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Discussion

Comment on "Construction and destruction of a volcanic island developed inside an oceanic rift: Graciosa Island, Terceira Rift, Azores" by Sibrant et al. (2014) and proposal of a new model for Graciosa's geological evolution

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ABSTRACT

Volcanoes rising above sea level within extensional oceanic plate boundaries provide accessible locations with which to study the effects of plate tectonic and volcanic processes of such areas. However, relying solely on subaerial observations can lead to biased interpretations. Reconciling the information provided by multibeam echo sounders on the submarine parts of volcanic islands with geology and geomorphology observable above sea level can potentially provide more robust interpretations. In this comment of the study of Sibrant et al. (2014), which is based almost solely on subaerial observations, we show how the published multibeam sonar data around Graciosa reveals that their proposed successive phases of destruction of the volcanic edifices composing the island by massive landslides is incompatible with the high-resolution bathymetry. The data reveal no large-scale debris avalanche deposits or characteristic flank collapse scars where Sibrant et al. (2014) propose these landslides to have occurred. Instead, the data show volcanic constructional areas, some of which have simply been eroded by wave abrasion. The interpretation of collapse structures appears to have originated partly from a misreading of the volcano-stratigraphy and tectonic structures. Overall, wave erosion coupled with subaerial erosion and tectonic activity can more easily explain the onshore observations of Sibrant et al. (2014), providing a less catastrophic explanation for the evolution of Graciosa Island.

1. Introduction

Graciosa, along with the other Azorean Islands of the central (Faial, Pico, São Jorge and Terceira) and eastern groups (São Miguel and Santa Maria) are important examples of areas lying above sea level where rifting and volcanism associated within an oceanic spreading centre occur. These subaerial spreading centres are rare; such centres only otherwise occur on Iceland and in the Afar/Danakil Depression (Wright et al., 2012). However, the interpretation of such processes based solely on subaerial observations can lead to mistaken conclusions because commonly the subaerial stratigraphy and tectonic morphology are complex and features inferred solely from discontinuous outcrops onshore can turn out to be incompatible with offshore evidence (Mitchell et al., 2008, 2012, 2013; Quartau and Mitchell, 2013).

Sibrant et al. (2014) proposed a new model for the evolution of Graciosa Island based on recent geochronological data. According to their study, the island, especially its SW area, was repeatedly reduced by catastrophic collapses. Their claim is predominantly based on interpretation of subaerial stratigraphic and morphological observations in which several volcanic complexes, specifically Serra das Fontes, Baía do Filipe and Serra Dormida, appear to be missing significant parts of their structures. The interpretations of Sibrant et al. (2014) are well expressed in their Fig. 11. Our main concern is the use of low-resolution bathymetry to support their claim for catastrophic flank collapses, leading to rejections of alternative explanations. For instance, Sibrant et al. (2014) interpret in their bathymetry small elevations as large debris blocks, resultant from some of the hypothesized collapses (black arrows in Fig. 1A), which may simply be volcanic cones or even artifacts given the low resolution of the bathymetry. The bathymetry in question can be found at http://w3.ualg.pt/~jluis/misc/ac_

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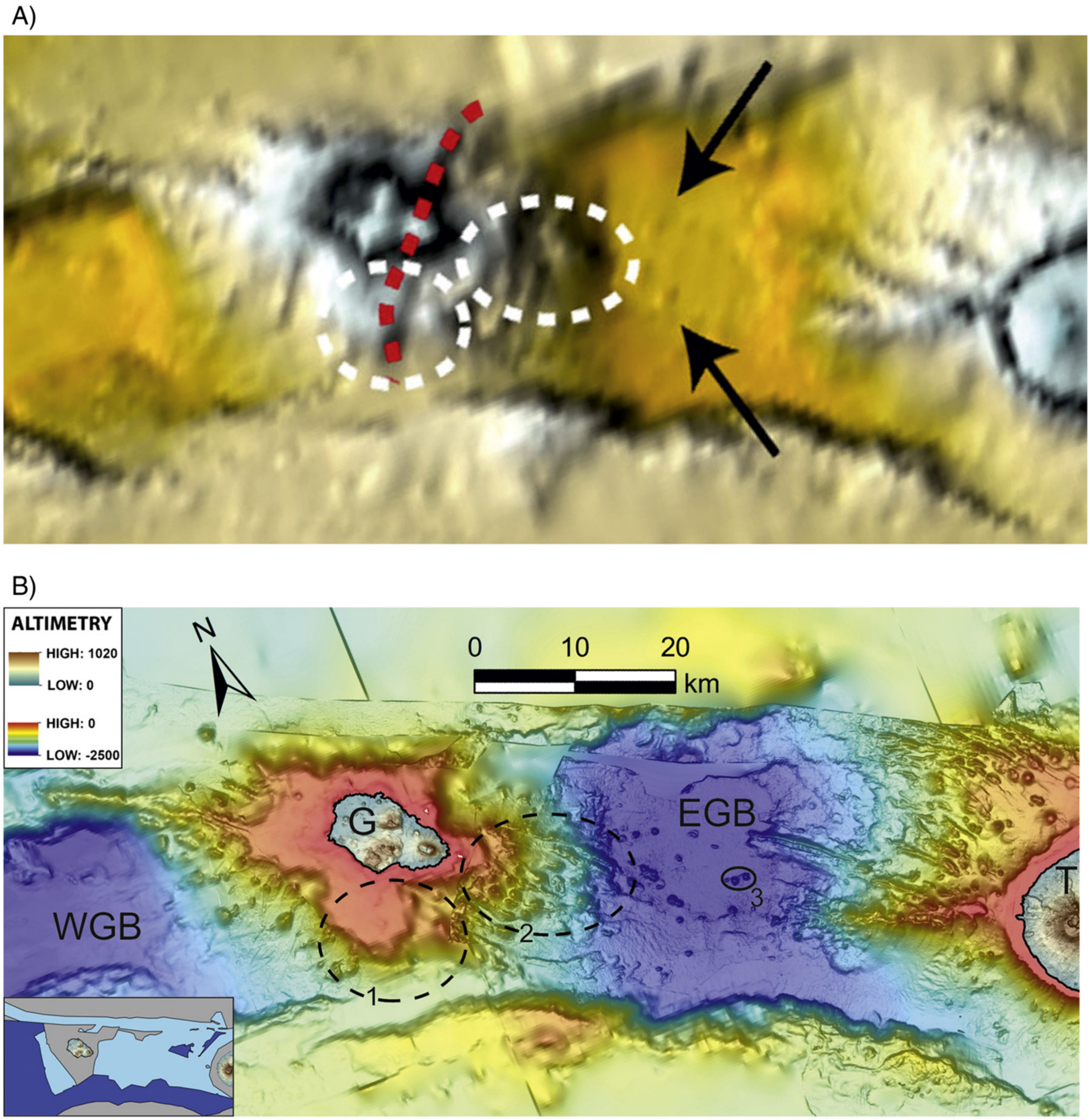

Fig. 1. Low resolution (1A, from Sibrant et al., 2014) and high-resolution bathymetry (1B) showing the same area of Graciosa (G) and Terceira (T) Islands and West Graciosa Basin (WGB) and East Graciosa Basin (EGB). Dashed black lines (1 and 2) in 1B have the same location as the dashed white lines in 1A, interpreted by Sibrant et al. (2014) as debris deposits from major flank collapses. Ellipse no. 3 encloses features not visible in the low-resolution map of 1A. Lower left inset is a key representing the bathymetric sources: dark blue, data from MARCHE cruises, light-blue, from EMEPC and, grey, from EMODnet.

plateau1km.grd with a 1 km × 1 km grid resolution. It was first published by Lourenço et al. (1998) and consists of compiled bathymetric mosaics with differing resolutions, some coarser than the final grid used by Sibrant et al. (2014). In the area under discussion, this bathymetry seems to have an exceptionally low resolution based on the size of the objects missing from Fig. 1A but clearly visible in the more recent bathymetric data (see ~3 km diameter ellipse enclosing volcanic cones, no. 3 in Fig. 1B).

Furthermore, the inference of collapses is partly a consequence of a misinterpretation by Sibrant et al. (2014) of the volcano-stratigraphy and onshore morpho-tectonic structures. In the following paragraphs, we present the onshore (Figs. 2, 3, 4 and 5) and offshore evidence (Figs. 1, 6, 7 and 8) which allowed a different and far simpler explanation of the structural and morphological evolution of Graciosa Island within a tectonic plate boundary.

2. Onshore observations and interpretation

Sibrant et al. (2014) suggested that two distinct episodes of volcanism produced two geographically separated volcanic edifices, Serra