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Holocene landscape development along the Portuguese Algarve coast – A high resolution palynological approach

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ABSTRACT

Along the Algarve coast, multi-proxy investigations of four estuaries detail the Holocene landscape evolution through high-resolution pollen and sediment analyses. This approach focuses on palynological results and enables the reconstruction of differentiated human impact around the studied archives between the Neolithic and modern times. During the Chalcolithic and Phoenician periods anthropogenic land use increases clearly and triggers erosional processes in the catchment. The increased agricultural area and the change in land use methods since the beginning of the second Islamic epoch form the actual landscape. According to the palynological results, since 8200 cal BP highly variable climatic conditions in terms of moisture availability have occurred during the entire Holocene. Arid periods occurred during the early Holocene prior to 8000 cal BP, around 7000 cal BP and between 6400 and 6200 cal BP. During the mid Holocene, two further dry periods with very different duration could be identified between 5000 and 3300 cal BP and between 2800 and 2500 cal BP. Finally, during the late Holocene between 1300 and 1050 cal BP and between 700 and 500 cal BP, further arid periods appeared. In conclusion, climatic and anthropogenic influences caused erosion in the catchments and in this way silting up of the estuaries along the Portuguese Algarve coast.

1. Introduction

The landscape development of the Atlantic Iberian coast has been influenced by different factors, e.g., climatic and sea-level changes (Zazo et al., 2008) as well as high-energy events (Ruiz et al., 2005). Especially during mid and late Holocene times, human impact affected vegetation composition as well as geomorphological processes. Together with climate changes this controlled landscape development in this region. Although these driving factors have been studied during recent decades, their significance and relative importance for landscape development is still under debate. While Chester and James (1991), Stevenson and Harrison (1992), Stevenson (2000), González-Sampériz and Sopena Vicién (2002), Arteaga and Gonzalez (2004), Schulz et al. (2004), and Delgado et al. (2012) argue that the long anthropogenic land use since the Chalcolithic could be responsible for changes in erosion and sedimentation processes, Dabrio et al. (1999, 2000), Zazo et al. (1999) and Santos and Sanchez Goñi (2003) focus on natural origins of these changes like climate and sea-level variations.

Many studies tried to unravel the anthropogenic and climatic contribution to landscape evolution along the west coast of Portugal. Palynological investigations have been used to document the landscape development of this area mostly based on estuarine sediments (Queiroz and Mateus, 1994; Santos and Sanchez Goñi, 2003; Van der Schriek et al., 2008). Studies on marine cores give an overview of vegetation changes along the western and southern Iberian coast covering the last Glacial and Holocene with a resolution between 100 and 300 years (Sánchez Goñi et al., 2000; Roucoux et al., 2005; Naughton et al., 2007; Fletcher and Sánchez Goñi, 2008; Combourieu Nebout et al., 2009). Only few studies have targeted the Portuguese Algarve south coast. Fletcher (2005) as well as Fletcher et al. (2007) investigated the entire Holocene in a temporal resolution of approx. 200 years for the middle and late Holocene periods in the Central Algarve. On the other hand Allen (2003) investigated the coastal wetland of Boca do Rio (West Algarve) for the last 1600 years with a temporal resolution of 25–30 years.

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The base of this study is the hypothesis that environmental changes resulting from climatic variations are visible on a regional scale and thus within several archives at the same time, whereas effects from human impact should differ on a local scale. Hence, a high resolution multidisciplinary investigation of four estuaries along the Portuguese Algarve coast was conducted to allow the reconstruction of environmental changes based on sedimentological, geochemical, archaeological, palynological and micropalaeontological analyses (Hilbich et al., 2008; Teichner, 2008; Schneider et al., 2010; Höfer, 2014; Trog et al., 2013, 2015). The present study solely focuses on the results of palynological analyses and botanical micro remains. It aims to contribute to the understanding of the proportion and importance of the mentioned driving forces of environmental and landscape change on the coast of South Portugal.

2. Regional setting

The study area covers the coastal zone catchments between Faro and Lagos along the southern Portuguese Atlantic coast, the Algarve (Fig. 1). This region is presently characterized by a Mediterranean climate with a mean annual air temperature of 16.3 °C and annual precipitation which varies from 500 to 1000 mm (Loureiro and Coutinho, 1995). The majority (80%) of precipitation falls from October to March, partly as torrential rainfall (Rother, 1993; Teixeira, 2006). Vegetation can be described as part of the Mediterranean Zone with evergreen forest (Grove and Rackham, 2003) and it is related to the thermo-Mediterranean oak forest and olive–carob–shrub forest (Lang, 1994).

In total, four estuaries with different catchment sizes were targeted as study areas (Fig. 1). The catchment of Ribeira de Quarteira covers 405 km^2 and reaches elevations of 500 m a.s.l. in the Serra do Caldeirão, whereas Ribeira de Carcavai has a catchment of 67 km^2 with elevations of up to 340 m a.s.l. Both catchments are mostly characterized by Jurassic limestones and Plio-/Pleistocene sands. Ribeira da Alcantarilha catchment measures 41 km^2 and is mostly distinguished by Miocene sandstones and Jurassic limestones. These estuaries have mostly silted up completely. In contrast, the estuary of Ribeira do Farelo and Ribeira da Torre has not silted up until today. The rivers have a catchment of 257 km^2, elevation reaches up to 900 m a.s.l. in the Serra de Monchique, and the substrate mostly consists of Palaeozoic rocks and Jurassic limestones.

3. Materials and methods

3.1. Field work

In total, 68 sediment cores (5 cm diameter) were drilled from the different estuaries using ramming drilling with a motor hammer. Most drill sites were aligned along longitudinal and transversal transects (Schneider et al., 2010; Trog et al., 2013). Core length varied between 3 and 11 m. For all cores, the stratigraphy was described and sketched in the field, colour was registered using the Munsell Colour Chart, and textural classes, sedimentary features, macroscopic organic content and the presence of mollusc shells were registered. Carbonate content was classified according to the reaction to hydrochloric acid (HCl, 10%) (AG Boden, 2005). According to profile length and sediment composition one or two cores from each estuary were used for palynological and sedimentological analyses – Ribeira de Quarteira (P01–5), Ribeira de Carcavai (VdL PB2), Ribeira de Alcantarilha (ADP 01/06), Ribeira do Farelo and Ribeira da Torre (Abi 05/07). Locations of the core sites were determined using a differential GPS device (Magellan ProMark X) with an accuracy of 0.01 m. The GPS-determined height information, the present-day local tidal levels and the sea-level curve of Vis et al. (2008), were used to estimate the prevailing environmental conditions at the time of sedimentation described in Schneider et al. (2010) and Trog et al. (2013). Furthermore, in this paper the reconstruction of local development uses the sea level curve of Delgado et al. (2012).

3.2. Laboratory analysis

After splitting, the cores were subsampled at 4 cm intervals using 1 cm thick slices of one core half for sedimentological, geochemical, micropalaeontological and palynological analyses (core P01–5, 74 samples; VdL PB2, 94 samples; Abi 05/07, 82 samples; ADP 01/06, 84 samples). The samples were mostly analysed with a resolution of 30–80 years between two samples.

The methods for sedimentological and geochemical treatments are described in Schneider et al. (2010). Micropalaeontolgical proceedings are specified in Trog et al. (2013, 2015). For this study the pollen samples (core P01–5 51 samples, VdL PB2 144 samples, ADP 01/06 16 samples, Abi 05/07 76 samples) were prepared according to Faegri and Iversen (1989), including acetolysis and treatment with hydrofluoric acid. After processing, pollen samples were mounted in silicon oil and analysed using a Zeiss Light

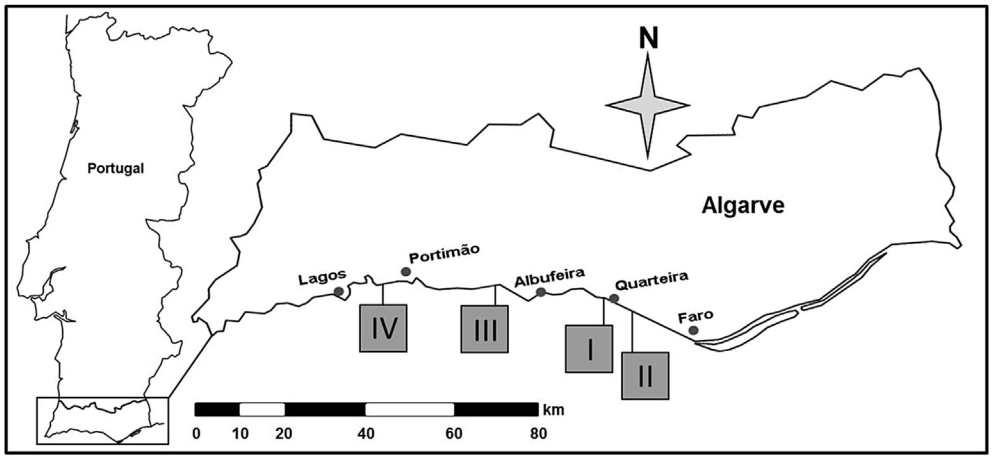

Fig. 1. Location of study sites: I – Estuary of Ribeira de Quarteira; II – Estuary of Ribeira de Carcavai; III – Estuary of Ribeira de Alcantarilha; IV – Estuaries of Ribeira do Farelo and Ribeira da Torre.