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Complexity of Quaternary aeolian dynamics (Canary Islands)

C-B. Roettig [a,*], T. Kolb [b], D. Wolf [a], P. Baumgart [a], C. Richter [a], A. Schleicher [c], L. Zöller [b], D. Faust [a]

[a] Dresden University of Technology, Germany
[b] University of Bayreuth, Germany
[c] GFZ German Research Centre for Geoscience, Germany

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ABSTRACT

Carbonate aeolianites are important Quaternary archives at the point of intersection between marine and terrestrial systems. Since they are composed of alternating aeolian sediments and several paleosol units, these sequences are highly suitable to reconstruct palaeoenvironmental conditions. In northern Fuerteventura, at least five different areas are characterised by successions of different dune generations and paleosols. Few studies have addressed the stratigraphic order of individual dune areas. Therefore, a comprehensive consideration spanning several dune fields is needed. Here, we aim to present a detailed stratigraphy of two different dune areas and to identify the contribution of different materials (shelf origin, dust origin, volcanic origin) along with processes (accumulation, soil formation, erosion/preservation) that build up these archives. Four key sections were selected and sampled for laboratory analyses (texture, elemental composition, CaCO3 content, palaeoenvironmental magnetics, luminescence dating, and gastropod assemblages). Based on main stratigraphic features, five major sedimentary sequences were identified indicating differences in prevailing sediment supply, humidity, and volcanic activity. First luminescence dating (IRSL) of the sequences revealed sedimentation ages between 360 ka and 15 ka. Finally, we are able to demonstrate that different dune areas show comparable stratigraphic patterns, but each studied site is defined by certain characteristics depending on the respective features of the closer surrounding. The knowledge of these peculiarities and the underlying background is essential in order to correlate different sites and to attempt an appropriate environmental interpretation of the sedimentary sequences.

1. Introduction

Most carbonate aeolianites of the mid latitudes are important archives of Quaternary climate and environmental changes, because the deposition of dune material seems to be linked to varying sea level and/or to climate change, whereas discontinuities between several generations of dunes are often marked by paleosols (Brooke, 2001). Appropriate deposits are situated in northern Fuerteventura.

In the last decade, most studies conducted across the Canary Islands focused on composition of Saharan dust (Engelbrecht et al., 2014; López-García et al., 2013; Menéndez et al., 2007, 2013), discussed the importance of dust availability (Moreno et al., 2001; Perez-Marrero et al., 2002), or pointed to the influence of dust input in soils (Von Suchodoletz et al., 2010, 2013). Yanes et al. (2007, 2011, 2013) focused on the significance of land snails for reconstructing paleoclimatic conditions. Beyond the theories of the volcanic origin of the island (Abdel-Monem et al., 1971; Anguita and Hernán, 2000), Coude-Gaussen and Rognon (1987) described sediment deposition which originates from shelf and dust input as one of the main parent materials in dune fields. Similar coastal stratigraphical studies aimed to date aeolian and volcaniclastic deposits (Bouab and Lamothe, 1995; Damnati et al., 1996; Meco, 2008; Ortiz et al., 2006), but only one study (Faust et al., 2015) examined sand paleosol sequences in four adjacent sites.

In 2011, Meco et al. reported a lack of age control in landward aeolian sand sections. The investigations of (Faust et al., 2015) act as a starting point for examinations in a much wider area of paleo dunes and sand sheets. Hence, it remains a challenge to work out stratigraphic sequences from different parts of the island to establish a standard profile for northern Fuerteventura. Two catchments were investigated by the study in hand. Of more than one hundred prospected sites, we chose four sampling sites which we present in order to correlate them, and also to correlate them to the sequences presented in (Faust et al., 2015). We aim to present a detailed stratigraphy of alternating aeolianite and paleosol sequences from northern Fuerteventura. Furthermore, this stratigraphy is based on a conceptual attempt that considers the spatial distribution pattern of materials and processes participating in dune formation. Finally, we present a standard profile with 13 sediment units which we classify into five main stratigraphic sequences. These sequences are characterised by different forcing factors including sediment supply, differing humidity, and changes in volcanic activity.

* Corresponding author.
E-mail address: christopher-bastian.roettig@tu-dresden.de (C.-B. Roettig).

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2. Geographical setting

Today, Fuerteventura is characterised by arid conditions with an annual precipitation of 147 mm Edwards and Meco (2000), and with wind direction dictated by the northeasterly trade winds. The northern part of Fuerteventura is mainly characterised by Tertiary and Pleistocene volcanism, Pliocene and Quaternary aeolian deposits in the form of paleo dune fields, and sand sheets (Fig. 1) (Criado et al., 2004; Edwards and Meco, 2000). The Oligocene-Pliocene age volcanic rocks, the so called 'Basal complex', are exposed near to the western coast and in the central part of the island (Anchocea et al., 1996; Balogh et al., 1999; Coello et al., 1992). These volcanoes are classified into four basaltic series (Fúster et al., 1968; Rothe, 1996): The 'Basal complex' and the volcanism of Series I are of Miocene age. The post-Miocene Series II is mainly represented in the centre of Fuerteventura. Some volcanoes of Series III (Pleistocene age) are located in the east, for example the Montana Roja, dated to 1.7 Ma (Ibarrola et al., 1989), near the eastern coast. The youngest eruptions of Series IV are of middle to late Quaternary age (Fúster et al., 1968; Rothe, 1996) and are mainly located in northern Fuerteventura (Fig.1). The Montana de la Arena and the volcanic chain of the Calderon Hondo are examples of these volcanic activities.

Several dune fields and sand sheets are embedded into this volcanic landscape. A Holocene dune field of barchans and transverse dunes is located along the eastern coast close to Corralejo (Criado et al., 2004) (Fig. 1).

The sedimentary environment of the paleo dune fields is characterised by coarse grained biogenetic sandy shelf material ('carbonate aeolianites' according to Brooke (2001), Coude-Gaussen and Rognon (1987), and Edwards and Meco (2000)) and Saharan dust (Menéndez et al., 2007). Volcanic ashes and lapilli fragments are admixed. Menéndez et al. (2007) reported dust accumulation rates of 17–79 g m^{-2} yr^{-1} on average on Gran Canaria, based on measurements in 2002 and 2003. Misota and Matsuhisa (1995) and Menéndez et al. (2007) described high amounts of quartz within the mineral composition of dust. Von Suchodoletz et al. (2013) mentioned that all quartz on Lanzarote is of aeolian origin. Even though the Basal Complex on Fuerteventura contains SiO_2, (Alcántara-Carió et al., 2010) describe Saharan dust as the main source of quartz in the sediments of Fuerteventura.

The study area includes the southern catchment of the Barranco de los Encantados and the northern catchment of the Barranco del Jable (Fig. 2). The watershed between the northern and the southern catchment is located in the SE of Montana Blanca. The catchment of Barranco de los Encantados is deeply incised by gully systems, and its middle reaches are dominated by huge whitish sand deposits.

The catchment of Barranco del Jable comprises three tributaries which coalesce in the centre of the catchment (Fig. 2).

The lower reaches of the three tributaries are characterised by lower relief energy and reduced gully incision, while the area of the middle and higher reaches shows higher relief intensity and deeply incised gully systems (Fig. 2(b)). All three tributaries were investigated, but detailed analytic work was carried out only in the central gully system. The richness of alternating paleosol aeolianite sequences and the given accessibility of lower parts, caused by incision, make the area highly suitable for the here presented study.

The *Encantado section* (28.63915° N/13.978792° W) is located close to the watershed between the catchment of the Barranco de los Encantados and the Barranco del Jable (Fig. 2(a)) in the area of deeply incised gullies. The profile is developed within slope sediments of the SE-facing flank of the Montana Blanca. *Jable 1* (28.643783° N/13.974378° W) is situated within the centre of the Barranco del Jable catchment, to the east of its thalweg, where gullies incised up to 10 m deep. *Jable 2* (28.647389° N/13.9773° W) is also situated within the central part of the Barranco del Jable catchment, but to the west of the thalweg. Around this site, slopes are steeper and the gullies are less broad in comparison to the site of Jable 1. The quarry of *Melián* (28.669258° N/13.953765° W) and *Lajares III* (28.664184° N/13.936153° W) are situated to the south of the village of Lajares. There are four pit walls of the subrectangular sandpit of Melián

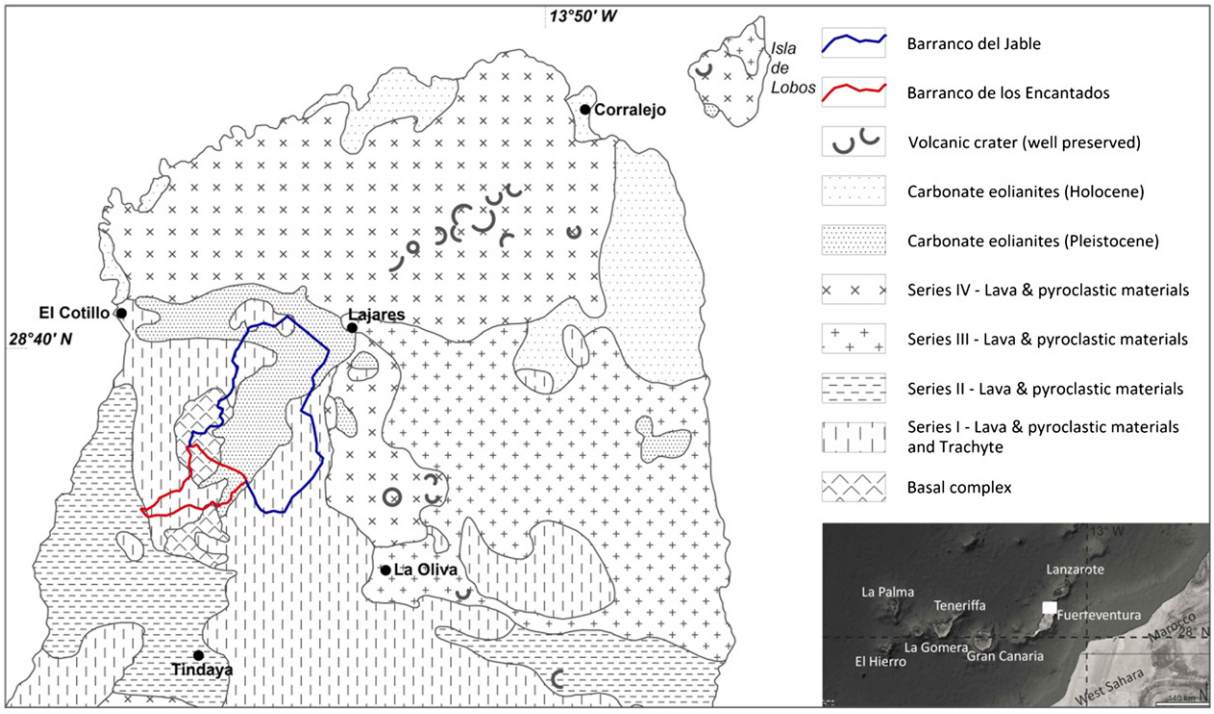

Fig. 1. Location map and major geological units of northern Fuerteventura (Rothe, 1996, modified) and the two catchments of the study area.