Preliminary geomorphological analysis of the Tagoro Volcano underwater eruption (submarine slope of El Hierro Island)

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ABSTRACT

Between October 2011 and March 2012 a submarine volcanic eruption took place at the offshore of El Hierro Island. The extensive study of the eruption and subsequent degassing process has allowed monitoring the newly generated volcanic edifice. Multibeam bathymetric has enabled building a digital high-resolution bathymetric model (grid 1x1 m). The preliminary analysis of the geomorphology of this volcanic eruption displays four main features: i) the edifice consists of a principal and a series of secondary cones distributed in NW-SE trend; ii) two escarpments NE-SW directed that partially match with inherited flanks of the previously existing valley; iii) three crests, one of them interpreted as the prolongation of a NE-SW scarp and the other as the head of gravitational instabilities of NE-SW and N-S direction at the main hill; and iv) mixed lava and dense pyroclastic flows extended from the volcanic edifice to the southwest and characterized by a high slope front, that probably represents the maximum distance reached by the main lava products.

INTRODUCTION

Between 10 October 2011, and 5 March 2012, an underwater volcanic eruption took place two nautical miles south of El Hierro Island, at the submarine slope (Fig. 1). As a result of this eruption a new submarine volcano was formed, Tagoro, which summit reached 88 m depth from the surface. This eruption was characterized by the emission of pyroclastic products of different sizes and gases into the water column. The most remarkable products were xenopumitas (xenoliths with high density of vesicles) and basaltic lava balloons [1]. The lava products were driven from the volcano in a channeled flow between the pre-existing reliefs.

The *Instituto Español de Oceanografía* (IEO) was mandated by the Government of Spain to advise the PEVOLCA (*Plan Especial de Protección Civil y Atención de Emergencias por riesgo volcánico en la Comunidad Autónoma de Canarias*) in monitoring this submarine eruption, considering their geological characteristics, seafloor modifications, physical and chemical changes taking place in the water column and its impact on the marine ecosystem, to help establish the influence of the eruption on environment and its possible interaction with human populations and socioeconomic activities. The monitoring was developed by means of the IEO cruises BIMBACHE [2, 3], and once ceased the magmatic eruption through two projects of the Spanish I+D+I Program, VULCANO and VULCANO2, and also by an IEO project (VULCANA).

The aim of this contribution is to define the major geomorphological features of volcanic origin generated as result of the Volcano Tagoro magmatic eruption and subsequent degassing process.

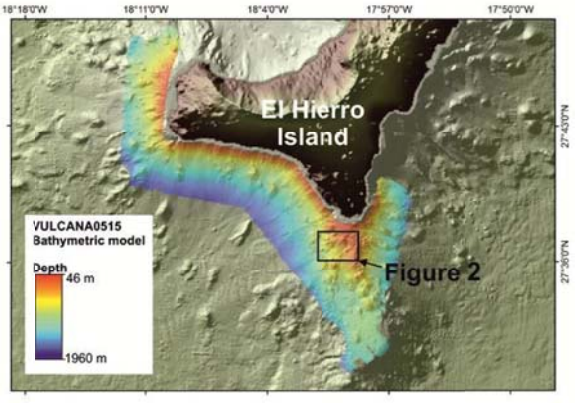

Fig. 1. Location of the study area (Figure 2 box) in the context of the VULCANA0515 cruise, at the southwestern flank of El Hierro Island.

MATERIAL & METHODS

This contribution uses the multibeam EM710 and parametric TOPAS PS18 echosounders data acquired along the VULCANA0515 cruise on board of the R/V Ángeles Alvariño. The geomorphological analysis is based on the interpretation of a bathymetric model 1x1m horizontal resolution. Software packages *Caris Hips & Sips* were used

for bathymetric process and *ArcGIS desktop* for geomorphological analysis.

RESULTS & DISCUSSION

The geological result of the volcanic eruption is the Tagoro volcano edifice on the submarine slope of El Hierro Island and some additional products ranging from 88 to more than 1500 m depth that consist of four main morphological features (Fig. 2). There is a main submarine hill rising from 400 to 88 m depth with a relatively irregular base around 1-1.3 km length, while the top is elongated in NW-SE direction. This hill consists of a quasi-circular principal cone, located in the northwestern part, and at least nine secondary cones extended towards the SSE from the main cone. This distribution could be explained in relation to a final phase of the eruption characterized by a fisural nature, probably connected with an internal NNW-SSE failure.

In the southwestern flank of the volcano, mixed lavas and high density pyroclastic flows are developed. They extend along more than 5 km length and 1500 m depth, outside of the study area (Figs. 1 & 2). This volcanic flow was channeled throughout a pre-existing valley before the eruption. This volcanic accumulation is characterized by an increase of the slope 2.5 km from the base of the hill that could correspond to the front of maximum accumulation thickness and probably with the maximum distance reached by the lava products.

Two main scarps and three crests have been observed. The scarps follow a main NE-SW trend and are relatively irregular. They have been named E1 and E2 from NW to SE, and correspond to the sides of the pre-existing valley before the eruption, although the scarp E1 move backwards to the NW as result of the eruption evolution itself [3]. The crests have been called R1, R2 and R3. R1 has a NE-SW trend and is the prolongation of the scarp E1, its arc-like shape could be related to a gravitational scar developed along the eruption and is partially fossilized by the pyroclastic rain. The R2 (NE-SW directed) and R3 (practically N-S) crests have been probably caused by the instability of the main building toward the SSE.

Finally, it is worth to mention that the pyroclastic activity has smoothed the surface of the surrounding reliefs especially to the NW of the Tagoro Volcano.

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REFERENCES

1 – Carracedo, J.C., *et al.*, 2015. The 2011-2012 submarine eruption off El Hierro, Canary Islands: New lessons in oceanic island growth and volcanic crisis management. *Earth-Science Reviews*, 150:168-200.

2 - Fraile-Nuez, E., *et al.*, 2012. The submarine volcano eruption at the island of El Hierro: Physical-chemical perturbation and biological response. *Scientific Reports,* 2, 486, DOI: 10.1038/srep00486

3 - Rivera, J., *et al.*, 2013. Construction of an oceanic island: Insights from the El Hierro (Canary Islands) 2011-2012 submarine volcanic eruption. *Geology,* 41 (3), pp. 355-358.

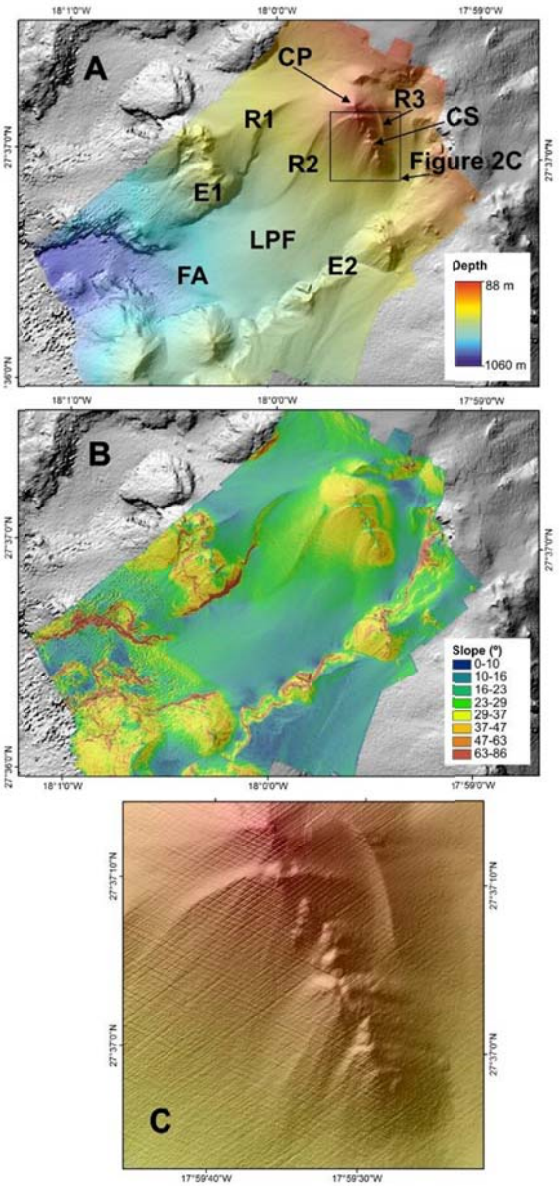

Fig. 2. Morphological features of Tagoro Volcano. A: bathymetric model; B: slope model; C: Detail of volcanic cones. CP: Principal Cone; CS: Secondary Cones; E: Scarps; LPF: Lava and dense pyroclastic flows; FA: Front of the main accumulation zone; R: Crests.