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Beachrock in South Jeddah, The Red Sea Coast of Saudi Arabia

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ABSTRACT. The geomorphological and petrographical characteristics of the beachrock in South Jeddah along the Red Sea Coast of Saudi Arabia, were investigated. On the basis of the mode of occurrence and genesis, the beachrock is divided into three types, (1) supratidal beachrock, (2) intertidal beachrock, and (3) subtidal beachrock.

The field occurrences and petrography of the beachrock vary from one place to another. However two types were recognized: quartzose beachrock, and conglomeratic beachrock. Aragonite and high Mg-calcite are the main carbonate cements in these rocks.

Introduction

Beachrock, generally understood to be sand and coarser grained sediments lithified in situ within or slightly above the intertidal zone. It has been described from numerous tropical and subtropical localities. Although most modern examples occur in regions of coral growth along the Mediterranean, Indian, African, Red Sea, Brazilian and Central Pacific coasts, beachrock also has been reported in more temporate region such as northern Italy (Stefanon, 1969) and New Zealand (Kear and Brown, 1970). Beachrock can form from sand and gravel of almost any composition, including quartz and even volcanic fragments (Emery and Cox, 1956), but carbonate sands provide the most common framework for beachrock.

Most studies of modern beachrock have emphasized origin of the cement (*e.g.* Ginsburg, 1953; Revelle & Fairbridge, 1957; Friedman and Gavish, 1971; Alexandersson, 1972, Durgaprasada Roa and Behairy, 1982 and El-Sayed, 1988), who

studied the erosion and the sedimentation along the Jeddah coast of Saudi Arabian Red Sea, no data were reported on the petrological and sedimentological characteristics of the beachrock along the southern and central part of the Red Sea. Therefore the present study deals with these characteristics of these beachrock.

Material and Methods

Beachrock samples were collected from the intertidal and supratidal zones of south Jeddah (Fig. 1). The tidal range of the Red Sea near Jeddah is low (30 cm) (Ahmed and Sultan, 1993). The constituents of cement of the beachbrock were

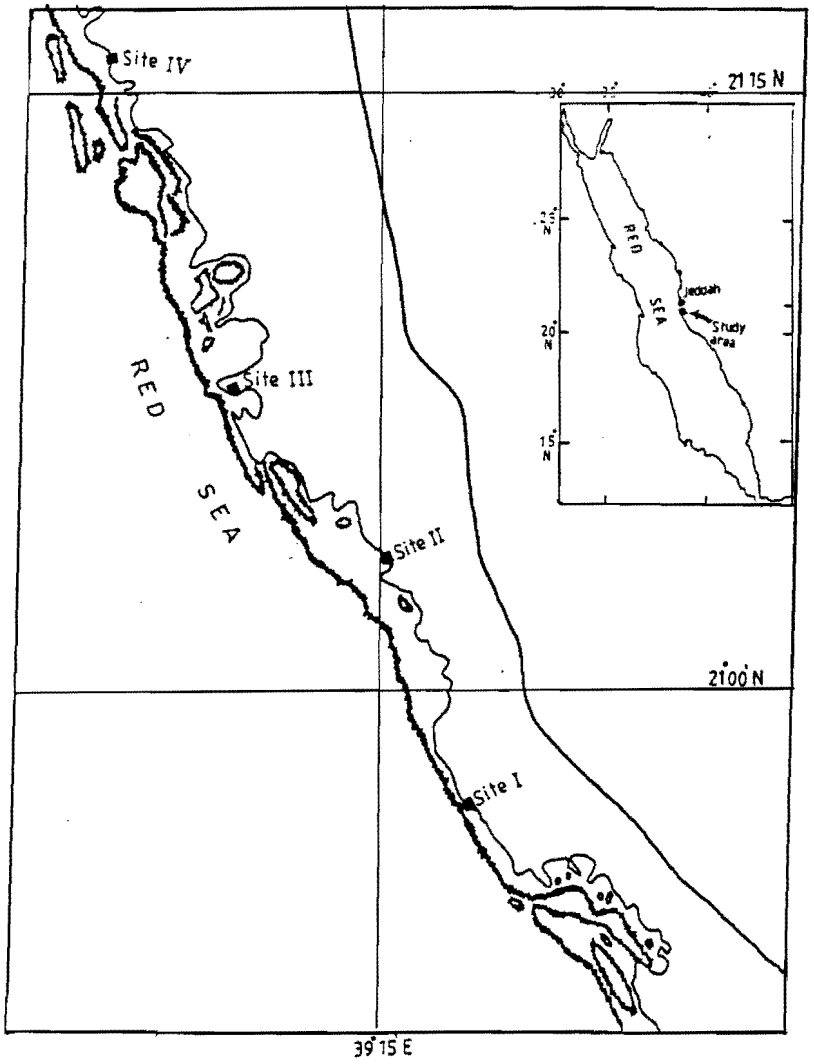

FIG. 1. Map of the study area and locations of beachrock sites.

studied in polished rock slabs surfaces after staining according to Friedman's (1959) technique for a quick examination of the carbonate petrography. Samples were also petrographically studied in thin sections. The precise identification of the mineral constituents of cements for four samples (only one sample from every beachrock site) were carried out by x-ray powder diffractometry using Ni filtered, Cu/Ka radiation.

The various components in the sand and gravel fractions of all samples were examined under binocular microscope after removing the carbonate cement with diluted HCl acid. The relative frequency of each grain type was determined.

Occurrence and Genesis of Beachrock

On the basis of the mode of occurrence and genesis, the Quaternary beachrocks in the coastal area south Jeddah are divided into three types :

1. Supratidal beachrocks.
2. Intertidal beachrocks.
3. Submerged beachrocks.

1 – Supratidal beachrocks

These beachrocks are carbonate-cemented types of varying composition. They occur in the form of slabs inclined towards the sea with a slope roughly equal to that of the foreshore (Fig. 2). Vertical variation in degree of cementation, grain size, and sorting cause layering structure (Fig. 3). The present position of these beachrocks

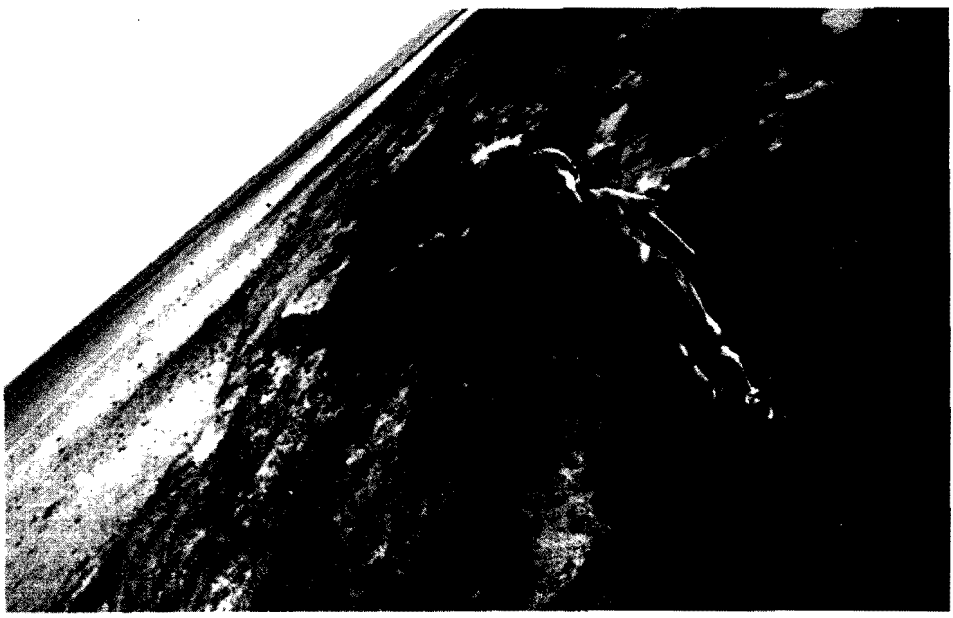

FIG. 2. Beachrocks pavement exposed in the supratidal zone.

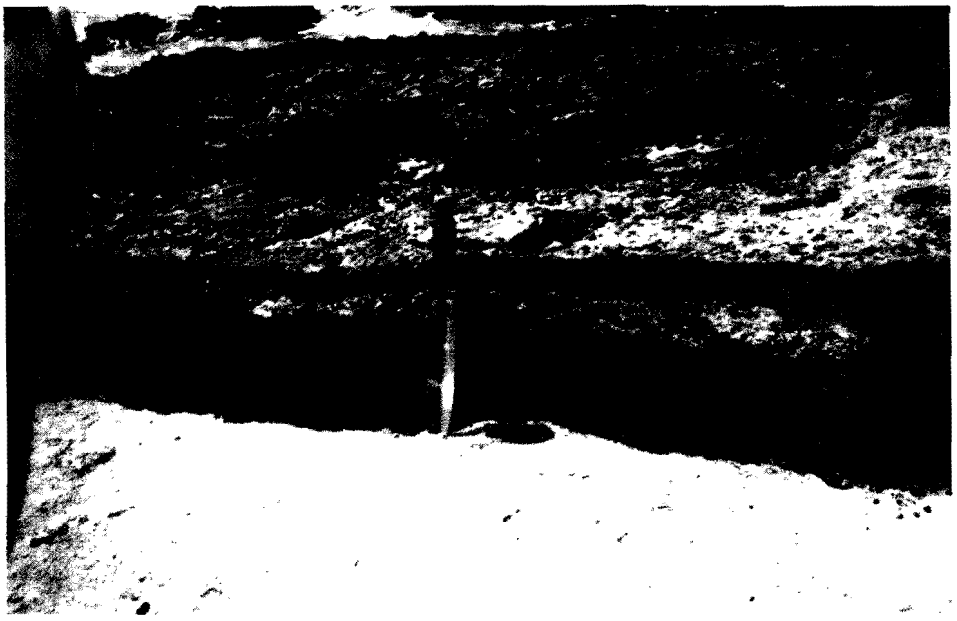

FIG. 3. Vertical variation in degree of cementation, grain-size, and sorting in supratidal beachrocks.

may be related to the Red Sea transgression (Behairy, 1983) or may indicate that their formation were in the intertidal zone and were later tectonically uplifted.

2 – Intertidal beachrocks

Few parts of the intertidal zone of south Jeddah area are paved with calcareous beachrocks. They are usually bounded towards the land by beach sediments, and towards the sea by subtidal muddy sand sediments, and are partially covered by Recent sands and mud.

These beachrocks form a hard, thick pavement that is essentially limited to the intertidal zone. The surface of beachrock generally dips gently seawards (Fig. 4). This general slope is being broken by small steep slopes formed by the landward edge of the beachrocks strata. Most of these beachrocks rest on base sand beach and Pre-Quaternary deposits (Jado and Zotl, 1984).

The beachrock is sporadically distributed, commonly outcropping over distances ranging between few and hundred of meters. In many instances the pavement disappears beneath a cover of loose sands. In some places, short stretches of beachrocks are clearly relics of former lengthy pavement that have been destroyed by erosion.

Beachrocks are well developed where the intertidal flat is paved with a sequence of flat-bedded beachrock having appearance of step-like terraces. The exposed thickness of these rocks is about 0.8 m and the individual layers range between 0.2 m and are characterized by flat tops and uneven bottoms.

FIG. 4. Eroded beachrocks by the action of waves.

Besides the typical step-like forms of the beachrock pavement, the surface is severally pitted and shows signs of abrasion by the action of waves that continuously wash back and forth across the surface (Fig. 5). This intensive pitting forms a highly characteristic jagged surface. The pavement is also destroyed as a result of its collapse caused by the removal of the underlying loose sand by the sapping action of the turbulent surf.

3 – Submerged beachrocks

Diving in the nearshore zone of the studied area revealed the presence of calcareous hard layers at various depths. They are mostly covered by a blanket of loose recent bottom sediments, but in some areas they are exposed. These submerged hard layers are generally porous, and are composed of a well-cemented mixture of shells, shell fragments, pellets and ooids.

Petrography of Beachrock

In general beachrocks in concern are composed of well-cemented framework grains vary in texture and composition. They show poorly sorted mixtures of gravely and sandy gravel to well-sorted grains. Results of x-ray diffraction analysis and petrography show that carbonate cement in the beachrock is mainly composed of aragonite of, high-Mg-calcite, and calcite. This indicates deposition in the marine phreatic zone (Longman, 1980) calcite (Fig. 6). These beachrocks show significant variation in the degree of cementation and therefore in their porosites.

FIG. 5. A photomicrograph showing quartzose beachrock.

On the basis of the composition of framework grains, the beachrocks of south Jeddah are grouped into two main types (1) quartzose beachrocks, and (2) conglomeratic beachrocks. Table 1 summarizes the textual and petrographical characteristics of the various lithotypes and Fig. (7) shows the distribution of these types along the coast.

1 – Quartzose Beachrocks

Quartz, feldspars, rock fragments and skeletal fragments, mainly of algal and molluscan fragments, are the main constituents of these rocks (Table 1). These constituents are cemented by micrite and/or aragonite. Quartz grains form more than 50% of the framework grains (Fig. 8). The grain-size distribution of the framework grains shows Uni-modal distribution falls in very coarse-grained size fraction (Fig. 9). The sand-size fractions mostly composed of quartz grains vary in roundness from well-rounded to angular.

The granule fraction is composed of quartz, rock fragments and feldspars. The quartz granules are commonly rounded, the feldspar granules are mostly plagioclase, and the rock fragments are represented by granules of basalt and granite.

2 – Conglomeratic Beachrocks

Conglomeratic beachrocks are mainly composed of gravel- and granule-sized grains cemented by calcareous mud matrix. Gravel grains form more than 50% of the framework grains (Fig. 10). The grain-size distribution of the framework grains show

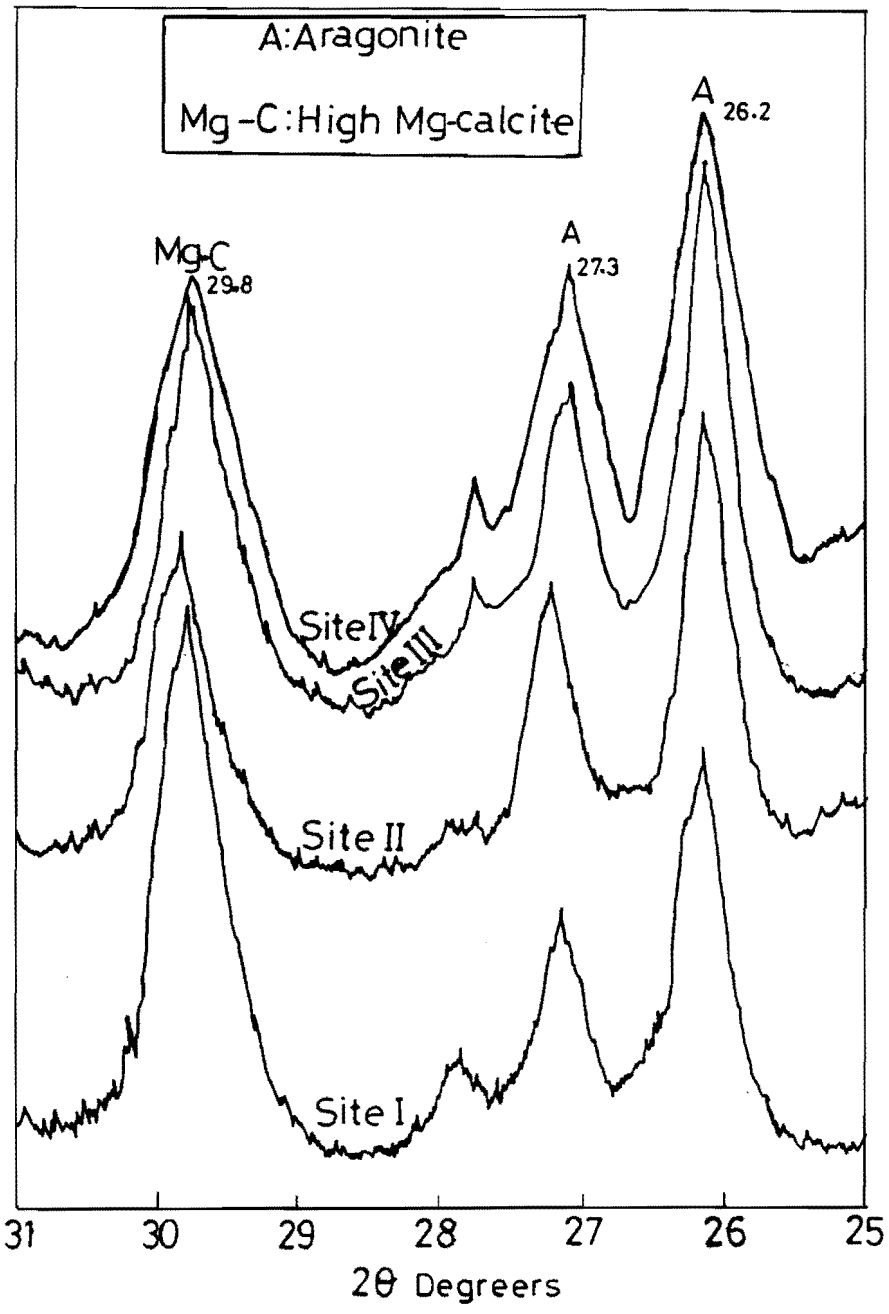

FIG. 6. X-ray diffraction patterns of the carbonate cement in the studied beach rocks.

TABLE. 1. Textural and compositional characteristics of various beachkrock.

Location	Sample no.	Texture		Composition %					
		Size-class	Sorting	Quartz	Rock fragments	Skeletal fragments	Feldspar	Cement	Beachrock type
Site I	1	Granule/sand	Poorly sorted	47	29	14	10	Micrite	Conglomeratic
"	2	Very coarse sand	Poorly sorted	63	12	9	16	Micrite	Quartzose
"	3	Coarse sand	Moderately sorted	71	7	5	17	Aragonite	Quartzose
"	4	Coarse sand	Moderately sorted	66	4	11	19	Aragonite	Quartzose
Site II	1	Gravely sand	Poorly sorted	52	33	9	6	Aragonite	Quartzose
Site III	1	Granule	Poorly sorted	52	37	–	11	Micrite	Quartzose
"	2	Very coarse sand	Moderately sorted	78	41	4	–	Aragonite	Quartzose
"	3	Granule	Moderately sorted	48	41	3	8	Aragonite	Quartzose
"	4	Medium sand	Well sorted	87	3	–	10	Aragonite	Quartzose
Site IV	1	Gravel	Poorly sorted	29	69	2	–	Micrite	Conglomeratic
"	2	Gravel	Poorly sorted	24	76	–	–	Micrite	Conglomeratic
"	3	Sandy gravel	Poorly sorted	31	68	–	1	Micrite	Conglomeratic
"	4	Gravely granule	Poorly sorted	26	66	5	3	Micrite	Conglomeratic

Bi-modal classes (Fig. 11). The gravel-size fraction shows a wide range of size and composition. The roundness of these grains varies from angular to well-rounded.

The granule- and sand-size fractions are similar in their character and composition to those of quartzose beachrocks.

Conclusions

Beachrock is found in the intertidal and supratidal zones along the Red Sea coast of Jeddah, Saudi Arabia. It occurs as beds or patches showing different degrees of hardness. The seaward dip of the beachrock is similar to that of the slop of the foreshore. Petrographically, these beachrocks were grouped into two main types: (1) quartzose beachrocks, and (2) conglomeratic beachrocks. Aragonite and Mg-calcite are the main carbonate cements in these beachrocks.

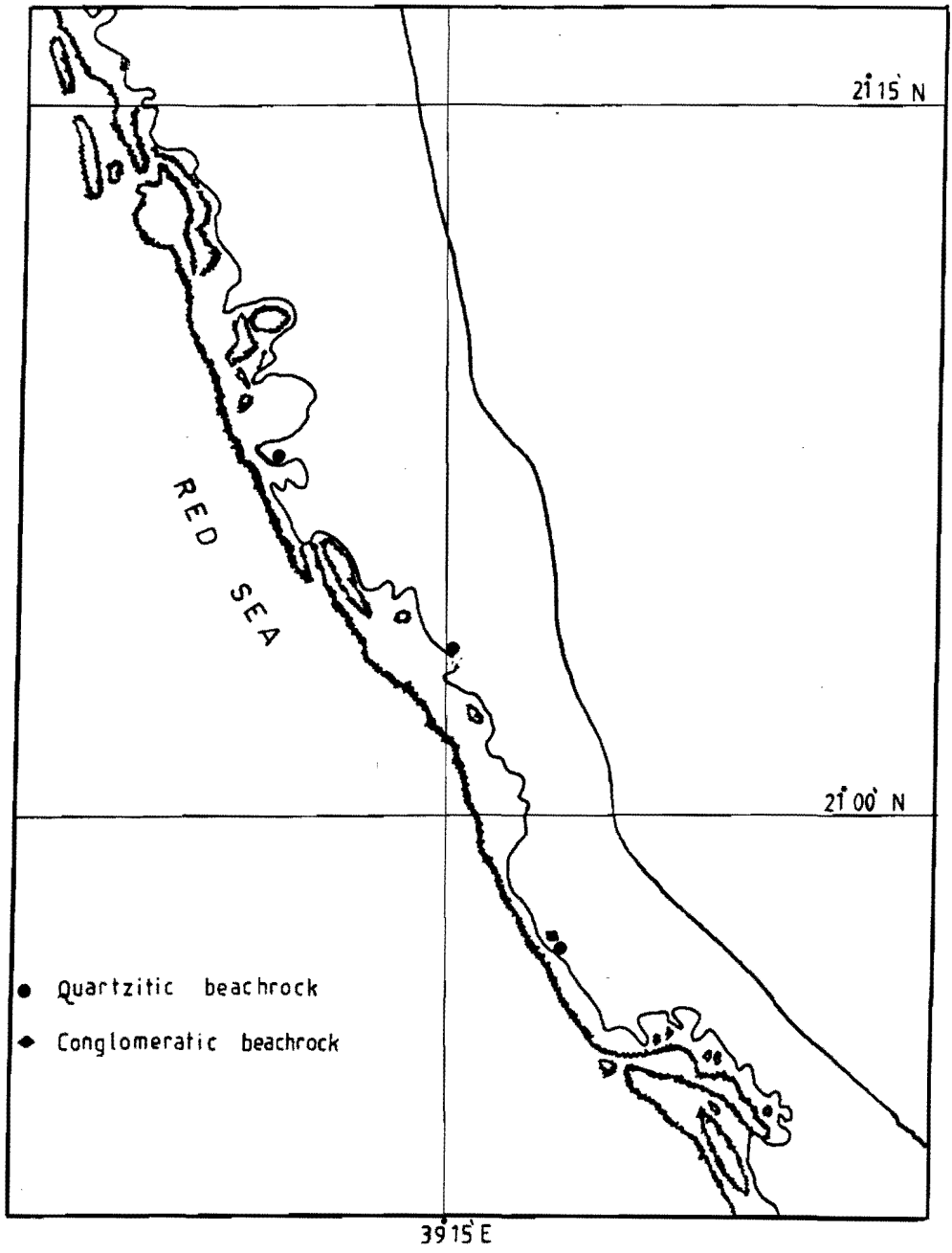

FIG. 7. Distribution of the various lithotypes of beachrocks along the coastal area of south Jeddah.

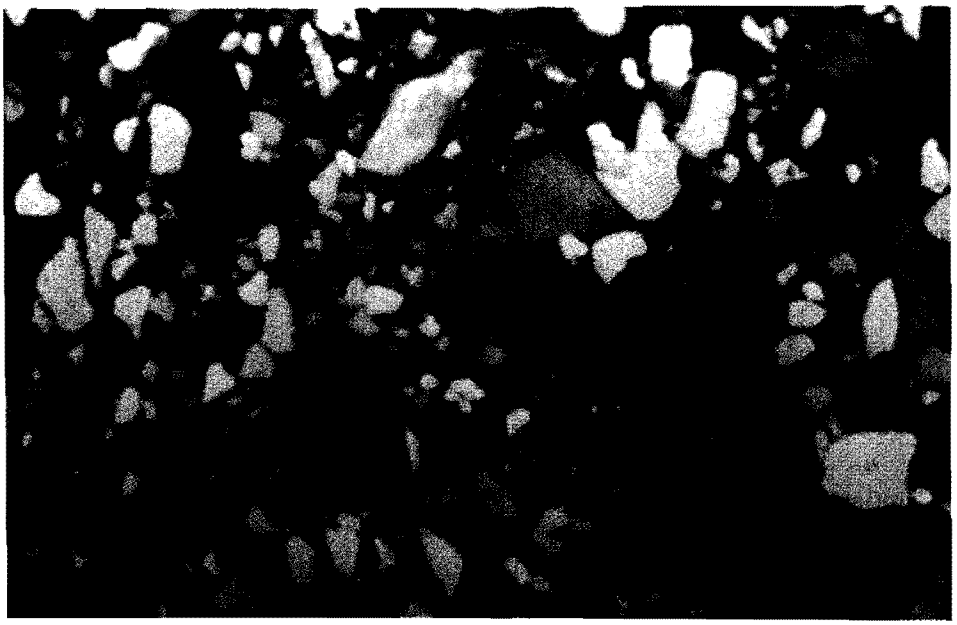

FIG. 8. A photomicrograph showing quartzose beachrock with moderately sorted quartz grains embedded in a micritic matrix from intertidal flat of Jeddah, Saudi Arabia, illustrating texture and composition of the framework grains.

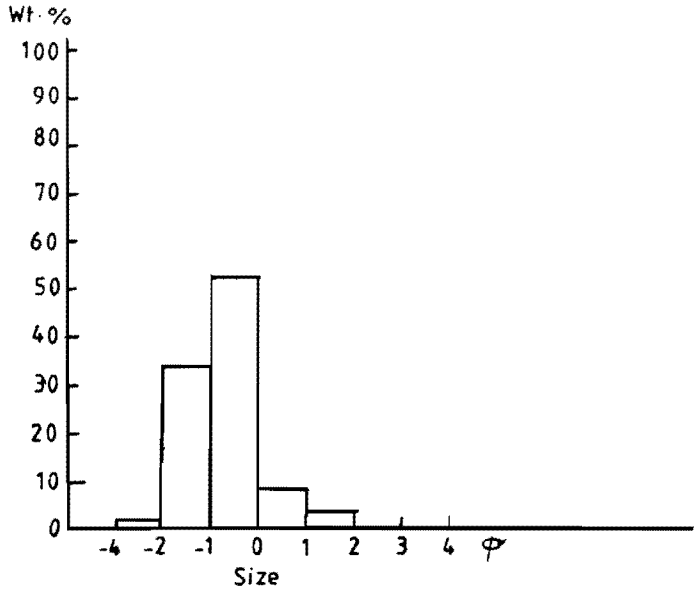

FIG. 9. Grain-size distributions of quartzose beachrocks.

FIG. 10. A photomicrograph showing conglomeratic beachrock.

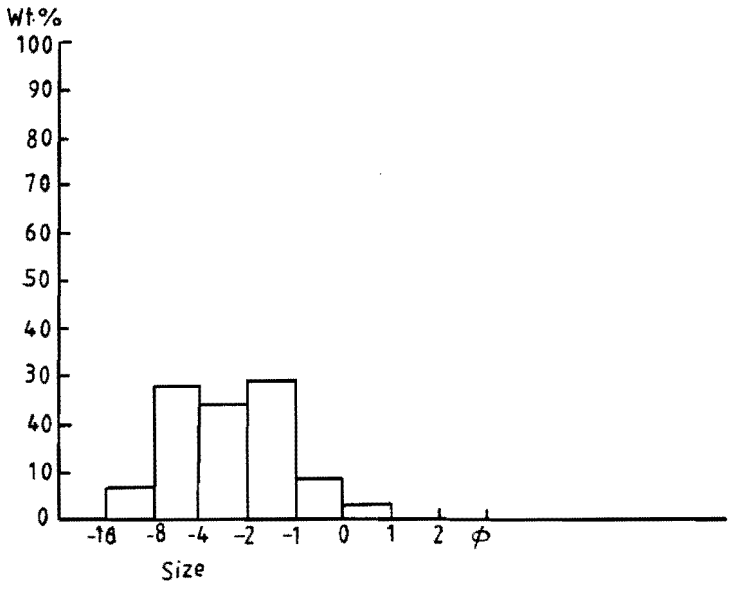

FIG. 11. Grain-size distributions of conglomeratic beachrocks.

References

Ahmed, F. and **Sultan, S.A.** (1993) Tidal and sea level changes at Jeddah, Red Sea, *Pakistan J. Marine Science,* **2**(2): 77-84.

Alexandersson, T.E. (1972) Mediterranean beachrock cementation: Marine precipitation of Mg-Calcite. In: **Stanely, D.J.** (Editor), *The Mediterranean Sea.* Dowden, Hutchincon and Ross, Stroudsburg, pp. 203-223.

Behairy, A.K. (1983) Marine transgressions in the west coast of Saudi Arabia between Mid-Pleistocene and present, *Mar. Geol.* **52:** 25-32.

Durgaprasada Roa, N.V.N. and **Behairy, A.K.A.** (1982) Erosion and Sedimentation: Vital Factors in the Jeddah coastal management. *J. Fac. Mar. Sci.*, V. 2, p. 25.

El-sayed, M.Kh. (1988) Beachrock cementation in Alexandria, Egypt. *Mar. Geol,* **80:** 29-35.

Emery, K.O. and **Cox, D.C.** (1956) Beachrock in the Hawaiian Island: *Pacific Sci.* **10:** 382-402.

Friedman, G.M. (1959) Identification of carbonate minerals by staining methods. *J. Sed. Petrol.*, **28:** 87-97.

Friedman, G.M. and **Gavish, E.** (1971) Mediterranean Sea and Red Sea (Gulf of Aqaba) beachrock. In: **O.W. Bricker** (Editor), *Carbonate Cement.* Johns Hopkins Uni., Studies in Geology, 19, pp. 13-16.

Ginsburg, R.N. (1953) Beachrock in South Florida. *J. Sed. Petrology,* **23:** 85-92.

Jado, A.R. and **Zotl, J.G.** (1984) *Quaternary Period in Saudi Arabia,* v. 2, Springer-Verlag, Berlin, pp. 409-422.

Kear, D. and **Browen, F.E.** (1970) Beachrock at Marble Bay, Northland, New Zealand, *New Zealand J. Geol. Geophys.*, **13:** 729-733.

Longman, N.W. (1980) Carbonate diagenetic textures from near surface diagenetic environments. *Amer. Assoc. Petr. Geol. Bull.*, **64**(4): 461-487.

Revelle, R. and **Fairbridge, R.W.** (1957) Carbonates and carbon dioxide. *Geol. Soc. America Mem.* **67**(1): 239-296.

Stefanon, A. (1969) First notes on the discovery of outcrops of beachrock in the Gulf of Venice (Italy). *Rapp. Comm. Int. Mer. Medit.*, **19:** 649.

صخـــر شـــاطئي في جنـــوب مدينـــة جـــدة ، الساحـــل السعـــودي للبحـــر الأحمـــر

عبد الحميد الشاطر و محمد أبو عوف
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المستخلص . لقـد درست الخصـائص الجيومورفولوجية والبتروجرافية للصخر الشاطئي لمنطقة جنوب جدة ، وقد أمكن التعرف على ثلاثة أنواع من هذا الصخر بناءً على مكان تواجده ونشأته ، وهي :

١ - صخر شاطئي في منطقة مافوق المد والجزر .
٢ - صخر شاطئي في منطقة المد والجزر .
٣ - صخر شاطئي في منطقة ماتحت المد والجزر .

ولقد دلت الدراسة أيضًا على أن هذه الصخور تتغير طبيعتها من مكان إلى آخر ، حيث وجد نوعين من هذه الصخور ، وطبقًا لمكونات حبيباتها هما :

١ - صخر شاطئي كوارتزي .
٢ - صخر شاطئي كونجلوميراتي .

أمـا المواد اللاصقة لهذه المكونات فوجد أنها في الغالب عبارة عن معادن الأراجونيت والكالسيت عالي الماغنسيوم .