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First record of beachrock on Black Sea coast of Turkey: Implications for Late Holocene sea-level fluctuations

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ABSTRACT

We present new data on the diagenetic characteristics, subsurface nature and radiocarbon ages of beachrock from the Thracian Black Sea coast of Turkey, indicative of sea-level changes and climatic conditions favoring lithification of beach sands between 5.4 ka and 3.5 ka cal BP. Micrite coatings and succeeding meniscus cements typify diagenetic history and suggest a two-stage cementation over this timeframe. The early cements are typical of upper intertidal zone when the sea-level was likely similar to that of today. The ensuing intergranular bridges refer to an approximate 2 m decline in sea-level, favoring downward percolation of meteoric waters related to subaerial exposure, marked by a reduction in Mg concentration and dissolution pits on early cement coatings. Formation of beachrock during this bimillennial period could be associated with relatively drier conditions promoting the precipitation of connective cements.

1. Introduction

As a kind of cemented beach deposit frequently found in the form of blocks or slabs, beachrock offers a record of the morphodynamic, climatic and oceanographic changes that have occurred in coastal areas. Amalgamation of sediments as well as fossil shells and microfossils entombed within cement or intergranular spaces provide a record of the diagenetic history of the beachrock. Since the very earliest studies, attempts have been made to pinpoint the origin, age, distribution and significance of beachrock on various coastal outcrops around the world (see Vousdoukas et al. (2007) and references therein). Since abiotic cement, i.e., aragonite and high Mg-calcite, is precipitated as a direct result of the evaporation of sea-water, predominantly as a connective carbonate, beachrock has been generally attributed to intertidal cementation and regarded as giving explicit indications of sea-level changes. Nevertheless, contribution of different specific processes regarding to precipitation of binding carbonates have been suggested (Vieira and De Ros, 2006 and references therein). Until recently, however, there was debate on the credibility of beachrock as a key indicator for sea-level changes due to differing viewpoints (Kelletat, 2006; Knight, 2007).

In contrast to authors who have focused on geomorphological data (Kelletat, 2006), many researchers have recently gained benefit from studying cementation characteristics (Kneale and Viles, 2000; Hillgaèrtner et al., 2001; Calvet et al., 2003; Rey et al., 2004; Vieira and De Ros, 2006) and stable isotope data (Holail and Rashed, 1992; Calvet et al., 2003; Friedman, 2005; Vieira and De Ros, 2006). One of the main problems regarding the solidity of intertidal beachrock in real terms is lack of information on the continuation of beachrock backshore under beach materials, since samples are mostly taken from slabs exposed at the coast. Along the 8333 km-long coastline of Turkey, beachrocks display a wide distribution, from the eastern end of the Mediterranean to the Gulf of Saros, comprising the northern limit of the Aegean Sea (Avşarcan, 1997; Desruelles et al., 2009).

In this study, results obtained from the first recorded beachrock on the Thracian Black Sea coast of Turkey are discussed (Fig. 1a, b). We considered that the formation of beachrock on the coast of the Black Sea is substantive in that this anoxic sea is presently characterized by low (17–20‰) surface salinity and a nominal amount of evaporation compared to the much greater amount of freshwater input by precipitation and rivers (Beşiktepe et al., 1994; Mertens et al., 2012). Based on diagenetic characteristics in conjunction with radiocarbon ages and

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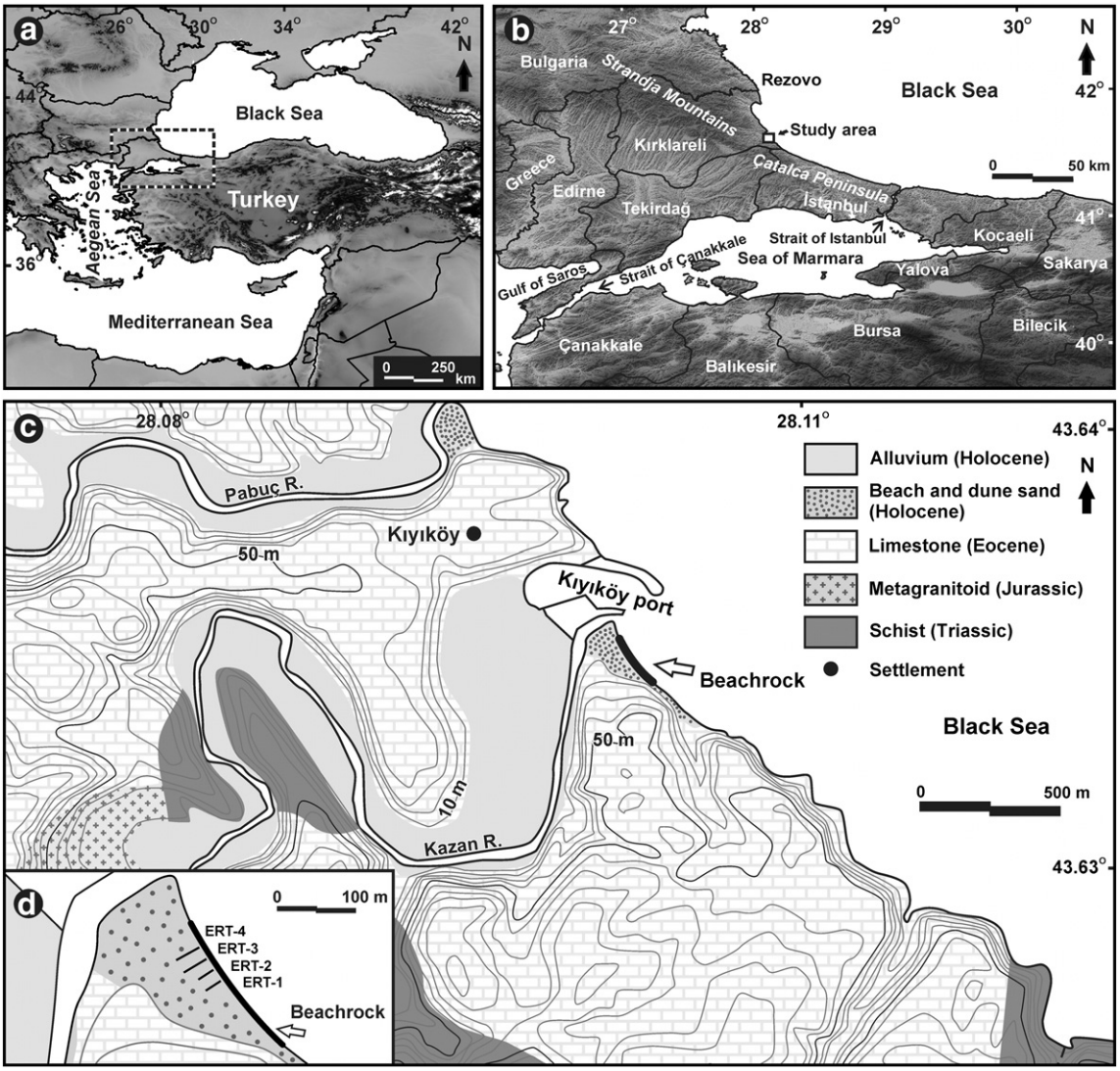

Fig. 1. (a–b) Location maps of study area; (c) geology map of the study area and its environs; (d) ERT lines taken perpendicular to the coastline.

geophysical imaging data, new findings in respect of Late Holocene sea-level fluctuations on the Turkish Black Sea coast are presented.

2. Study area

On the eastern coast of Kıyıköy, Kırklareli, NW Turkey, the studied deposits constitute the first record of beachrock from the northwestern Thracian Black Sea coast of Turkey (Fig. 1a, b). Comprising the European part of the country, Thrace is bounded by the Sea of Marmara to the south and Black Sea to the north and has a coastline of about 786 km. The Black Sea coast of Thrace starts from the mouth of the River Rezve (Rezovo) at the Bulgarian border and extends in a northwest–southeast direction down to the strait of Istanbul (Bosphorus) (Fig. 1b). The eastern part of Thrace comprises the Çatalca Peninsula and is characterized by a nearly straight coastline. However, in the northwestern section, the Thracian coast is rather indented as the coastal area forms a seaward (northeast) prolongation of the Strandja Mountains, a massif consisting of basement rocks such as gneiss and amphibolite, and cover deposits formed of schist, limestone, sandstone and igneous rocks (Pamir and Baykal, 1947).

The geology of the backshore at the southern end of the cemented beach in this study is composed of Middle to Late Eocene fossiliferous limestones with sandstone and claystone intercalations (Fig. 1c). On the northern coast is the mouth of the Kazandere River which flows into the sea from between Kıyıköy port and a coastal spit (Fig. 1c). On the backshore, a low ridge made up of a 5-m thick coastal dune stands between the river mouth and the present sandy beach. Meteorological data (1975–2006) from Kumköy meteorology station 85 km to the southeast indicate that the area receives a yearly precipitation of 831.4 mm. The average annual air and sea-water temperatures were recorded as 13.8 °C and 14.3 °C, respectively. During the hot period between May and September, evaporation values from sea water reach a total of 600 mm, which is lower than the Mediterranean (approximately 2000 mm). Climatically, a humid-temperate Black Sea climate dominates (Türkeş, 1996). Tidal range is nominal with an average of 10 cm (Goudie, 2001).

3. Methods

3.1. Analyses of beachrock materials

Five samples of beachrock were collected for analysis and radiocarbon dating. Petrographic analysis was carried out based on thin section interpretations. Energy Dispersive Spectroscopy (EDX-Bruker AXS XFlash) analysis of the beachrock was performed to shed light on elemental composition of connective cements. Using Scanning Electron