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Cement fabrics and optical luminescence ages of beachrock, North Cyprus: Implications for Holocene sea-level changes



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ABSTRACT

CaCO₃-cemented beachrocks are widely found along the northern coast of Cyprus. In this study, we aim to discuss the cementation history of beachrocks at ten particular sites within the context of Holocene sea-level changes. Cement fabrics, petrographic and geochemical characteristics, and optically-stimulated luminescence ages of buried quartz grains were studied. The seaward-inclined (~5–10°) parallel-stratified beds are composed mostly of sandstone alternating with conglomerate. Ooids, benthic and planktic foraminifera, bioclasts of red algae, echinoid spines and gastropods make up a significant proportion of the cemented beds. With CaCO₃ content ranging between 37% and 65%, poorly-sorted grains are bonded by four distinct cements: circumgranular micritic coatings, sparry calcite infillings, pore fills, and meniscus bridges. This consecutive nature of cementation is typical of a marine phreatic and meteoric vadose environment when the sea level was lower than present but had a tendency to increase during middle to late Holocene. OSL ages ranging from 5.4 ka to 0.38 ka indicate that the deposition and ensuing cementation of the quartz grains occurred during two main stages; younger beds dated between 2.3 ka and 0.38 ka and older beds from 2.3 ka to 5.4 ka. A period devoid of beachrock formation was attested between 3.5 ka and 2.3 ka.

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1. Introduction

As a kind of carbonate-cemented sandstone or coastal conglomerate typical of intertidal cementation, beachrock has extensively been considered a key indicator in studies dealing with both sea-level changes and neotectonic deformations in various coastal environments (Fouache et al., 2005; Kelletat, 2006; Desruelles et al., 2009; Thomas, 2009; Mourtzas, 2012; Mourtzas and Kolaiti, 2013; Stattegger et al., 2013; Mourtzas et al., 2014; Psomiadis et al., 2014; Mauz et al., 2015). To the contrary of common belief until the 1960's stressing that the formation of beachrock occurred particularly in tropical and subtropical environments (Ginsburg, 1953; Russell, 1959), several authors later attested to its existence in temperate (Zenkovitch, 1967; Rey et al., 2004) and cold climate zones (Binkley et al., 1980; Kneale and Viles, 2000). The Mediterranean (Friedman and Gavish, 1971; Alexandersson, 1972;

Bernier and Dalongeville, 1988; Holail and Rashed, 1992) and Caribbean coasts (Ginsburg, 1953; Moore, 1973; Hanor, 1978; Beier, 1985), as well as tropical and subtropical coasts of the Atlantic Ocean, are among the areas where beachrocks are found.

The common distribution of beachrock beds was pinpointed along various sections of the micro-tidal coast of the Mediterranean by Vousdoukas et al. (2007). A vast number of outcrops have been reported on the Eastern Mediterranean coast from the 19th century onwards (Beaufort, 1818; Spratt and Forbes, 1847; Taillefer, 1964; Goudie, 1966; Schattner, 1967; Lipkin and Safriel, 1971; Bener, 1974; El-Sayed, 1988a,b; Kampouroglou, 1989; Mourtzas, 1990; Holail and Rashed, 1992; Avşarcan, 1997; Sanlaville et al., 1997; Neumeier, 1998; Fouache et al., 2005; George et al., 2006; Kelletat, 2006; Morhange et al., 2006; Vousdoukas et al., 2007, 2009; Ertek et al., 2008; Desruelles et al., 2009; Çiner et al., 2009; Erginal et al., 2010; Friedman, 2011). Promoting the precipitation of connective calcium carbonate and the ensuing amalgamation of beach materials, the arid climate of the island throughout the year plays an important role in the formation of beachrocks in Northern Cyprus.

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Ertek et al. (2008) reported the existence of beachrocks at five different sites and examined the petrographic composition of the cemented beds. However, the cementation history and age of the beachrocks have not been considered. In this study, we present results concerning the composition, cement characteristics, diagenetic history and OSL ages of beachrocks ascertained at 10 different sections of the northern coast of Cyprus within the context of Holocene sea-level changes (Fig. 1).

2. Study area

The island of Cyprus rises in the central part of the Eastern Mediterranean basin (Fig. 1a) at a convergent boundary between the Arabian, African and Eurasian plates (Gülen et al., 1987; Poole and Robertson, 1998; Robertson and Mountrakis, 2006; Wdowinski et al., 2006; Waters et al., 2010). Located at 34.55°–35.69° N and 32.27°–34.58° E, the island is 70 km from the coast of southern Anatolia. Its climate is typically characterized by arid and semi-arid conditions according to the Thornthwaite water balance (Türkeş and Sarıç, 2007). The average temperature is above 0 °C all year round. With mean values ranging between 18 °C and 20 °C, maximum summer temperatures may reach 45 °C, resulting in an increase in evaporation and thereby precipitation of

carbonates from seawater. The tidal range is about 10 cm according to the principal (M2) lunar tide around the island (AVISO, 2013). The average sea-level amplitude is 14.9 cm all year around. The mean long-term maximum and minimum sea-level amplitude is 36.5 cm in the Eastern Mediterranean (Öztürk, 2011).

3. Methods

3.1. Sampling and analyses

A coastal zone about 320 km long was surveyed during field studies to map the distribution of beachrock beds and to collect samples for analysis and dating. Changes in bedding and composition from bottom to top together with the length, width and thickness of slabs and angle of dip were measured. Sampling sites shown in Fig. 1b were recorded using a global positioning system receiver (GPS; Garmin GPSMAP 60CSx). Out of 23 possible sites, a total of 21 beachrock samples from ten selected localities were collected for analysis and Optically Stimulated Luminescence (OSL) dating (Fig. 2). Mineral content and textural characteristics of the beachrocks were described based on petrographic thin sections. Closer examination of the cemented components was performed using Scanning Electron Microscopy (SEM-ZEISS EVO 50 EP) in

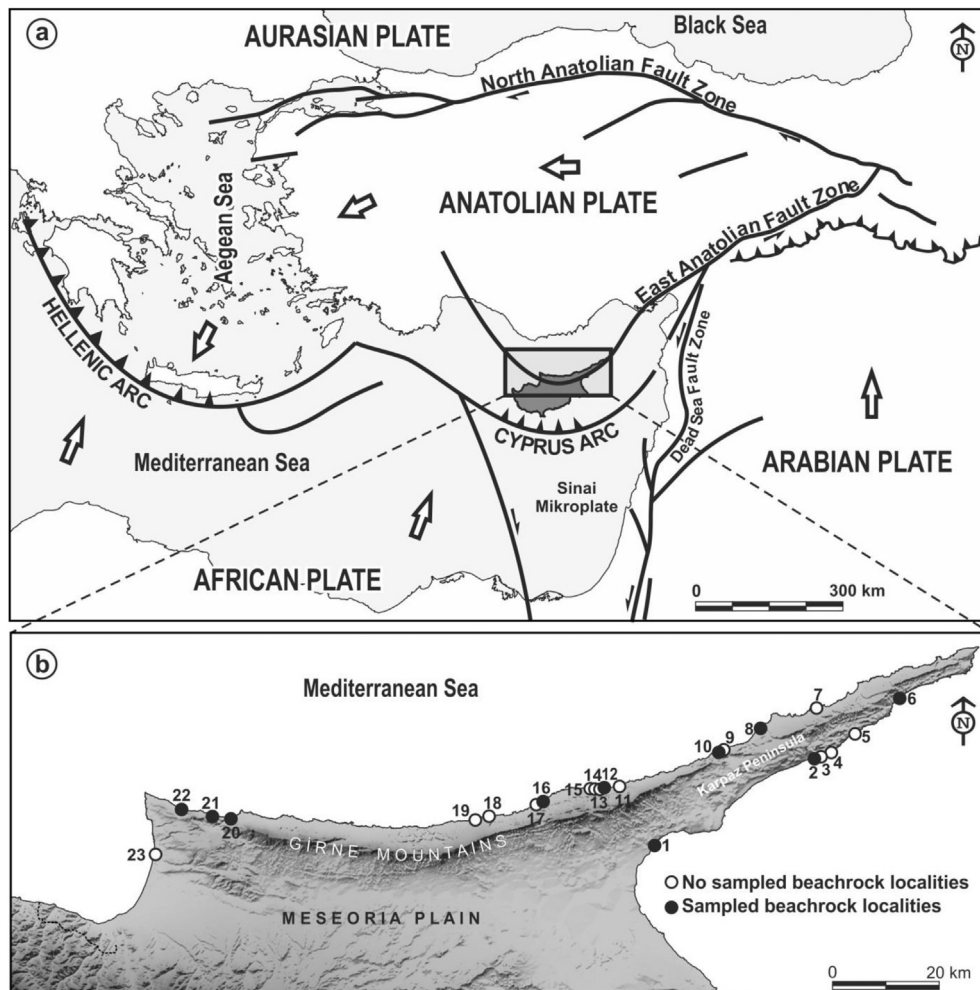


Fig. 1. (a) Generalized tectonic map of Eastern Mediterranean (Compiled from Şengör et al., 1985; Barka and Reilinger, 1997; Bozkurt, 2001; Robertson and Mountrakis, 2006), (b) distribution of 23 beachrock locations and 10 selected sampling sites on North Cyprus coast.

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