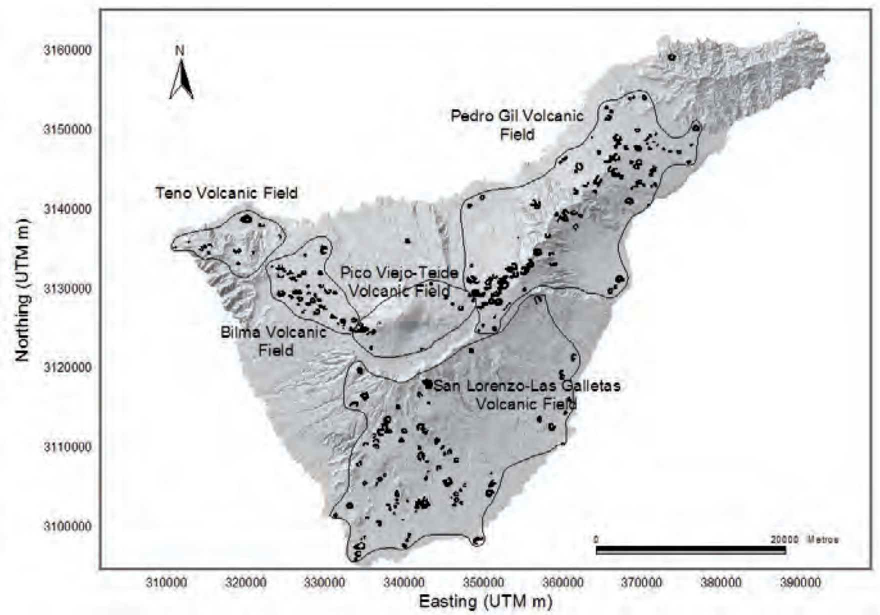

Figure 1. Distribution of cinder cones and volcanic fields of Tenerife.

METHODOLOGY

A methodology based on the analysis of morphological and morphometric data has been used to define the morphology, size and the volcano-type of Tenerife. The morphometric parameters used in this study include cone height, cone major diameter, cone width ratio, cone volume, cone area, number of craters, crater depth, crater major diameter and crater minor diameter, crater width, separation index between cones, cone slope, cone elongation and crater elongation. Dóniz (2004) and Dóniz et al., 2008 on the meaning of each of those parameters.

RESULTS AND DISCUSSION

Geomorphology of cinder cones

The application of morphometric parameters to scoria cones allows for the distinction of four morphological types: (A) ring type cones, (B) horseshoe volcanoes, (C) multiple scoria cones and (D) mountains of lapilli (Figure 2). The first and second type of cinder cones are divided to obtain a total of seven geomorphological types. The percentage of volcanoes is different for each scoria cone~~s~~ type**:** the horseshore cinder cones are the 69.03%, the ring type cones are 13.14%, the mountains of lapilli are 11.45% and multiple escoria cones are 6.38%. This is a simple geomorphological clasification to also apply to other volcanic regions and volcanic fields.

Size of scoria cones

The morphometric parameters that best show the magnitude and size of volcanic edifices, as height, volume and area, have been chosen in order to classify the size of these volcanoes. Height has been selected as a guide indicator due to the fact that Pearson correlations between height and volume and between height and area are always over 70% (Dóniz et al., 2006), this meaning that both parameters (volume and area) are, generally speaking, directly proportional to height (Dóniz, 2004). The result is a simple quantitative classification, easy to use for estimating the size of monogenetic volcanoes. 98.98% of the monogenetic basaltic volcanoes of Tenerife fit in this classification, distinguishing between big, medium and small volcanoes (Table 1) (Dóniz et al., 2006). The majority of the volcanoes on the island are small in size and represent more than 60% of the whole.

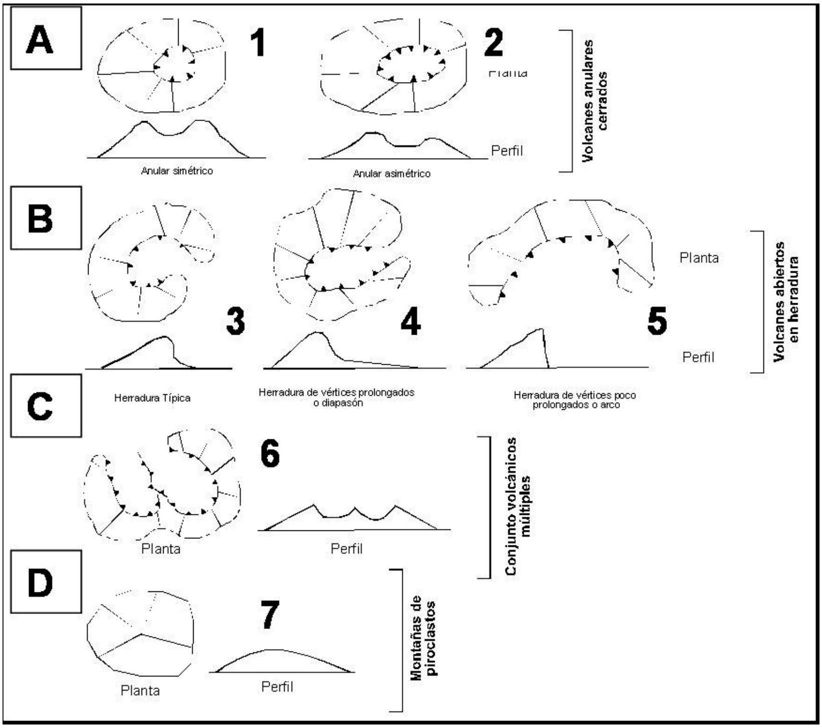

Figure 2. Outline of the plant and the profile of the different scoria cones types.

Table 1. Morphometric classification of cinder cones the size.

Size volcanoes	Height m	Volumen km^3	Area km^2	Number cones/%
Great	>200	>0,1	>0,5	20 / 6.73
Medium	>100 ≤200	≥0,01 ≤0,1	≥0,2 ≤0,5	92 / 30.97
Small	≤100	<0,01	<0,2	182 / 61.28
others	-	-	-	3 / 1.02

This method tries to set aside the influence of visual perception and classical subjectivity when referring to the size of volcanoes, in order to classify simple eruptive edifices as a function of size and, thus, intends to be objective. A simple and innovative method is proposed to calculate the size of monogenetic basaltic volcanoes.

Cinder or scoria cones volcano type

The most frequent basaltic 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.). A self-designed and simple methodology has been applied, based on statistical correlations and modal intervals of the morphological and morphometric parameters best defining their morphology (Table 2) (Dóniz et al., 2008).

Table 2. Quantitative and qualitative parameters of Tenerife basaltic cinder cones used for establishing the volcano-type.

Cone parameters	modal interval	Num. cones	% island
Height	<100 m	169	56.9
Major diameter	≤500 m	150	50.51
Minor diameter	≤500 m	211	71.04
Width ratio	≤500 m	172	57.91
Volume	<0.01 km^3	185	62.28
Area	<0.2 km^2	176	59.26
Crater major diameter	201-500 m	137	52.09
Crater minor diameter	≤200 m	164	62.36
Crater width	201-500 m	140	53.23
Crater depth	≤50 m	105	39.54
Size	Small	182	61.23
Cone shape	Open in horseshoe	195	65.66
Crater shape	Open crater	224	75.42
Material	Only basic	203	68.35
Site emplacement	Slope >20º	188	63.29

According to table 2, the most frequently identified mafic monogenetic volcano corresponds to a scoria cone with strombolian or violent strombolian dynamics, constructed by fissural eruptions, horseshoe morphology, small size volcano (≤100 m height, <0.01 km^3 volume, covering an area <0.2 km^2).

CONCLUSIONS

Bearing in mind all these details, it is possible to establish simple models that enable quantitative comparisons with other globe volcanic regions, both continental and insular. In a similar vein, with the definition of this volcano-type we may provide key information on the nature of a potential volcanic event on Tenerife in the future.

REFERENCES

- Dóniz, J., 2004. Caracterización geomorfológica del volcanismo basáltico monogénico de la isla de Tenerife. Ph.D. Thesis, Department of Geography, University of La Laguna, Tenerife, Spain.
- Dóniz, J. 2005. Los campos volcánicos basálticos monogénicos de la isla de Tenerife (Canarias, España). *Estudios Geográficos*, 66 (259), 461-480.
- Dóniz, J., Romero, C., Guillén, C., Coello, E. and García-Cacho, L.(2006). Propuesta metodológica para el cálculo y clasificación del tamaño de los volcanes basálticos monogénicos: el ejemplo de Tenerife (Canarias, España). Proceedings 5ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica. Sevilla. España. Publicación CD. ISBN: 84-8320-373-1.
- Dóniz, J., Romero, C., Coello, E., Guillén, C., Sánchez, N., García-Cacho, L. and García, A. 2008. Morphological and statistical characterisation of recent mafic volcanism on Tenerife (Canary Islands, Spain). *J. Volcanol. Geother. Res*. 173 (3-4), 185-195.
- Wood, C. 1980. Morphometric evolution of cinder cones. *J. Volcanol. Geotherm. Res*. 7, 387-413.