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Research Article

Petrographic Analysis of Beach Rocks from the Souiria Laqdima Coastline in Morocco

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Abstract – The beach rock formations along the Souiria Laqdima coast in Morocco present an intriguing area of study due to their unique characteristics and the limited research conducted in this region. In our investigation, we concentrated on collecting rock specimens near the estuary of the Oued Tensift, a key location for understanding the geological and biological interactions affecting coastal formations.

The primary goal of our study was to conduct a detailed petrographic analysis of thin sections extracted from these collected beach rocks. This involved examining the microscopic features of the rocks to identify the mineralogical and textural components of the cement binding the rock particles. The analysis revealed that the predominant cements in these beach rocks are calcite and magnesian calcite. These findings are significant as they help elucidate the types of cementation processes occurring in coastal environments, particularly in terms of carbonate mineral precipitation under varying environmental conditions.

Moreover, our study provides insights into the biological aspects of beach rock formation, particularly through the identification of bioturbation. Bioturbation refers to the disturbance of sedimentary deposits by living organisms, which in this case involves the activity of organisms within the rock matrix that affects the deposition and cementation processes. The study specifically noted the role of burrows created by these organisms, which contribute significantly to the stabilization of pebbles and further influence the cementation process of the beach rocks.

These burrows not only help in anchoring the pebbles within the rock matrix but also modify the local environment in ways that affect the chemical processes leading to cementation. Such interactions between biological activity and geological processes are crucial for understanding the natural engineering that stabilizes and shapes the coastal rock formations.

This comprehensive examination of beach rocks in Souiria Laqdima adds valuable knowledge to our understanding of coastal geology, highlighting the complex interplay between biological activities and geological processes in shaping beach rock formations. The findings from this study not only broaden our understanding of sedimentary rock formations in coastal areas but also contribute to the wider field of geosciences with implications for environmental conservation and coastal management.

Keywords – Beach Rock, Coastline, Souiria Laqdima, Petrographic Study.

I. INTRODUCTION

Beach rock, also known as beach sandstone [1], [2], represents an early form of coastal carbonate cementation, often appearing in slab formations inclined towards the sea. This geological feature, commonly found in the mediolittoral zone, is characterized by its hardening through carbonate cements, primarily aragonite or magnesian calcite. The intricate formation process of beach rock is influenced by the interface between marine and meteoric environments, embodying the transition from sea to land.

In the context of Souiria Laqdima, Morocco, a region with a substantial but understudied geological footprint extending from the primitive to the Eocene epochs, beach rocks offer a unique insight into coastal dynamics. The petrographic study of thin sections from these beach rocks is crucial for deciphering the complex interplay of environmental factors and geological processes [3], [4]. This analysis primarily focuses on the mineral composition and textural features of the carbonate cement, which are pivotal in understanding the cementation mechanisms [5], [6].

Our research involved collecting beach rock samples along the shoreline, near significant geological features such as the mouth of the Oued Tensift. Petrographic examination of these samples involved detailed analysis under the microscope to identify the mineral constituents and the nature of the cement binding these formations. We specifically looked for evidence of bioturbation—disruptions in the sedimentary structure caused by biological activity—which can significantly influence the mechanical properties and porosity of the beach rocks [7].

Moreover, the petrographic analysis aimed to delineate the textural characteristics of the cement, such as grain size, the degree of sorting, and the rounding of particles, which collectively provide insights into the depositional environment [3], [4]. This detailed scrutiny helps in understanding how different environmental conditions, such as water temperature, salinity, and biological activity, contribute to the formation and stabilization of beach rock.

Through this focused study, we seek to contribute to the broader understanding of coastal geomorphology and the natural processes that govern the formation and evolution of beach rock. This not only enhances our knowledge of geological formations in Moroccan coastal regions but also supports broader geological theories related to sedimentary rock processes and coastal ecosystem dynamics.

II. MATERIALS AND METHOD

A comprehensive geological study was conducted prior to the field missions. The sampling was performed on the intertidal zone of the beach-rock slabs at Souiria laqdima beach.

Figure 3 depicts three distinct locations: the beach on the right bank of the wadi Tensift, the mouth of the wadi, and the beach on the left bank of the wadi. At each site, we collected two samples weighing approximately 1.5 kg each, which were then placed in plastic bags and properly labeled. The samples were transported to the laboratory where they underwent thorough cleaning and removal of the surface crust.

Figure 2 Beach rocks of Souiria Laqdima

A. Study area

The coastline of Souiria is located at a longitude of 9° 20' 27.33" W and a latitude of 32° 2' 39.63" N. It spans a distance of 6 kilometers. Safi is located 36 kilometers away from the mouth of the Tensift wadi on the Atlantic coast of Morocco (Fig. 1). The study area in the north is bordered by the Doukkala Plains, in the northeast by the Rehamna Plateaus, in the southeast by the Chichaoua Plateaus, in the south by the Essaouira Province, and in the west by the Atlantic Ocean. The geological formation consists of a sequence of sedimentary layers ranging from the primary era to the Eocene epoch. On top of these layers, there are more recent deposits from the Plio-Quaternary period that were formed as a result of transgression. The area being studied is a component of the western coastal Meseta, which is a significant geological formation[8]–[13].

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Figure 2. Localisation map of the study area

III. RESULTS AND DISCUSSION

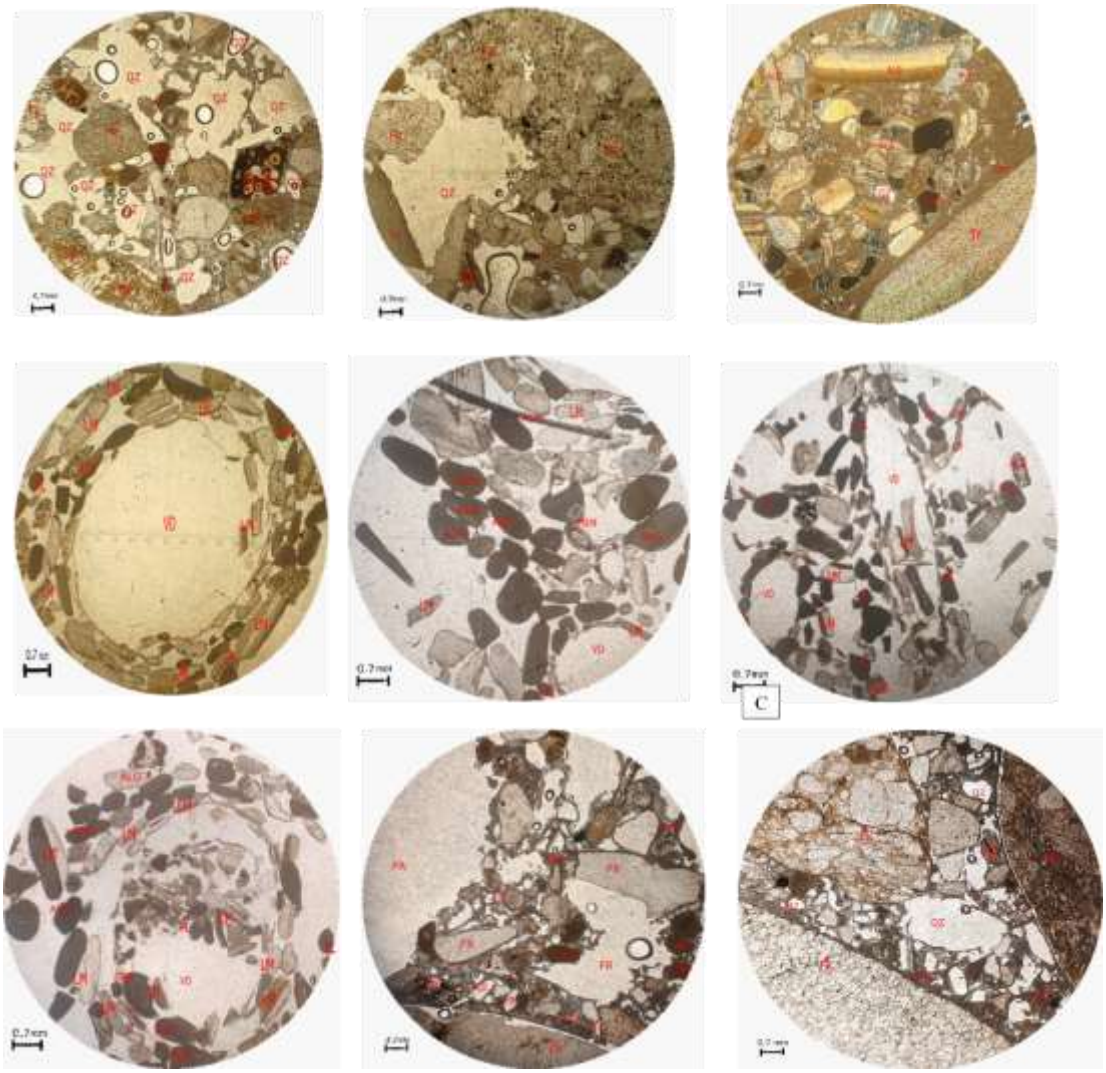

Figure 3. Thin sections of different beach rock samples under the microscope, A: a view of BR.PA with 40 magnification, B: a view of BR.PA with 100 magnification, C: a view of BR.an with 40 magnification, D: a view of BR.an with 100 magnification, E: a view of BR.r with 40 magnification, F: a view of BR.r with 100 magnification, O, M, N: a view of BR.md with 40, A.E: algal encrustation, M: meniscus cement, Ech: echinoderm, S: Micro-stalactitic cement, M: Micritic binder, MSp: Secondary microspartic binder, Qzt: Quarrtzite, Mq.C: micritic calcite binde

Microscopic examinations: Slides were created from collected beach rock samples in order to examine them using a binocular microscope. We will exclusively showcase the utmost

Thorough and important thin sections. The petrographic analysis of the thin slides of beach rocks shows variation in the constituents, including the presence of quartz and quartzite (Fig. 5O–5B), algal encrustations with a cortex that surrounds bivalves, known as oncolites (Fig. 5A–5B), and remnants of echinoderms (Fig. 5D). Figures 6I, 6K, 6L, 6P, and 6Q of the identical thin slide exhibit a variety of components, including remnants of foraminifera, algae, bivalves, and pellets.

Thin-section petrographic analyses of rocks from Souiria Laqdima beach, Safi, indicate that these rocks experienced early diagenetic cementation. This cementation occurred either in the form of carbonate meniscus with a low magnesium content (Figs. 5B–5C) or microstalctitic cement (Figs. 5D–5E) (Fig. 5E). Furthermore, alongside the micrite, we discovered a microspartic binder that serves a supplementary function (Fig. 5F). Figures 5M and 5N show both the meniscus cement and the micrite. The presence of meniscal and microstalactitic cementing phases indicates that these cements formed in a vadose zone

influenced by meteoric conditions12. Figures I, K, L, P, and Q (Fig. 6) show rounded and elongated voids surrounded by grains. These voids are filled with a yellow or brown film, which is the result of bioturbation. Bioturbation is caused by worm tubes secreting an adhesive sticky substance that acts as a glue, binding and compacting the grains together with clastic sediments.

IV. CONCLUSION

Based on the comprehensive petrographic analyses of thin-section slides from Souiria Laqdima beach, several significant conclusions can be drawn regarding the geological and biological processes influencing beach rock formation. The observed variation in mineral constituents, such as quartz and quartzite, alongside biological features like algal encrustations and remnants of marine life such as bivalves and echinoderms, illustrates a dynamic interplay between abiotic and biotic factors in beach rock cementation.

The presence of early diagenetic cements, including carbonate meniscus with low magnesium content and microstalactitic cement, suggests that these cementation processes predominantly occurred in a vadose zone where meteoric conditions prevail. This indicates a significant influence of atmospheric water in the geochemical processes forming these cements.

Additionally, the bioturbation effects observed, marked by the presence of voids filled with a yellow or brown film likely resulting from the secretion activities of worms, underscore the role of biological activity in modifying the textural and structural properties of beach rocks. These biogenic processes not only contribute to the physical structuring of the rocks but also influence the chemical environment, promoting or altering the cementation process.

In conclusion, the petrographic study of beach rocks from Souiria Laqdima provides valuable insights into the complex mechanisms of beach rock formation, driven by both geological and biological factors. This study not only enhances our understanding of coastal sedimentary processes in a relatively understudied region but also highlights the intricate connections between life forms and geological phenomena in shaping the earth's coastal landscapes.

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