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Fossil beaches as evidence for significant uplift of Tenerife, Canary Islands

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Abstract

Numerous uplifted fossil beaches have been described for the Eastern Canary Islands; only a few publications on these uplift markers exist, however, for Tenerife Island. We found fossil beaches at an altitude of about 10.5 m above present sea-level in the Anaga Mountains in the northeast of Tenerife. In the south of Tenerife four localities with fossil beach deposits can be found up to a height of 65 m above sea-level. An additional uplift marker, represented by a submerged developed tuff cone, has been discovered in the south of Tenerife, thereby indicating uplift during the past ~300 ka. The altitude of the fossil beaches and the tuff cone above the present sea-level cannot merely be explained by fluctuations in the sea-level. The uplift markers suggest an asymmetrical uplift of the island complex with no distinct uplift in the northeast but significant uplift rates, to a maximum of 45 m during the last 11 ka, in the south of Tenerife. The uplift of the southern part of Tenerife was probably caused by ascending magma.
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1. Introduction

The Canary archipelago is a group of volcanic islands in the Central Atlantic near Morocco's west coast. With a base area of >2.000 km^2, Tenerife is the largest and topographically highest (Pico de Teide 3718 m) island of the Canaries. The origin of the islands has been controversially discussed; a hotspot model is currently favoured (e.g., Carracedo, 1999; Guillou et al., 2004; Paris et al., 2005). The island of Tenerife is situated in the centre of the archipelago (Fig. 1) and is an example for a "rejuvenated stage island" (Paris et al., 2005), associated with remarkable historic volcanic activity.

The younger western Canary Islands are still in the shield building stage associated with intense magma intrusion and concomitant positive vertical movements (Hildenbrand et al., 2003). For the older central and eastern Canary Islands, stable conditions without uplift or subsidence (e.g., Carracedo, 1999) have been assumed; Zazo et al. (2003a,b) even ascertained a slight subsidence of Tenerife since the upper Pleistocene. However, in numerous publications on the Canary Islands, fossil beaches have been described in various positions above the present sea-level (for readability we use ASL for "above present mean sea-level" hereafter).

The intention of this publication is to re-evaluate the known fossil beaches of Tenerife as well as to identify further fossil beaches as potential uplift markers. In addition a further investigation was carried out to determine whether tuff cones developed within the range of the sea-level. An overview of the study areas is depicted in Fig. 1.

2. Geological background

The oldest volcanic units exposed on Tenerife are the shield massifs of Roque del Conde (S-Tenerife), Anaga

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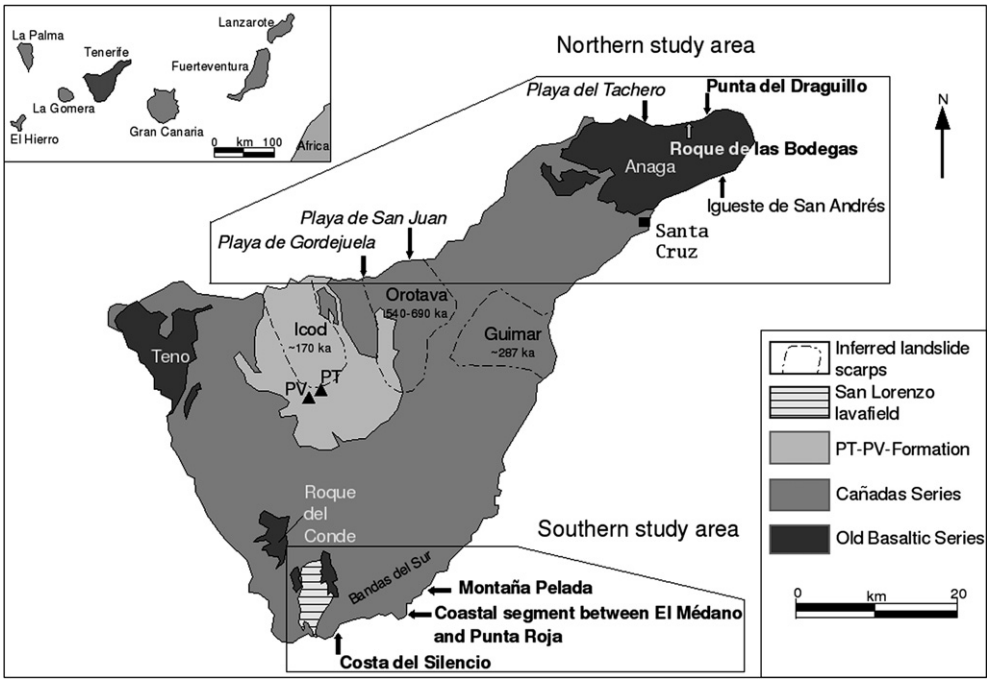

Fig. 1. Position of Tenerife Island and the northern and southern study area. Arrows point to localities studied in this work: bold type, predominantly studied by the authors; light face type, re-examined by the authors; italic type, compiled from literature. PV: Pico Viejo; PT: Pico de Teide; after Ablay and Martí (2000) and Hürlimann et al. (2001), modified.

(NE-Tenerife), and Teno (NW-Tenerife; Fig. 1), with a constructional age between 11.9 and 3.9 Ma (Guillou et al., 2004). In the central part of Tenerife the Las Cañadas volcano formed >3 Ma ago (Fúster et al., 1994). Effusive basaltic eruptions dominated the early construction stage of the Las Cañadas volcano. Volcanic activity changed to more evolved and explosive eruptions in the time span between 2 and 0.17 Ma (Bryan et al., 1998). Subsequently, a large summit depression formed; the origin of this "Las Cañadas caldera" is subject of controversy to date: gravitational collapse resulting in giant landslides (e.g., Icod flank collapse, see Fig. 1), or vertical collapses caused by emptying of a shallow magma chamber have been proposed as the most plausible processes (for detailed discussion see Carracedo et al., 2007). In the Las Cañadas caldera two stratovolcanoes (Pico de Teide and Pico Viejo) with a constructional age of >150 ka postdate the caldera-forming events (Araña et al., 1989). Volcanic activity of the stratocones continued till prehistoric and historic time. Historic basaltic eruptions on Tenerife Island occurred at numerous sites in and outside the Las Cañadas caldera; the youngest basaltic eruption formed the Chinyero cinder cone in 1909. On the basis of moderate recent seismic activity, currently no further eruptions are expected. Since surveillance began in 1985, only one bigger earth quake (magnitude 5.3; Carracedo and Valentine, 2006) has been recorded. According to Mezcua et al. (1992) two moderate earthquakes occurred within historic time associated with volcanic activity in the years 1706 and 1909, respectively. Frequent earthquakes with magnitudes >5 have been reported from the seafloor area between Tenerife and Gran Canaria. The sole record of an earthquake (magnitude 6.8) in Holocene times has been given by González de Vallejo et al. (2003); seismites in El Médano area are mentioned as evidence for this event. However, sedimentary structures in the "seismites" of this site have been alternatively interpreted as the product of hot ignimbrites flowed over wet beaches (Carracedo and Day, 2002).

3. Vertical movements on the Canary Islands

Positive vertical movements of volcanic islands can generally be caused by major earthquakes, ascending magma or mass loss as a consequence of giant land slides. According to Pirazzoli et al. (1982) and Kontogianni et al. (2002), major earthquakes can enforce vertical movements of tectonic blocks resulting in a symmetric or asymmetric uplift of entire islands.

Amelung et al. (2000) detected widespread uplift on the Galápagos Islands enforced by ascending magma; positive vertical movements enforced by magma injection have also been described for the Nisyros volcano (SE Aegean Sea) by Stiros et al. (2005). Significant uplift of volcanic islands as the result of giant land slides and flank collapses with concomitant mass loss have been described in detail by Smith and Wessel (2000) for the Hawaiian Islands.

On the western Canary Islands, submarine series presently expose at the surface have been described as evidence for significant uplift of La Palma by Staudigel and Schmincke (1984). Uplifted and re-incised conglomerate

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