

On the Occurrence of Raised Beach Sediments in the Hammam Faroun Area, Sinai, Egypt.

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ABSTRACT. This work describes the occurrence of typical beach sediments, elevated at about 30 m above sea level in the Hammam Faroun area of the Gulf of Suez. These sediments are mainly gravel and sand with a thin Oyster bank and coralline bioclasts. The gravel mostly discoidal in shape.

The sedimentology of the sediments is studied and a lowering of the sea level during the Quarternary Period is demonstrated.

The Gebel Hammam Faroun area (Plate I), lies on the eastern side of the Gulf of Suez (lat. 29° 11' N and long. 32° 58'E) with a maximum altitude of about 495 m above sea level. The stratigraphic sequence in the area ranges in age from Late Cretaceous to Recent (Moon and Sadek 1923).

The geomorphologic pattern of the study area is controlled by its geological structure, with faulted blocks of different magnitudes forming prominent cuesta-like scarps. The main drainage lines extend E-W and NW-SE, parallel to the major fault trends in the area (Said 1981).

Valleys between cuestas descend towards the Gulf of Suez. The eastern region is mountainous and receives a considerable amount of precipitation resulting in the formation of ephemeral streams. Maximum flow in the form of torrents occurs during the winter. Although, the amount of precipitation is relatively low, running water is the main geomorphologic agent in the inland part of the study area.

At Gebel Hammam Faroun, the coastal plain is narrow and bounded directly by vertical cliffs facing the Gulf of Suez (Plate II). The width of the beach in the area is very narrow and does not exceed 15 m. The valleys draining the eastern

mountaineous region exit here as hanging valleys. They are deep with acute V-shape cross section belonging to a youthful stage.

The relief of the area is relatively high so that wind action plays a minimum role in the study area. The only exception is the action of wind on the narrow coastal plain. Weathering and mass-wasting processes play an appreciable role in the configuration of the land forms in the study area.

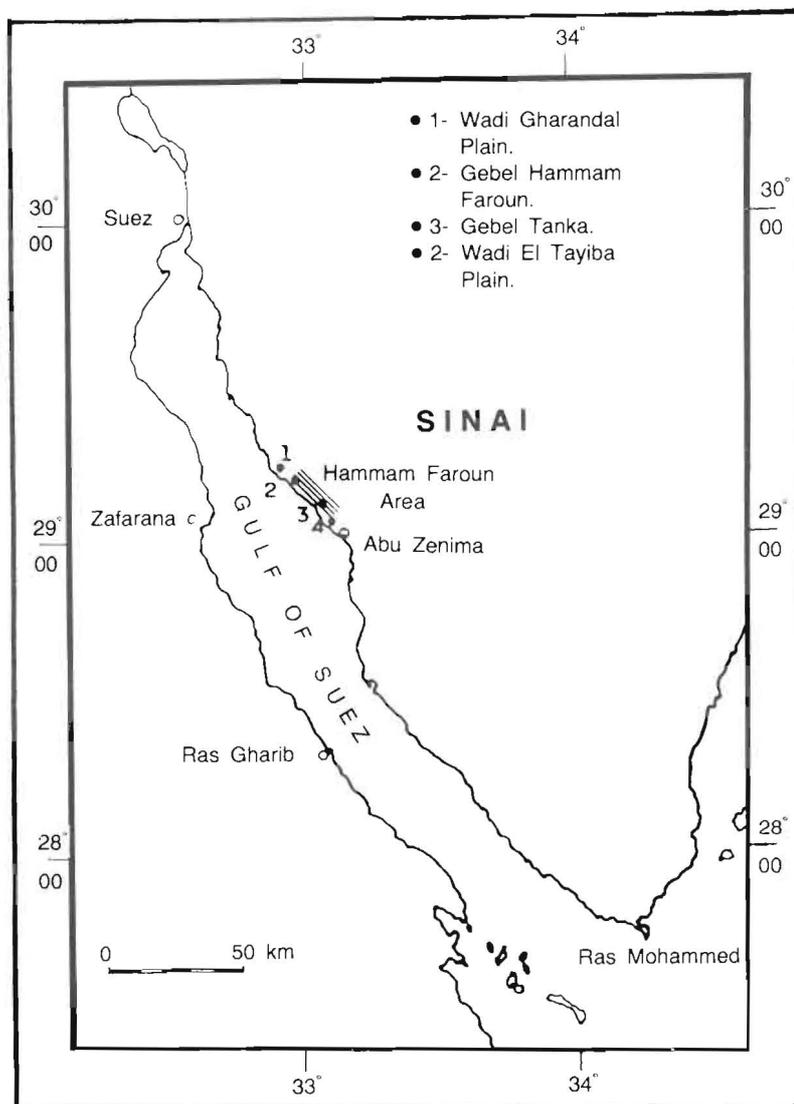


Plate I. Location Map of Hammam Faroun area.

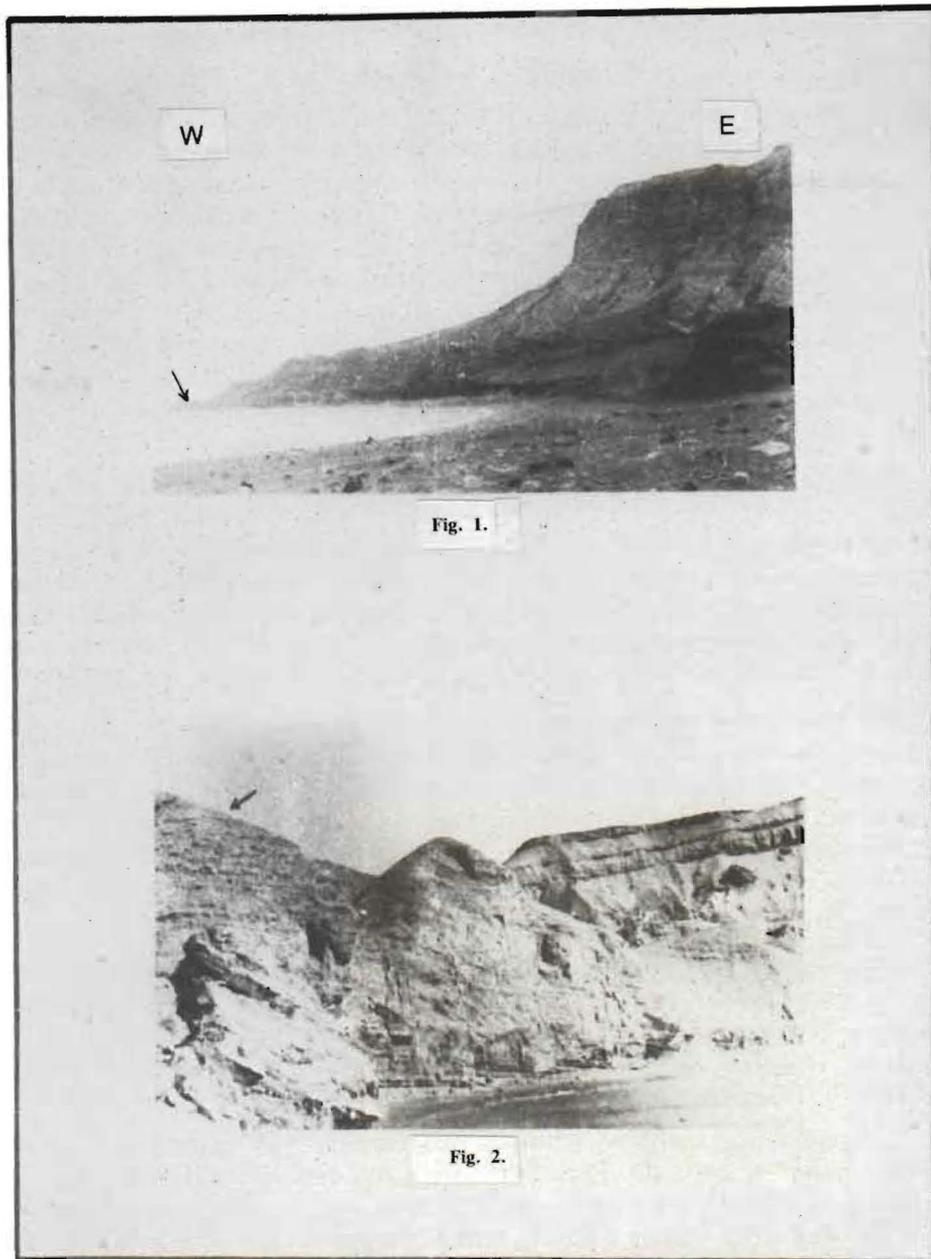


Plate II. Eocene cliffs and Cretaceous slopes border the beach at Hammam Faroun area. Arrow indicates the site of the raised beach sequence, which is unconformably overlying the Cretaceous.

Lithostratigraphy and Sedimentology

A section of raised beach deposits is recorded, overlying unconformably Upper Cretaceous limestone, Eocene limestone and dolomite and post-Eocene basalts. The present height of these beach sediments was measured, using a plane table and stadia, as about 30 m above sea level. Elsewhere, to the south of the study area (Gebel Tanka), other beach sediments occur at higher levels up to 60 m above sea level. The higher beach sediments are of Pleistocene age (Ball 1939). Several raised beaches can be traced towards the north and south of Hammam Faroun area, at Wadi Gharandal and Wadi El Tayiba, respectively. The variation in altitude may reflect a difference in the magnitude of tectonic uplifts during different phases in the Quaternary, since the Sinai subplate was subjected to different phases of tectonic uplift during the Late Pliocene - Late Holocene time (Neev and Friedman 1978).

Stratigraphically, the Pleistocene beach sediments occur in the area as a blanket of gravels, sands and skeletal organic remains (coralline and molluscan debris) on the exposed surface of the cliff forming outcrops, where the recent overburden has been eroded (Plate III). They are missing along the channel courses due to erosion. On the other hand, a complete sequence is exposed on the coastal road between Hammam Faroun spring and Abu Zeneima where the younger recent sediments are still present protecting it from erosion (Plate IV).

The thickness of this sequence varies from a few centimeters (Plate III, Figs. 1 and 2) to more than 1.5 m in the section described here (Plate IV). This section lies unconformably above the Upper Cretaceous limestone (Plate II). It consists of three gravel layers capped by a thick weakly consolidated sand layer (Plate IV, Fig. 1). The second gravel layer (Plate IV, Fig. 2) is associated with a thin continuous Oyster bank of about 5 cm thickness containing remains of many typical shallow marine organisms (Plate IV, Fig. 3 and Plate V, Fig. 1).

The coarse gravels are composed of Nummulitic limestone and dolomite of Eocene and Late Cretaceous ages. A few basalt pebbles and cobbles were detected. The frequency of basalt pebbles increases with the decrease in grain size (Plate VI, Figs. 1-3). In general, the degree of roundness of the beach sediments is much better than that of the alluvial sediments in the area Bluck 1967.

Granulometric analysis of the gravel fraction was carried out on the representative samples (10 kg) collected from the three gravel layers. Also, the sand fraction and a representative sample of bed no. 4, were mechanically analysed by dry sieving method using a Ro Tap shaker and a set of sieves with 1 Phi interval scale. The results are given in Table 1 and are illustrated graphically in Plate V. The histogram of the top sand bed (no. 4) is unimodal, fine skewed with a modal class in the coarse sand size. The second modal class of the histograms of beds 1-3, coincides with the main modal class of bed no. 4. The modal class of layer no. 1 lies

between -4ϕ and -6ϕ while in layers 2 and 3 it lies between -3ϕ and -5ϕ . This indicates that the gravels of the basal layer are coarser than that of the above two layers. According to the terminology of gravels proposed by Folk (1968), the studied beach gravels consist of sandy pebble gravels with minor amount of cobbles (Plate V, Figs. 1 and 2). The roundness of grains decreases with the decrease in size (Plate VI).

Table 1. Mechanical analysis results of the studied raised beach sediments.

	Sample No.		1	2	3	4
	Size					
	mm	ϕ units	%	%	%	%
GRAVEL	32	- 5	25	5	14	—
	16	- 4	25	28	40	—
	8	- 3	13	23	29	—
	4	- 2	10	10	5	—
	2	- 1	3.8	5.4	0.25	—
SAND	1	0	5.9	6.1	2.1	1.2
	1/2	1	11.9	11.1	3.0	65.7
	1/4	2	3.4	3.9	1.8	28.1
	1/8	3	0.8	3.6	1.4	3.2
	1/16	4	0.4	2.1	0.3	1.9
Silt & Clay	1/32	5	0.5	2.3	1.5	0.7
Total %			99.7	100.5	98.35	100.8

In order to determine the shape of the gravel, the length (a), breadth (b) and thickness (c) of 319 representative pebbles were measured. A plot of the ratios b/a and c/b , according to Zingg (1935), is shown on Plate VII. The distribution of the pebbles for each grain size among the Zingg shape classes is presented as histograms (Plate VII). The results of the shape analysis indicate that the oblate (disc) pebble is the dominant shape in the study sediments and its frequency reaches (61 %) for the coarsest pebbles and cobbles, while it decreases to (34 %) in the finer pebble size (Plate VII). On the other hand, the bladed pebbles show an increase in frequency with the decrease of size, varying from 14% for the coarsest pebble and cobbles to 34% in the finer pebble and granule sizes.

These sediments were derived originally from the mountainous region to the east as alluvial material. Therefore, the fluvial nature is still clear in the granule

and fine pebble grades which show less flattened shape. After deposition in the beach environments, waves and currents affected to a great extent the elongate shape of the grains, transforming them into oblate (disc-shaped) and bladed shapes. Pettijohn (1975) stated that the shapes of pebbles are believed to be largely determined by the original shape of the fragment. However, Dobkins and Folk (1970) found that beach pebbles tend to have higher roundness and lower sphericity and to be distinctly oblate in contrast to the gravels of rivers carrying material of the same composition.

The beach sediments show a spatial size variation with finer grain sizes nearer to the sea and coarser and less rounded grains towards the land (Plate III, Fig. 1).

Different surface features are common on the studied beach gravels. The dominant features on the limestone gravels are: smoothing, polishing, dissolution, burrowings, borings and pitting (Plates VI and VIII). The biogenous features are more common on the coarser grains.

A comparison between the roundness, shape and surface features of the studied sediments, and of the present day beach sediments of the recent shoreline, shows an excellent similarity (Plate VIII, Figs. 1-3).

The granule fraction is characterized by a higher percentage (about 20%) of basalt grains (Plate VI, Fig. 3). Elongate grains are more common in this fraction than in the coarser pebble fraction, probably due to the columnar jointing in the original basalt mass at Hammam Faroun area (Plate III, Fig. 2). The lower abundance of basalt clasts in the coarser pebble and cobble fraction, the bedded nature of the source limestone rocks and the wave action on the beach resulted in the predominance of the disc-shaped grains in this size class. The basalt grains are more angular than the limestone grains of the same size. This indicates that the physico-chemical action of the sea water is more effective on carbonate grains than on the basaltic gravels.

Biostratigraphic Characteristics

The beach sediments are rich in fossils. A thin continuous band (about 10 cm), in the form of Oyster bank, marks the top of the second gravel layer. Patchy colonial coral reefs are commonly distributed (Plate IV, Fig. 3); they are associated with *Anadara antiquata*, *Dosinia (D) radiata*, *Periglypta reticulata*, *Ostrea cucullata*, *Tridacna* sp., *Cyprea nebrites*, *Conus* sp., *Cerithium (C.) nodulosum*, *Cymatium* sp., *Nerita albicilla*. The pelecypod and gastropod fossils occur in the coarse gravel layers, while the coralline colonies and debris occur in the finer sediments. All the above mentioned species are characteristic fossils of Pliocene-Quaternary age (Plates IX and X). Similar raised beaches along the Red Sea and Gulf of Suez were dated as Pleistocene in age by Ball (1939) and El Shazly (1982). Ball (1939) recorded two series of coral reefs in southern Sinai, the lower one at altitude 25 m and a higher one at levels up to 200 m above sea level. He assigned

Pleistocene age to the lower series (less than 100 m) while those higher 100 m are of Pliocene and Miocene ages. Therefore, the study raised beach sediments could be assigned a Pleistocene age.

Discussion and Conclusion

1. Ancient raised beaches are recorded in the Gebel Hammam Faroun area, at elevations between 30 and 60 m above sea level. The sediments are characterized by a predominance of discoidal gravels and fossils typical of a beach environment.
2. The granulometric analysis results for the sand layer (no. 4) are similar to that of the sand fraction of the gravel layers. This denotes that the origin of the sands in the lower levels similar to that of layer no. 4.
3. The dominance of the coarse gravels (-5ϕ) in the lowermost layer may indicate a high energy transportation during the earlier stage of sedimentation.
4. The largest pebbles of the study sediments are flatter than the smaller ones. According to Dobkins and Folk (1970), this indicates that the beach was gravelly and of high wave energy.
5. The sequence indicates that the sea level was higher during the Quaternary Period. This is clear from the presence of coral reefs as well as the Oyster bank in addition to the associated well preserved fossil assemblages at a high elevation above the modern sea level.
6. The biostratigraphic study of these sediments clearly indicates that the sequence was deposited under tectonically active conditions. According to Nelson *et al.* (1962) reefs are generally built up of wave resistant organisms and are associated with tectonically active substrate and/or belts. The restricted distribution of the colonial coralline debris and reefs on the Hammam Faroun - Gebel Tanka cliffs and the absence of the reefs on Wadi Gharandal plain northwards and Wadi El Tayiba at the south, confirm the tectonic activity of the Gebel Hammam Faroun - Gebel Tanka block during the Quaternary. It is worth mentioning that the activity of the blocks within the Sinai sub-plate was differed in magnitude during the Quaternary (Neev and Friedman 1978).
7. The absence of such raised beach sediments on the western side of the Gulf of Suez, may denote that the Sinai sub-plate was independently and tectonically active during the Quaternary time. This is confirmed by the greater development of the basaltic dykes and sills on the eastern side of the Gulf of Suez, than on the western side.
8. To elucidate the Quaternary tectonics of the Gulf of Suez, it is necessary to study the regional extension of these raised beach sediments along the whole eastern side of the Gulf of Suez, accompanied by age dating by C^{14} to determine the exact duration of this movement.

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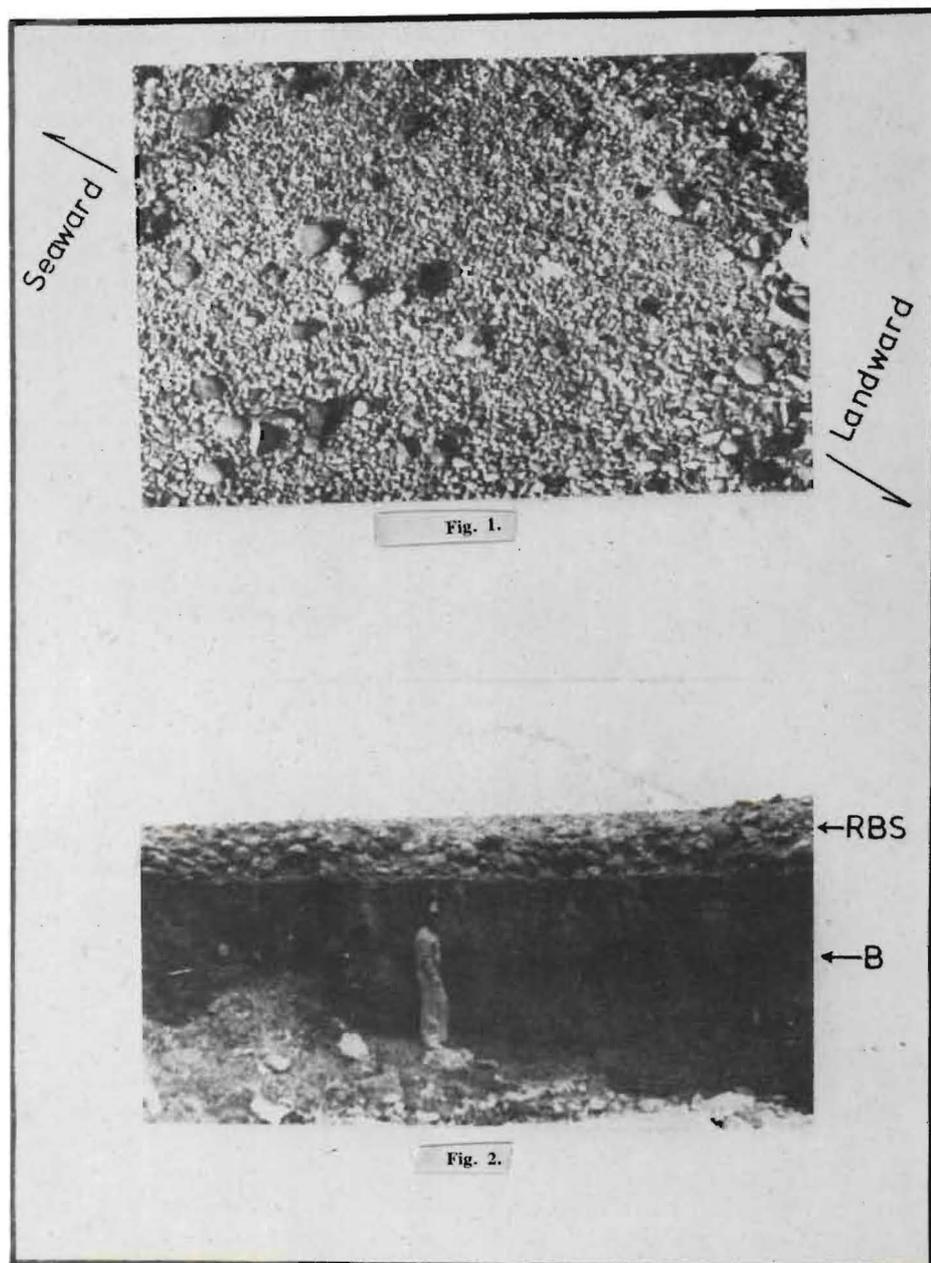


Plate III. Fig. 1. Plan view of the raised beach sediments showing discoidal cobbles and pebbles in the form of blanket overlying basalt. Coarser grains are scattered landwards.

Fig. 2. Lateral view of the above mentioned sediments. (B) basalt and (RBS) raised beach sediments.

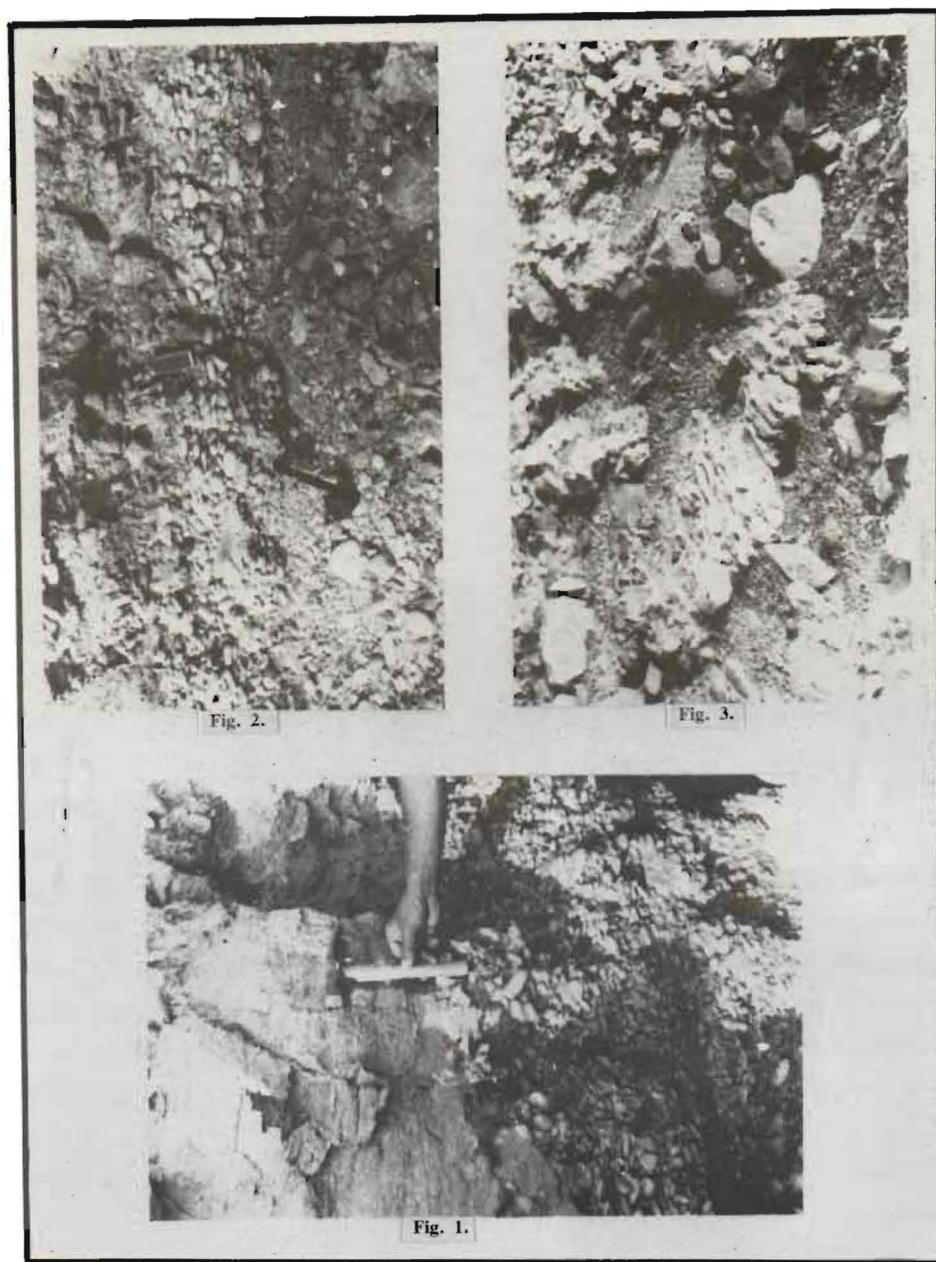


Plate IV. Fig. 1. Typical raised beach sediments at Gebel Hammam Faroun area.

Fig. 2. Close up of Fig. 1, showing imbricate structure of gravels.

Fig. 3. Colonial coral debris and bioclasts embedded within the raised beach sediments.

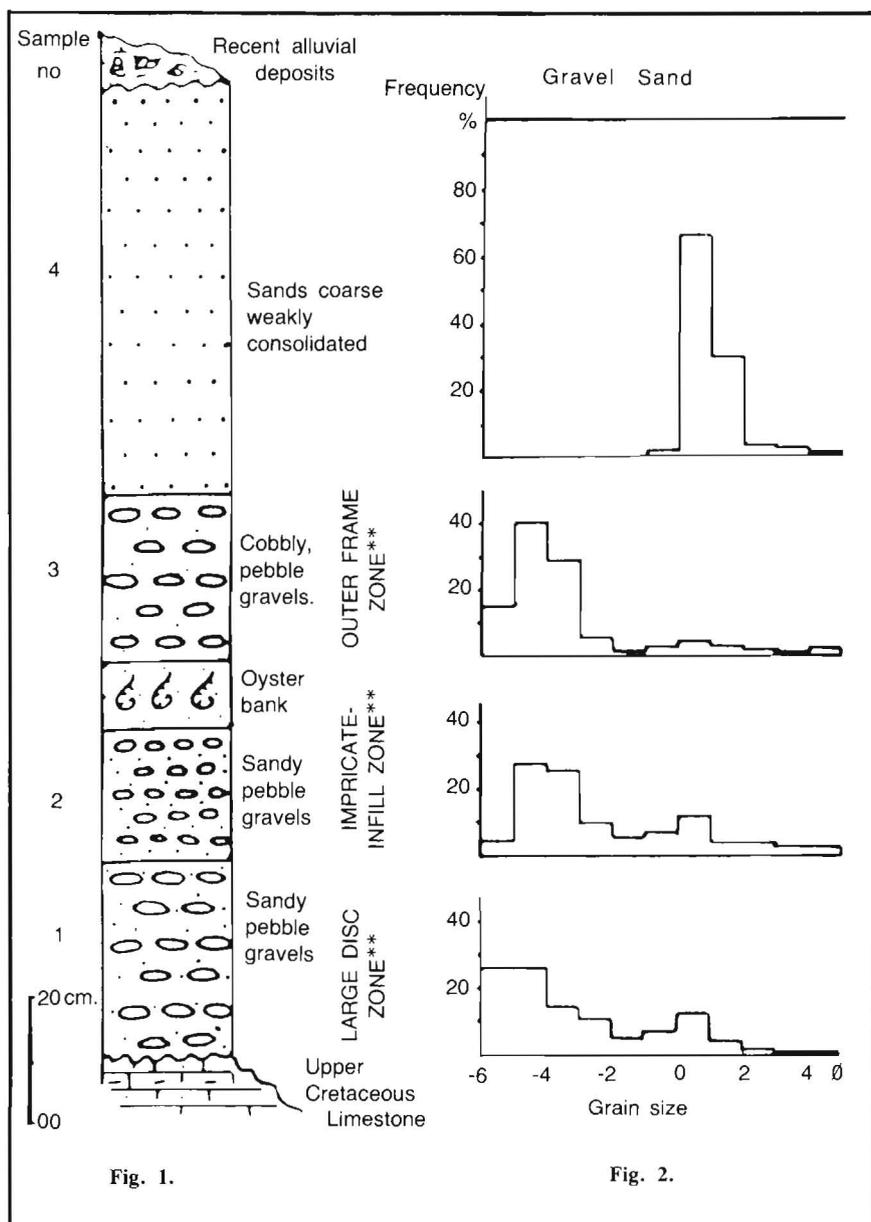


Plate V. Fig. 1. Lithologic log of the measured section.

Fig. 2. Histograms show the grain size distribution of the four terrigenous layers of Fig. 1.

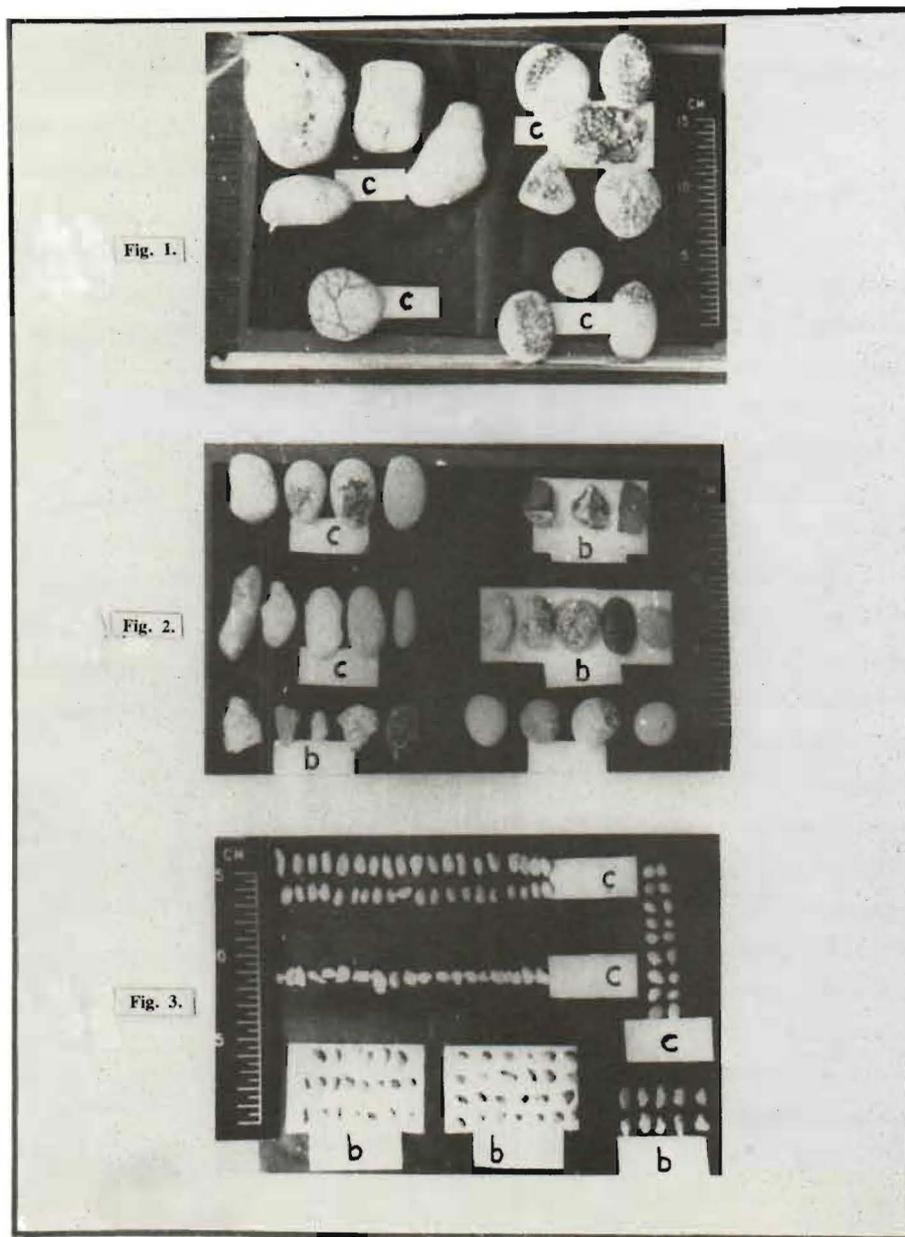


Plate VI. Illustrates the following:

- 1) Decrease in the gravel size is associated with an increase in elongation (Figs. 1-3).
- 2) Basalt gravel grains dominate more in the fine size (Fig. 3) than in the coarse size (Fig. 1).
- 3) Carbonate gravel grains (C) are more rounded than basalt ones (b) of the same size (Fig. 2).

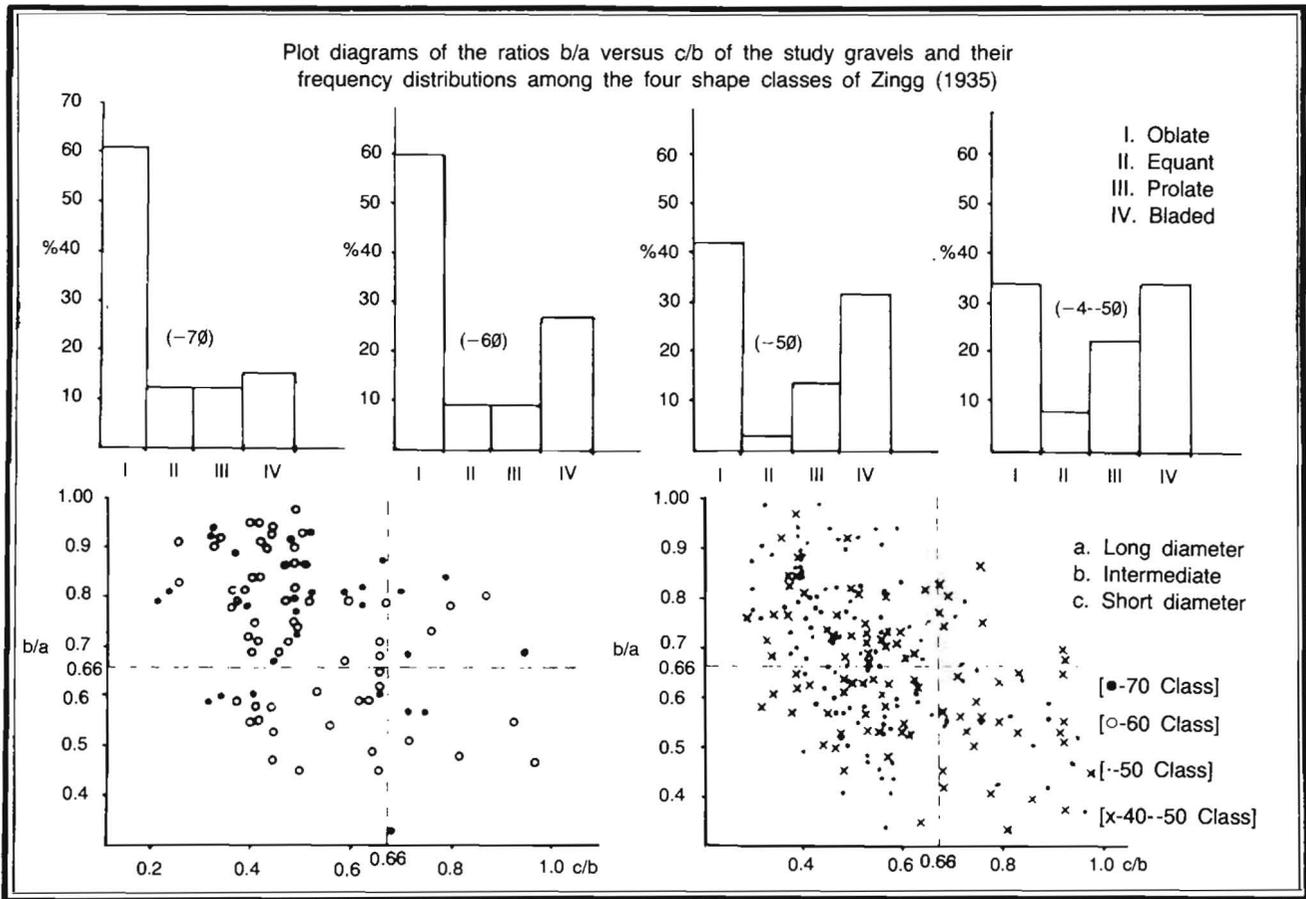


Plate VII. Plot diagrams of the ratios b/a versus c/b of the study gravels and their frequency distributions among the four shape classes of Zingg (1935).

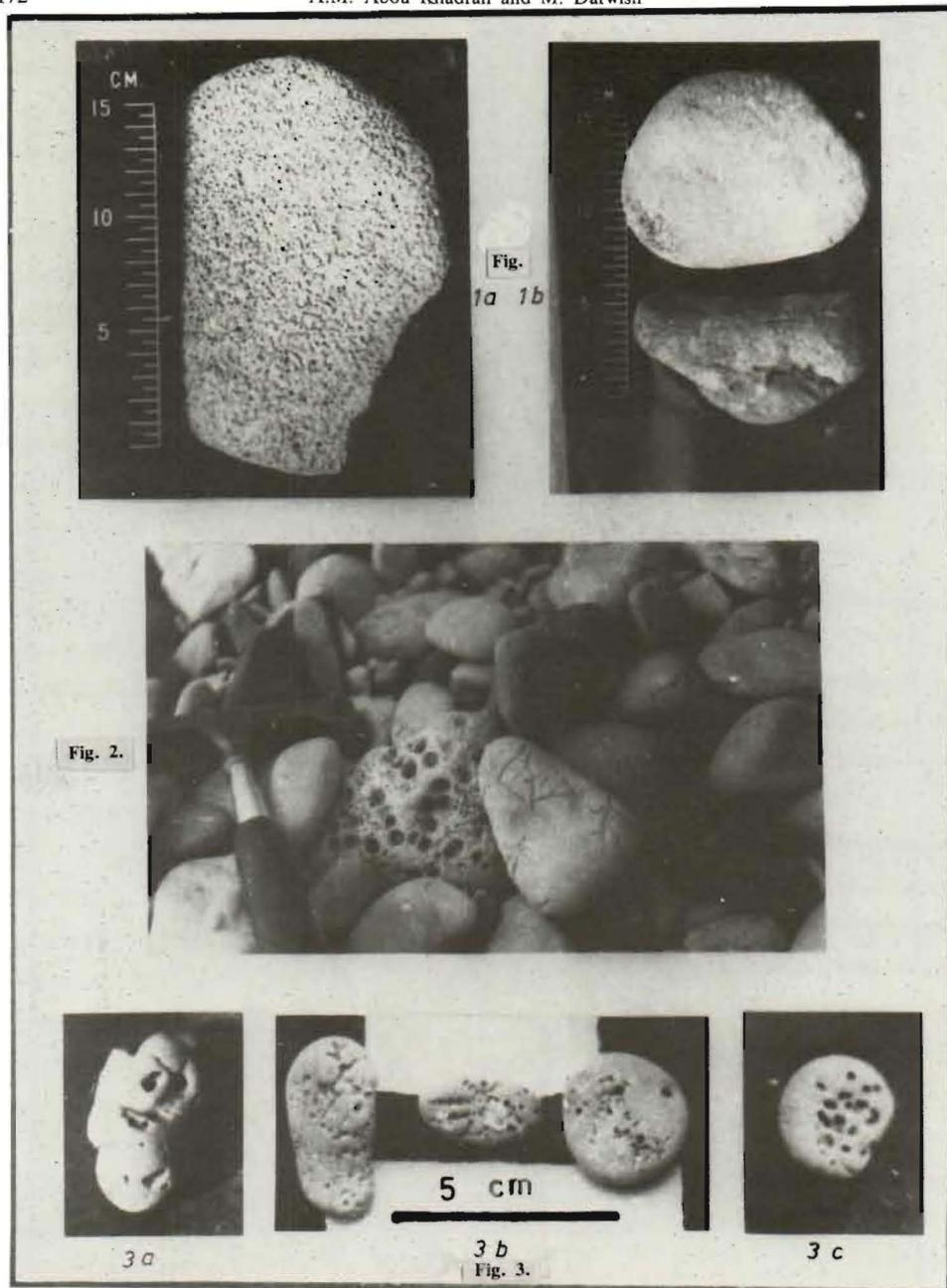
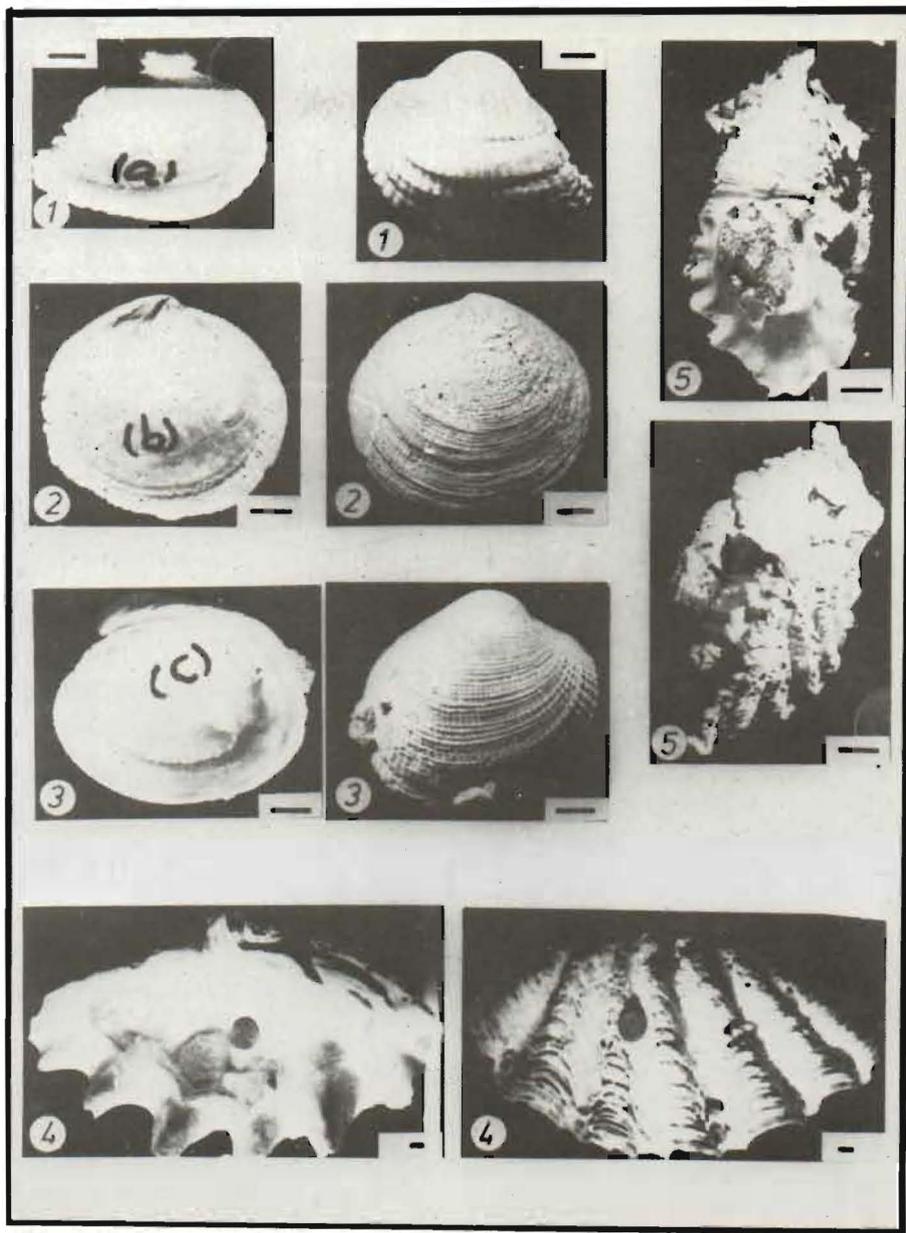


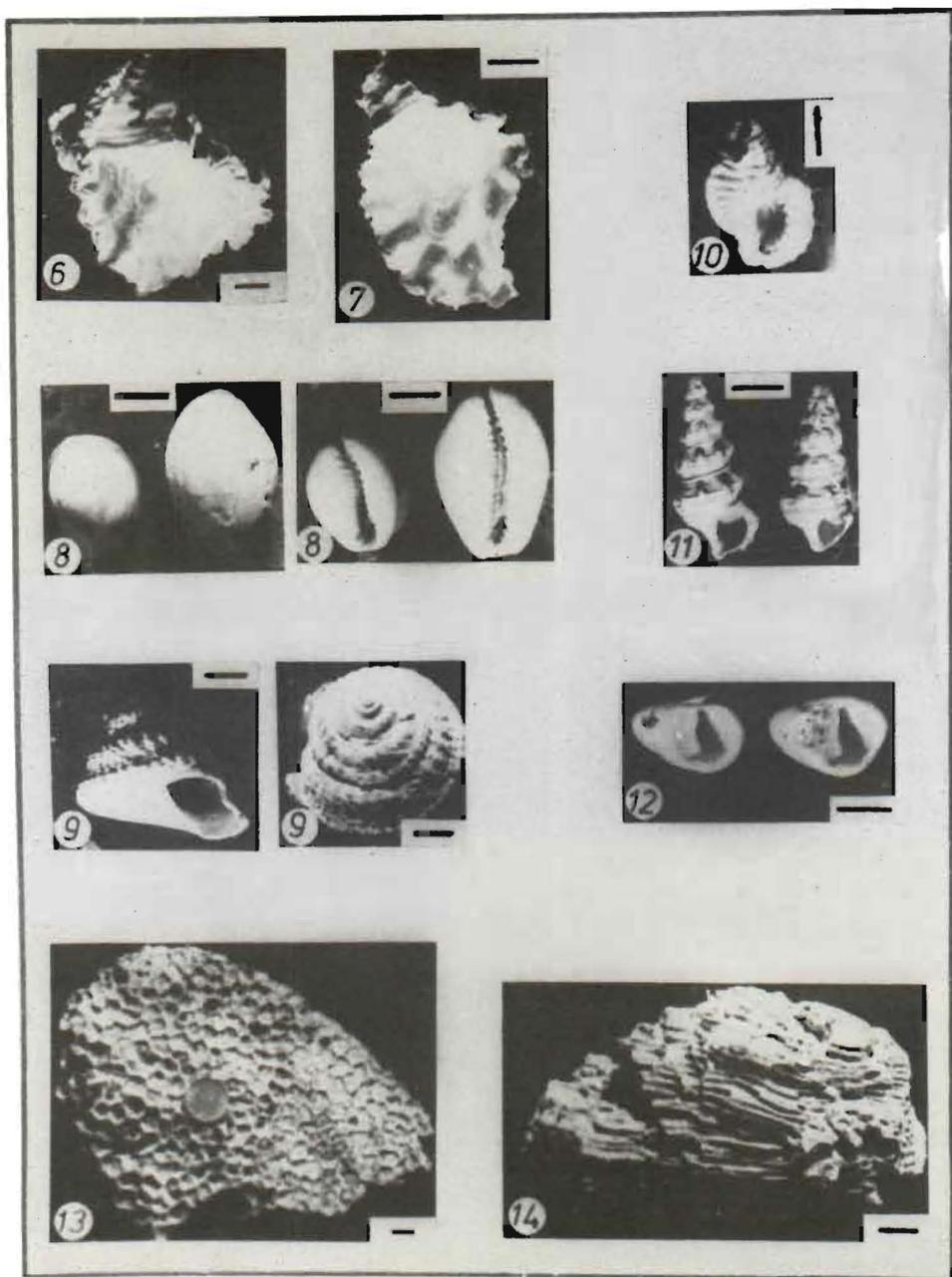
Plate VIII. Shows the characteristic surface features of the study gravel: **Fig. 1a**, Pitted grains and **Fig. 1b**, polished grains.

Fig. 2-b. Origins and burrowings on the surface of modern beach gravel being similar to that of the raised beach sequence in the study area (**Fig. 3**).



Plates IX and X. Collected fossils:

- | | |
|---------------------------------|--|
| 1) <i>Anadara antiquata</i> | 8) <i>Cypraea nebrites</i> |
| 2) <i>Dosinia (D.) radiata</i> | 9) <i>Trochus</i> sp. |
| 3) <i>Periglypta reticulata</i> | 10) <i>Cymatium</i> sp. |
| 4) <i>Tridacna</i> sp. | 11) <i>Cerithium (C.) nodulosum</i> |
| 5-7) <i>Ostrea cucullata</i> | 12) <i>Nerita albicilla</i> |
| | 13 and 14) Coralline colonial fragments. |



عن تواجد رواسب شاطئية مرتفعة بمنطقة حمام فرعون - سيناء - مصر

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تتناول الدراسة تواجد رواسب شاطئية مثالية بمنطقة حمام فرعون بسيناء على ارتفاع ٣٠ متراً من مستوى سطح البحر الحالي بخليج السويس .

وتتكون الرواسب من الحصى والرمل وطبقة رقيقة من المحاريات والفتات المرجاني ويغلب الشكل المفلطح على الأحجام الحصوية .

وقام الباحثان بدراسة المعاملات الحجمية والشكلية للرواسب ومناقشة انخفاض مستوى سطح البحر خلال الحقب الرابع .