EGU21-11017
https://doi.org/10.5194/egusphere-egu21-11017
EGU General Assembly 2021

Insights in beachrock formation mechanism using multiproxy experimental data: Case study of Diolkos, Corinth, Greece

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Many studies have been published concerning the occurrence and formation mechanism of beachrocks around the world. However, there are only few quantified data on the precipitation mechanism and the parameters affecting it. The formation mechanism of beachrocks is directly related to their palaeoenvironmental significance, as it provides insights into sea level evolution and palaeogeographic evolution. In this study we corelate analytical data of natural and artificial beachrocks, which were created by the microbially induced carbonate precipitation (MICP) technique using sediments and ureolytic bacteria from the coastal zone of Diolkos, Corinth, Greece.

A multiproxy analysis was accomplished which included the mineralogical and geochemical analysis of both natural and artificial beachrocks, and the sedimentological and mechanical properties analysis of the artificial ones. This study focuses on four parameters that concern the cementation processes of artificial beachrocks: (a) sediment granulometry, (b) $CaCO_3$ content, (c) bacteria type and (d) cement type. Diolkos, due to its location and history, presents great palaeo-geographic and geoarchaeological interest; for this reason, luminescence dating was accomplished on selected beachrock samples, in order to elucidate the relative sea level changes (RSL) and palaeogeographic evolution of the site.

For the artificial beachrocks formation, we conducted solidification test using ureolytic bacteria *Micrococcus yunnanensis sp.* and *Virgibacillus sp.* isolated from local sand samples. In order to determine the solidification of the beach sediments we estimated the unconfined compressive strength (UCS) by using needle penetration test on the surface of each sample. Furthermore, the precipitated $CaCO_3$ cement of the artificial beachrock samples, was calculated using HCl rinsing method. The artificial beachrocks were examined under SEM-EDS, XRD and XRF for their mineralogical and chemical composition accordingly.

Microscopy studies (optical and SEM-EDS) revealed that the cement of the artificial beachrock consists of calcite, in form of acicular sediment coating forming fans and multilayer concentrations. The cement in many cases was amorphous calcite crystals or microcrystalline, with thickness varying between 5 μm and 40 μm. The analysis from the artificial beachrock was

correlated with the natural beachrock of Diolkos area. Our results revealed that the artificial beachrocks had different type of cement with microstratigraphy of an early digenesis. Moreover, amongst the artificial beachrocks, the sample with very well sorting (in terms of granulometry) has shown high values of $CaCO_3$ content, which corresponds to cement, a mean value of UCS 11 MPa and the best cement precipitation.