Bull. Inst. Oceanogr. & Fish., ARE, 13 (2), 1987: 147 - 167.

GRAIN SIZE ANALYSIS, AREAL DISTRIBUTION OF SEDIMENTS AND ENVIRONMENT OF DEPOSITION OF TIDAL AND BOTTOM SEDIMENT FROM GHARDAQA REGION, RED SEA AREA.

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ABSTRACT

The texture characteristics of recent sediments in the Ghardaqa region of the Red Sea shelf are investigated and compared with similar characteristics of Recent tidal and beach island sediments in the same region. On going from the beach (tidal and island sediments) towards the sea (shelf sediments), the mean size generally decreases and the sediment type changes from coarse sand to muddy sand and sandy mud. The sorting generally worsend, the skewness values generally decreased, i.e. changed from coarsly skewed to very finely skewed. Kurtosis values did not show any general trend of variation. The areal distribution of sand, silt and clay fraction indicates that, on going from land towards the sea, the sand fraction decreased, silt fraction and clay fraction generally increased. This probably due either to longshore currents (waves and winds) or to longer transportation factors depending on the conditions of the continental slope, i.e. topographic factors of the sea bottom. Furthermore, distribution map of each fraction is drawn.

The discriminant function of Sahu (1964) for environmental interpretation have been used.

INTRODUCTION

The distribution of particle size in sediments is a function of the availability of different sizes of particles in the parent material and the processes operating where the particles were deposited, (Folk and Sanders, 1978).

The shelf and the beach sediments of Ghardaqa region have been selected to be studied in order to shed some light on the physical properties, areal distribution of sediments and the depositional environment.

This study also aims at exploring: (1) the composition of statistical parameters of size distribution, and (2) the interpretation of data on particle size distribution for inferring the environments of deposition.

The statistical treatments applied are mainly the methods introduced by Folk and Wards (1957) in an attempt to deduce the depositional environment of each sample.

The area of study extends from latitude 21° 05'N to 28 00' N, between Magawish Island to Gebel El-Zeit and lies between the Ghardaqa shore and a line joining Shadwan and Gafton Islands at about 34°E, (Fig. 1).

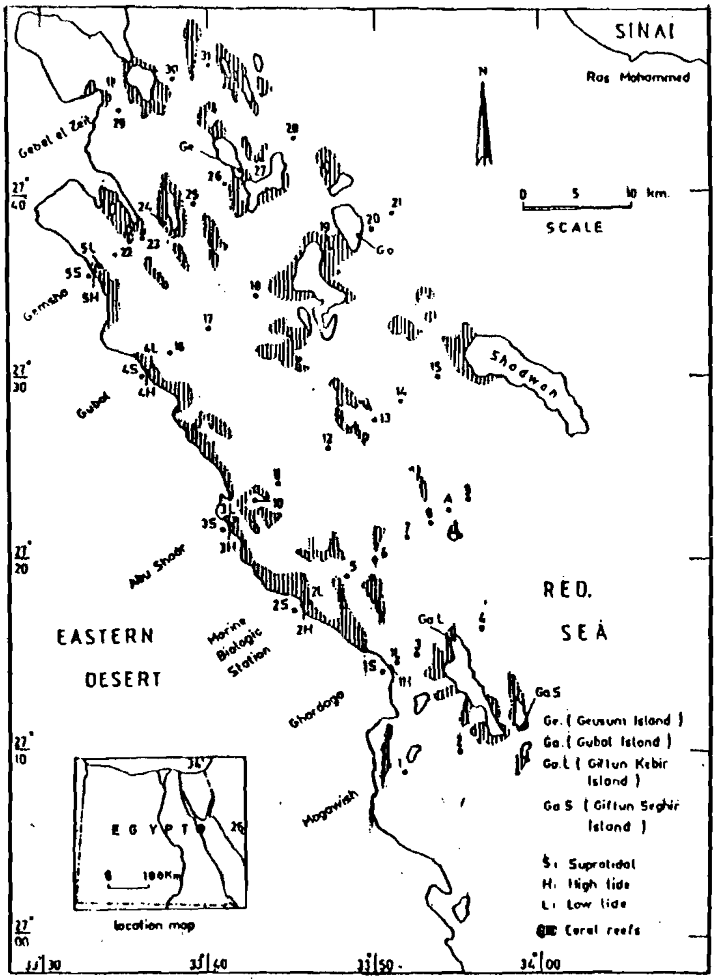

Fig. (1)
Map showing location of sampling stations of the s.
area between Magawish and Gebel el Zeit.

MATERIALS AND METHODS

Sediments samples were collected during the period from December 1982 to January 1983 on board of the boat of the Ghardaqa Marine Biological Station. The bottom sediments were sampled using a Peterson grab sampler.

Thirty two samples were chosen to cover the shelf zone and were taken by the grab sampler. Four samples were chosen to cover islands (Gafton El-Kebir, Gafton El-Saghir, Gubal and Geusum); these were collected by hand from the supratidal sediment of the islands. Eigteen samples were chosen to represent the supratidal and interidal sediments (these also were collected by hand). Figure (1) is a map showing the sampled localities, and figure (2) shows the bottom topography of the sampled traverses.

The sediment samples were subjected to mechanical analysis according to the method described by Folk (1968). Samples containing more than 95% of fractions coarser than 4 phi were subjected to dry sieving, while those containing more than 5% of fractions finer than 4 phi (0.063 mm) were subjected to dry sieving and gravity sedimentation according to the method described by Jackson (1956). The clastic sediment textural nomenclature has been employed using a triangle after Folk (1968).

RESULTS

The data obtained from the mechanical analysis were graphically presented in the form of histogram and caumulative curves (Figs. 3 and 4).

From the cumulative curves, various statistical parameters were obtained (Tables 1,2 and 3) to characterize the studied samples and to use them for inferrence regarding their depositional environments (Stewart, 1985).

Mean Size Distribution

As given in Table (1), the mean size of the sediments ranges between 0.60 to 2.90 phi with an average of 1.75 phi (i.e. medium sand fraction). The mean size of the sediments sampled from the supratidal zone has an average of 1.12 phi while the average mean size of the sediments from the high tide zone is 1.88 phi and the average mean size of the sediments from the tide zone is 1.93 phi. Generally, most of the samples from the tidal zone belong to the medium sand fraction, and the sediments from the low tide zone exhibit particle sizes finer than those from the supratidal zone, due to mechanical sorting of sediments by sea and tidal currents.

As given in table 2, the mean size of the sediments sampled from islands (El-Gafton, Gubal and Geusum) ranges between 0.90 to 0.57 with an average of 0.17 phi. Generally most sediments of the above mentioned islands are coarse to very coarse sand grains due to the influence of the different rock types that are found on the coasts of the islands.

As given in table 3, the mean size of the shelf sediments ranges between 0.75 to 5.27 phi with an average of 3.01 phi. Generally, the particle sizes of the shelf sediments in the study area change from coarse sand near the beach to fine muddy sand with increasing distance from the beach towards the deeper sea.

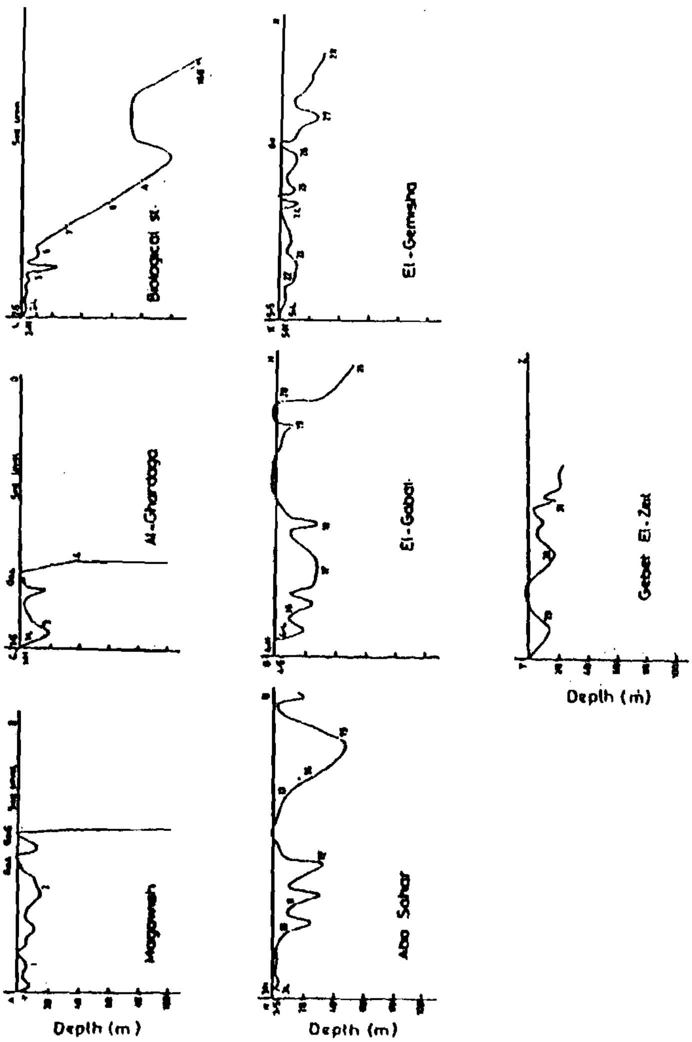

Fig. (2)
Topographic profile of the sampled traverses in the Ghardaga - Gebel el Ziet area.

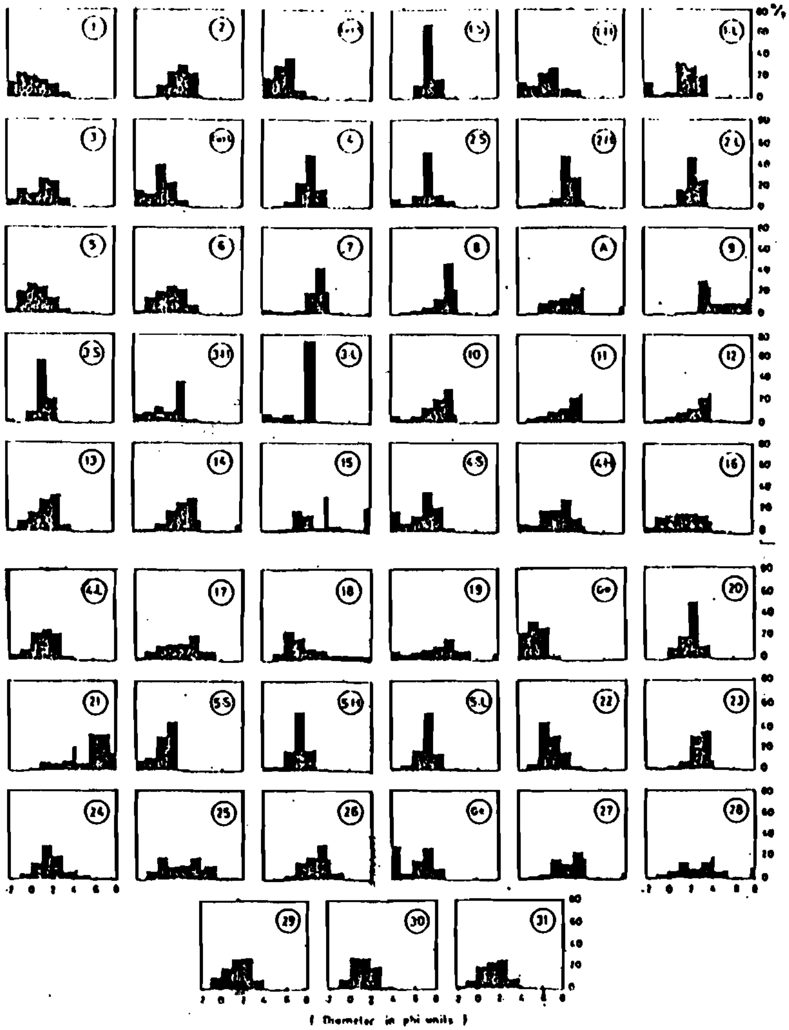

Fig. (3)
Histograms showing the size distribution in the studied samlpes.

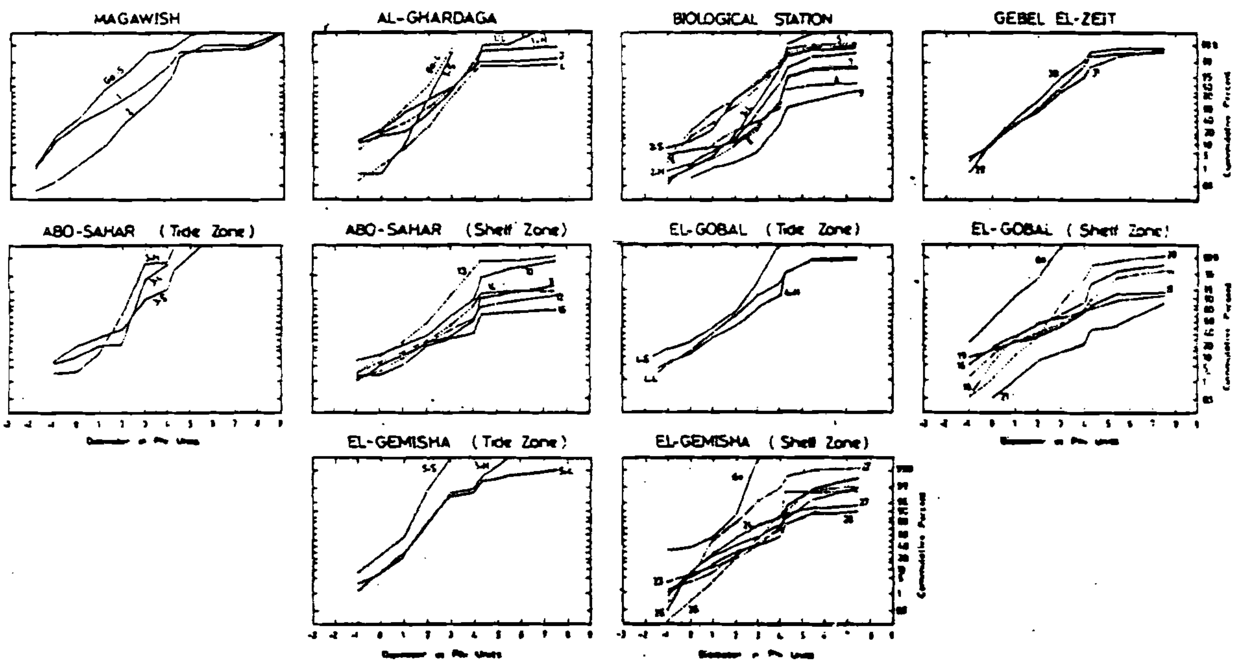

Fig. (4)
Cummulative curves for the studied samples.

TABLE 1

Percentage of gravel, sand, silt and clay again size parameters of the tidal sediments near Ghardaqa. *

Sample No.	Gravel %	Sand %	Silt %	Clay %	Sediment	type	Mean size Mz	Sorting So So	Skewness SK	Kurtosis K
1.5	0.6	99.42	-		gravelly	sand	1.65	0.50	-0.09	1.23
1-H	15.74	83.33	1.74	0.19	gravelly	sand	0.87	1.69	0.13	1.12
1-L	14.53	84.63	0.83	-	gravelly	sand	1.33	1.24	-0.38	0.14
2-S	9.36	89.43	1.18	0.04	gravelly	sand	1.4	1.24	-0.19	1.75
2-H	0.99	90.44	8.21	0.38		sand	2.9	0.9	10.14	1.23
2-L	0.68	97.94	0.94	0.03		sand	2.53	0.74	10.11	0.57
3-S	3.33	96.45	0.23	-		sand	1.63	0.61	-0.09	1.13
3-H	9.75	85.6	4.59	0.06	gravelly	sand	1.37	1.6	-0.37	0.88
3-L	7.69	91.92	0.41	-	gravelly	sand	1.8	1.13	-0.75	3.28
4-S	17.75	82.25	-	-	gravelly	sand	0.73	1.5	-0.28	0.97
4-H	6.66	86.71	6.49	0.14	gravelly	sand	1.87	1.57	-0.18	1.08
4-L	5.67	92.13	2.12	0.18	gravelly	sand	1.37	1.18	-0.06	0.87
5-S	9.31	90.68	-	-	gravelly	sand	0.60	0.9	-0.37	1.00
5-H	3.73	95.22	1.05	-		sand	1.4	0.92	-0.22	1.45
5-L	2.43	95.08	2.41	0.08		sand	1.33	0.87	-0.1	1.58

TABLE 2

Percentage of gravel, sand, silt and clay and grain size parameters of island sediments of the Red Sea near Ghardaqa

sample No.	Gravel %	Sand %	Silt %	Clay %	Sediment	type	Mean Size Mz	Sorting So So	Skewness SK	Kurtosis K
Ga-S	19.00	80.84	0.16	-	gravelly	sand	-0.07	1.03	-0.14	-0.37
Ga-L	15.82	84.18	-	-	gravelly	sand	0.57	1.22	-0.95	1.09
Go	26.25	73.75	-	-	gravelly	sand	-0.90	0.97	-0.32	0.98
Ge	32.23	67.77	-	-	gravelly	gravel	0.23	0.74	-0.36	0.63

TABLE 3

Percentage of gravel, sand, silt and clay and grain size parameters of shelf sediments of the Sea near Ghardaqa.

sample No.	Gravel %	Sand %	Silt %	Clay %	Sediment	type	Mean size Mz	Sorting So	Skewness SK	Kurto-sis K
1	14.00	84.10	00.94	00.19	gravelly	sand	0.75	1.55	0.12	0.88
2	00.4	95.4	4.13	0.1		sand	2.37	0.97	-0.019	0.87
3	6.9	91.35	0.97	0.72	gravelly	sand	1.27	1.46	-0.12	0.8
4	0.3	97.2	1.02	1.13		sand	2.37	0.88	-0.11	1.0
5	4.09	94.94	0.94	0.03		sand	0.98	1.23	0.12	0.9
6	3.44	94.94	1.5	0.12		sand	1.33	1.34	-0.04	0.9
7	4.12	71.01	22.67	2.2	muddy	sand	3.32	1.18	-0.36	1.45
8	0.26	72.64	24.63	2.74	muddy	sand	3,43	0.9	-0.42	0.9
9	0.18	62.44	29.76	7.9	muddy	sand	3.02	1.77	-0.11	1.2
10	7.98	82.72	9.02	0.38	gravelly	sand	2.25	1.69	-0.27	0.5
11	1.06	61.75	33.45	3.59	muddy	sand	3.07	1.69	-0.36	1.33
12	2.29	63.57	26.5	7.66	muddy	sand	3.07	2.13	0.0	1.38
13	1.79	97.55	0.59	0.06		sand	1.62	1.14	-0.17	0.8
14	1.37	82.04	11.1	5.65	muddy	sand	2.8	1.78	0.15	1.8
15	1.46	39.55	38.01	21.0	sandy	mud	4.56	2.71	0.21	1.25
16	5.18	81.82	12.61	0.40	gravelly	muddy	1.8	1.65	0.6	0.6
17	2.81	76.81	19.6	0.78	muddy	sand	2.37	1.74	-0.25	0.71
18	0.11	75.77	18.08	6.05	muddy	sand	2.1	2.08	0.44	0.94
19	10.35	62.44	20.38	6.54	gravelly	muddy	2.47	2.62	-0.11	1.18
20	0.11	98.13	1.69	0.09		sand	2.19	0.87	-0.2	1.16
21	-	23.69	60.4	16.16	sandy	mud	5.27	2.0	0.09	0.95
22	0.41	98.63	0.9	0.02		sand	1.23	0.88	0.33	0.95
23	3.55	84.96	11.04	0.45	muddy	sand	2.8	1.22	-0.29	1.25
24	0.85	84.65	14.14	0.38	muddy	sand	2.1	1.48	0.24	0.97
25	0.1	73.84	25.03	1.03	muddy	sand	2.47	1.76	-0.13	0.73
26	0.03	73.41	25.63	0.93	muddy	sand	3.1	1.13	-0.23	0.75
27	1.05	68.27	24.09	6.61	muddy	sand	2.97	1.84	0.0	1.24
28	1.9	57.53	29.89	10.68	muddy	sand	3.3	2.21	-0.12	1.31
29	0.82	97.8	0.84	0.55		sand	1.43	1.19	-0.02	0.86
30	2.95		96.08	0.85		sand	1.23	1.08	0.13	0.99
31	3.35	91.72	4.57	0.37		sand	1.7	1.35	0.0	0.94

The mean size of the studied sediments show a progressive decrease in particle size with increasing water depth (Table 4).

Measure of Uniformity (Sorting)

Sorting is a measure of the standard deviation, i.e. the spread of the grain-size distribution. It is one of the most useful parameters since it gives an indication of the effectiveness of the depositoinal medium in separating grains of different classes (Tucker, 1981).

As shown in table 1, the sorting of the sediments of the tidal zone varies from 0.50 to 1.60 phi, having a mean 1.05 phi, i.e. moderatly sorted. However, 54% of the samples from the tidal zone show values denoting poor sorting, while 46% of the tidal samples are moderatly to moderatly well sorted.

From table 2, the sorting of island sediments ranges between 0.74 to 1.22 phi with an average of 0.89 phi. Generally, most sediments of the islands are moderatly sorted.

TABLE 4
Variation of mean size with water depth in the studied area

Number of sample	Water depth	Average of mean size: Phi	Average of mean size: Standard deviation	Sediment type
38	Water depth between 0 and 20 m	1.48	± 0.68	Very coarse to medium sand fraction
11	Water depth between 20 and 50 m	3.31	± 0.91	Fine to very fine grain sizes
2	Water depth 50 m	3.99	± 0.94	Very fine grains

As shown in table 3, the sorting of the shelf sediments ranges between 0.87 phi and 2.71 phi, with an average of 1.79 phi. Moreover, 84.4% of the samples representing shelf sediments show sorting values denoting poorly sorted sediments, and 14.6% of the samples show moderatly sorted sediments.

The results of the sorting coefficients of the shelf,tidal and island sediments show that the sediments vary from moderatly and well sorted near the beach, to poorly and very poorly sorted with increasing water depth (Table 5).

TABLE 5

Variation of sorting coefficient with water depth in the studied area

Number of sample	Water depth	Average of sorting		Sediment type
		phi	Standard deviation	
38	Water depth between 0 and 20 m	1.08	± 0.33	well sorted to poorly sorted
11	Water depth between 20 and 50 m	1.74	± 0.53	pooly to very poorly sorted
2	Water depth 50 m	1.72	± 0.06	very pooly sorted

Measure of the Symmetry of the Distribution (Skewness)

The inclusive graphic skewness of the sediments sampled in the tidal zone ranges from -0.75 to 0.13 (Table 1). About 13.3% of the samples are positively skewed (i.e. finely skewed), while 86.7% of the sediments are negatively skewed (i.e. coarsely skewed). Moreover, 26.7% of the sediments from the tidal zone are nearly symmetrically skewed.

As given in table 2, the skeweness of sediments sampled from the islands ranges between -0.14 and -0.95. Moreover, all island sediments are coarsely to very coarsely skewed.

The skeweness of the sediments sampled from the shelf zone ranges from -0.42 to 0.53 phi (Table 3). About 43.8% of the samples collected from the shelf zone are negatively skewed (i.e., coarsely skewed). Moreover, 21.9% of the samples are nearly symmetrically skewed.

Generally, the sediments sampled in the Ghardaqa region show change from coarsely and very coarsely skewed near the beaches to nearly symmetrically distribution with increasing water depth (Table 6).

TABLE 6

Variation of skewness with water depth in the studied area

Number of sample	Water depth	Average of skewness		Sediment type
		SK(phi)	Standard deviation	
38	Water depth between 0 and 20 m	-0.5	± 0.45	Strong coarsely to coarsely skewed
11	Water depth between 20 and 50 m	0.0	± 0.13	Coarsely, nearly symmetrically and Finely skewed
2	Water depth 50 m	0.21	± 0.3	nearly smmetrically and finely skewed

Peakendness of the Frequency Distribution

In the sediments sampled from the tidal zone near Ghardaqa the graphic kurtosis ranges from 0.14 to 3.28, averaging 1.22 (table 1). About 53.3% of the tidal sediments are leptokurtic and 46.7% are mesokurtic and platykurtic.

The graphic kurtosis of sediments sampled from the islands ranges from -0.37 to 1.09, averaging 0.58 (Table 2). All sediments from islands are either very platykurtic or platykurtic to mesokurtic.

The graphic kurtosis of the sediments sampled from the shelf zone ranges between 0.50 and 1.45, averaging 0.95 (Table 3). About 62% of the samples from the shelf sediments are platykurtic and mesokurtic with increasing water depth (Table 7).

TABLE 7

Variation of Kurtosis with water depth in the studied area

Number of Sample	Water depth	Average of Kurtosis K (phi)	Standard deviation	Sediment type
38	Water depth between 0 and 20 m	1.22	± 0.66	Platykurtic, mesokurtic and leptokurtic
11	Water depth between 20 and 50 m	1.48	± 0.5	Leptokurtic and mesokurtic
2	Water depth > 50 m	1.17	± 0.03	Leptokurtic

Areal Distribution of Sediments

The method used in this work to construct the basic surficial sediment distribution map follows fundamentally that used by Folk (1968). The method of map construction is as follows:

1. Sand fraction (2000 µ -62.5 µ). This map is drawn, using contour interval or 20% by weight. Sand size fraction in the studied area ranges between 100% to 20%, Fig. 5.
2. Silt fraction (62.5 µ - 5 µ). The map is drawn using contour interval of 10% by weight. Silt size fraction in the studied area ranges between 70% to 0.0%, Fig. 6.
3. Clay fraction (<5 µ). The map is drawn, using contour interval of 5% by weight. The clay size fraction in the studied area ranges between 20% to 0.0%, Fig. 7.

Areal Distribution of Sand Fraction

The sand fraction of sediments sampled from the tidal zone has a uniform distribution towards the deeper sea, the sand fraction decreases reaching a value of 63%.

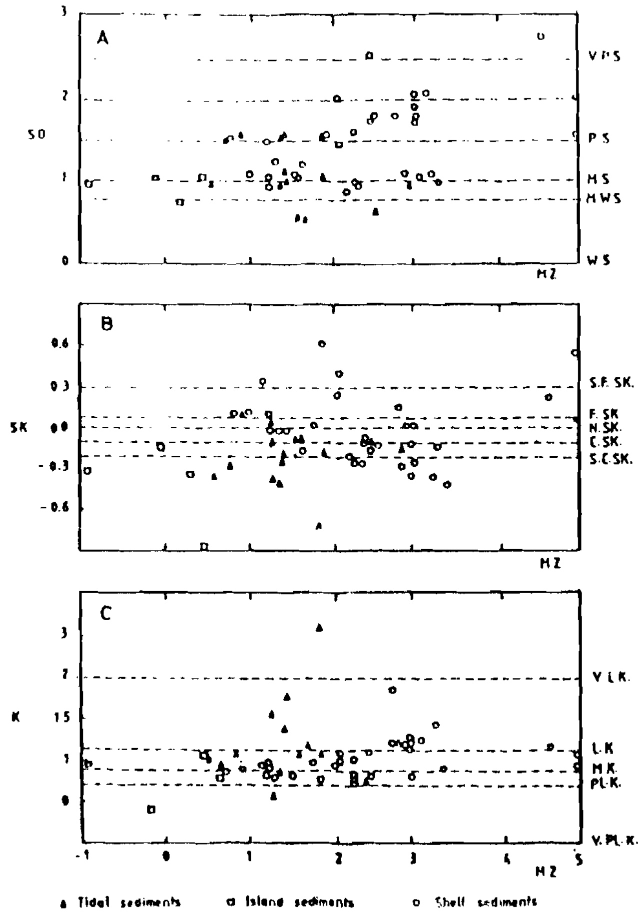

Fig. (5)

A : Relationship between sorting and mean size.

B : Relationship between skewness and mean size.

C : Relationship between kurtoisis and mean size.

The island sediments include some patches in which relatively high sand fractions are recorded.

Generally, it can be that the sand fraction increases towards the shore.

Areal Distribution of Silt Fraction

According to the distribution map of the silt fraction (Fig. 6), the tidal zone proved to have a high silt fraction, reaching values as high as 8.6% toawrds the sea.

The shelf zone has a high silt fraction reaching 47% towards the deeper sea. Towards the tidal zone, this value becomes very low.

The sediments sampled from some islands have a very low silt fraction.

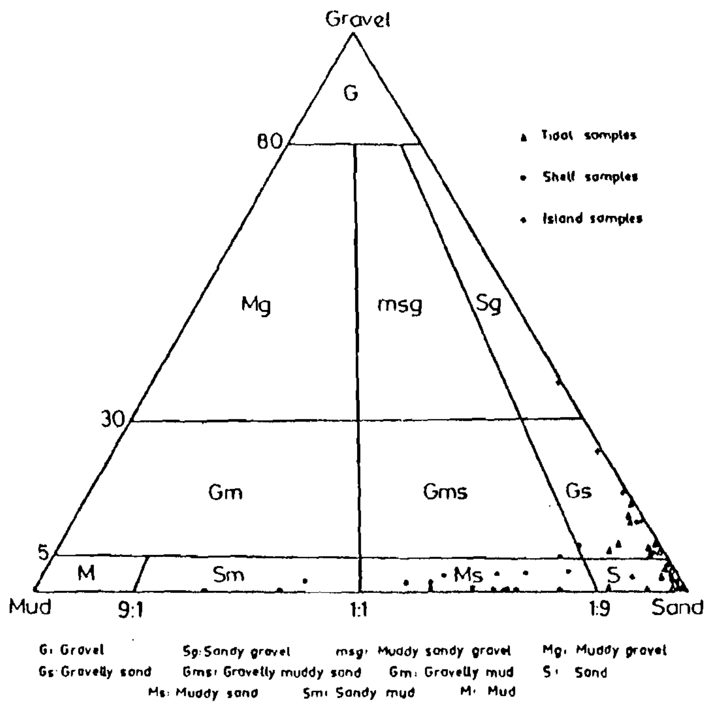

Fig. 6
Triangle showing the clastic sediment textural namenclature according to gravel ratio, sand ratio and mud ratio.

TABLE 8

Results of the application of the discriminant functions of Sahu (1964) on the mechanical analysis data provided by the studied samples.

X+ Environmental interpretation in agreement with field location.

Samples	Discriminant function Y_1	Y_2	Y_3	Y_4	X	Environments
1	8.71	188.1	- 6.688	-	+	shallow agitated marine
2	-2.00	114.7	- 7.000	-	+	shallow agitated marine
Ga-S	4.75	67.75	-70.300	-	+	shallow agitated marine
1-S	0.88	63.33	-	-	+	shallow agitated marine
1-M	9.47	202.82	- 6.65	-	+	shallow agitated marine
1-L	5.48	173.44	- 5.94	-	+	shallow agitated marine
3	6.10	172.58	- 5.65	-	+	shallow agitated marine
Ga-L	-8.84	109.7	- 2.41	-	+	shallow agitated marine
4	-2.41	104.6	- 6.69	-	+	shallow agitated marine
2-S	5.82	154.93	- 5.81	-	+	shallow agitated marine
2-M	-3.23	-	-	-	+	eolian deposition
2-L	-3.32	-	-	-	+	eolian deposition
5	4.66	133.58	- 7.511	5.94		turbidity current
6	1.84	154.74	- 6.74	-	+	shallow agitated marine
7	-1.432	163.78	- 8.11	7.64		turbidity current
8	-5.59	-	-	-		eolian deposition
A	4.78	273.35	- 5.25	-	+	shallow agitated marine
9	-5.09	-	-	-		eolian deposition
3-S	-0.73	69.25	- 7.65	-6.37		turbidity current
3-M	8.1	200.90	- 3.90	-	+	shallow marine
3-L	0.9	159.3	- 3.2	-	+	shallow marine
10	4.5	231.40	- 3.7	-	+	shallow marine
11	4.4	256.1	- 2.95	-	+	shallow marine
12	9.5	364.3	- 3.35	-	+	shallow marine
13	4.5	138.6	- 6.11	-	+	shallow marine
14	6.8	292.2	- 5.5	-	+	shallow marine
15	13.1	559.6	- 1.02	-	+	shallow marine
4-S	9.59	170.2	- 4.7	-	+	shallow marine
4-M	6.43	216.4	- 4.6	-	+	shallow marine
4-L	3.09	133.78	- 7.19	-	+	shallow marine
16	5.98	234.2	- 5.7	-	+	shallow marine
17	4.86	237.9	- 3.7	-	+	shallow marine
18	11.1	346.97	- 5.8	-	+	shallow marine
19	20.1	509.2	- 0.65	-	+	shallow marine
Go	10.3	58.07	-	-	+	beach deposition
20	0.98	106.5	- 6.16	-	+	shallow marine
21	-1.5	368.4	- 3.66	-	+	shallow marine
5-S	4.7	73.66	- 5.8	-		shallow marine
5-M	4.0	99.3	- 6.6	-		shallow marine
5-L	4.1	102.6	- 6.995	-	+	shallow marine
22	1.4	97.2	- 9.0	7.5		turbidity current
23	-0.39	156.1	4.89	-	+	shallow marine
24	3.85	206.0	- 6.4	-	+	shallow marine
25	5.16	262.2	- 4.26	-	+	shallow marine
26	-2.159	135.4	- 5.8	-	+	shallow marine
Ge	5.3	278.4	- 4.6	-	+	shallow marine
27	2.2	40.1	-	-	+	beach deposition
28	10.7	388.0	- 2.28	-	+	shallow marine
29	3.01	131.3	- 6.95	-	+	shallow marine
30	3.23	120.5	- 7.36	-	+	shallow marine
31	3.9	185.2	- 6.25	-	+	shallow marine

Areal Distribution of Clay Fraction.

From the values of the clay fraction in the different sampled stations, a distribution map is drawn (Fig. 7)

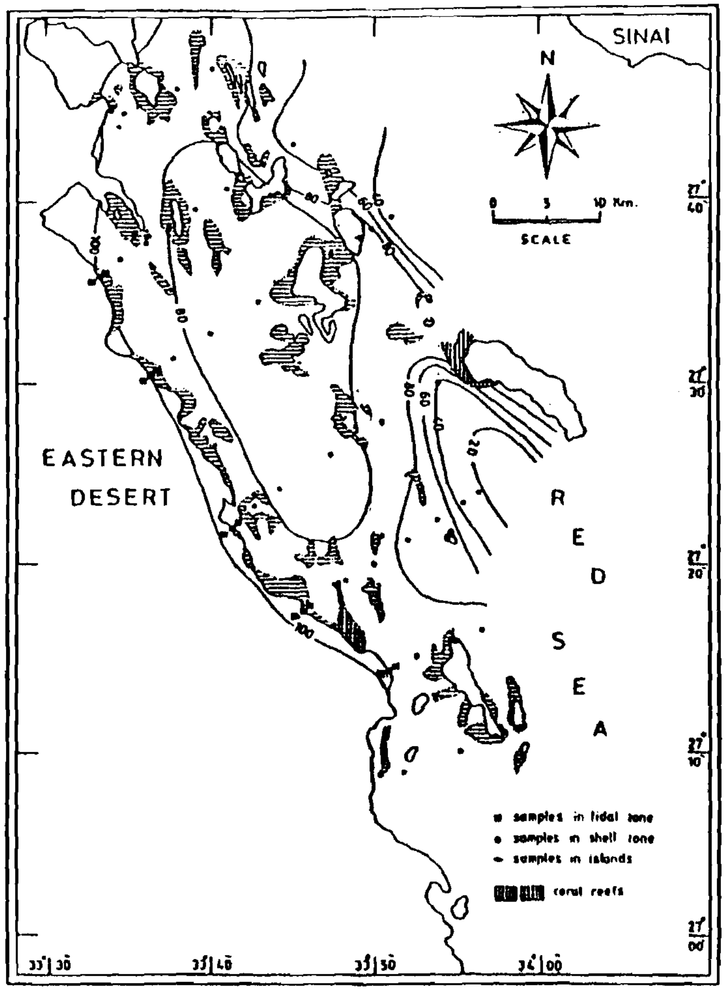

Fig. 7
Contour map showing the areal distribution of sand fraction in the area of study (sand %).

Areal Distribution of Clay Fraction.

From the values of the clay fraction in the different sampled stations, a distribution map is drawn (Fig. 7)

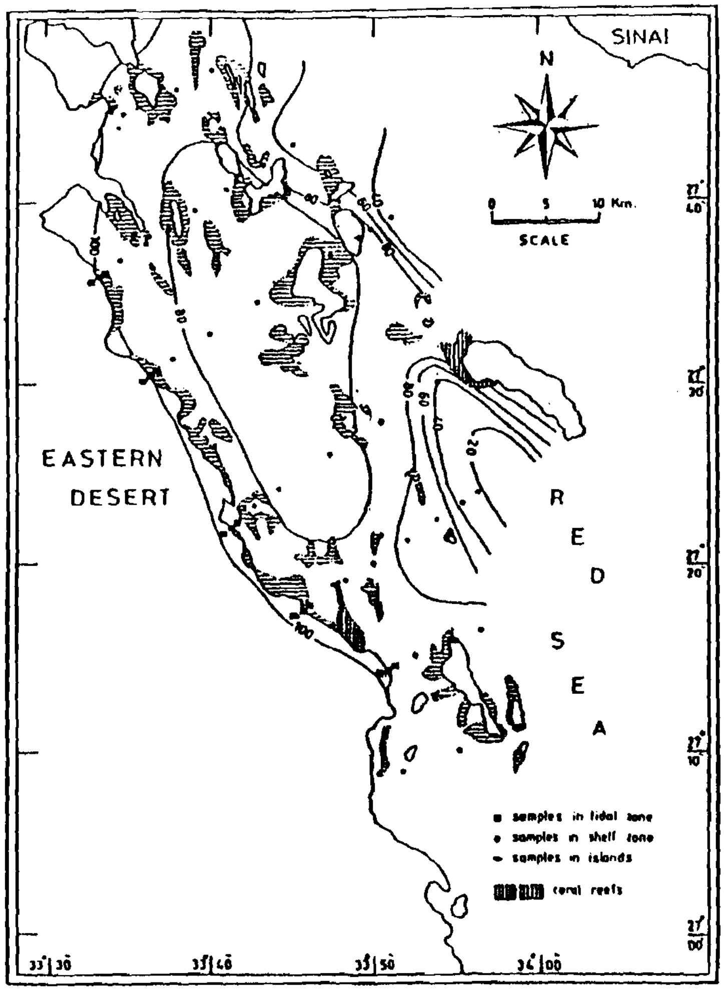

Fig. 7
Contour map showing the areal distribution of sand fraction in the area of study (sand %).

Sediments of the shelf zone has a high caly fraction, reaching 15.1% toawrds the deeper sea. The sediments of the tidal zone and some islands have a very low caly fraction ranging between 0.0% to 1%.

Thus, it can be concluded that the clay fraction increases seawards.

DISCUSSION AND CONCLUSION

The results of the mechanical analyses performed in this work indicate that, supratidal and intertidal sediments are coarsely to medium grained, moderatly to well sorted, coarsely skewed, and leptokurtic to mesokurtic. Island sediments are very coarsely, skewed and very platykurtic to meskurtic. Shelf sediments are coarsely to finely and very finely grained, poorly sorted to very poorly sorted, coarsely to finely and very finely skewed, and platykurtic, changing to leptokurtic, very leptokurtic and mesokurtic with increasing distance from the shore (Fig. 8).

These results, furthermore, indicate that from the shore towards the open sea, the mean size generally decreases and the sediments change from gravelly and coarse sand to sandy mud and muddy sand (Tables 1,2 and 3 Fig. 9). The sorting generally worsens, the skewness values generally decreases (i.e. changed from coarsely skewed to very finely skewed) and the kurtosis values generally change from very platykurtic and mesokurtic to meskurtic and leptokurtic, with increasing depth (Tables 4, 5, 6 and 7).

The variation may be due to one or more of the following resasons:

1. After the deposition of the sediments, longshore currents and waves may have sorted and transported the fine grains towards the sea, leading to the increasing of grain size and skewness, and also to improvement of sorting towads the beach, i.e. the sediments change to finer grains, increasing towards more poorly sorted and coarsely skewed toawrds the sea. Krissek et.al (1980), El-Wakeel and El-Sayed (1978), and Chowdhurry (1980), think that the effect of winds and currents on the shore is responsible for the decrease of grain size seawards.

2. Variation in mineralogy and sedimentation rates may affect the sediment grain-size properties. Trask (1961) and Ross (1971) noticed that the influence of sedimentation rate on the grain size parameters is very difficult to be determined. It appears that this factor is generally masked by compositional and textural characters of sediments. Folk (1974) thinks that trends in grain size over large areas can be used to infer the direction of sediments despersal, with size decreasing away from the source area.

3. Pettijohn (1975) noticed that sorting is dependent on the grain size, in that, coarse sediments (gravels and conglomerates) and fine sediments (silts and clays) are generally more poorly sorted than sand-sized sediments, which are more easily transported, and therefore sorted by winds and water.

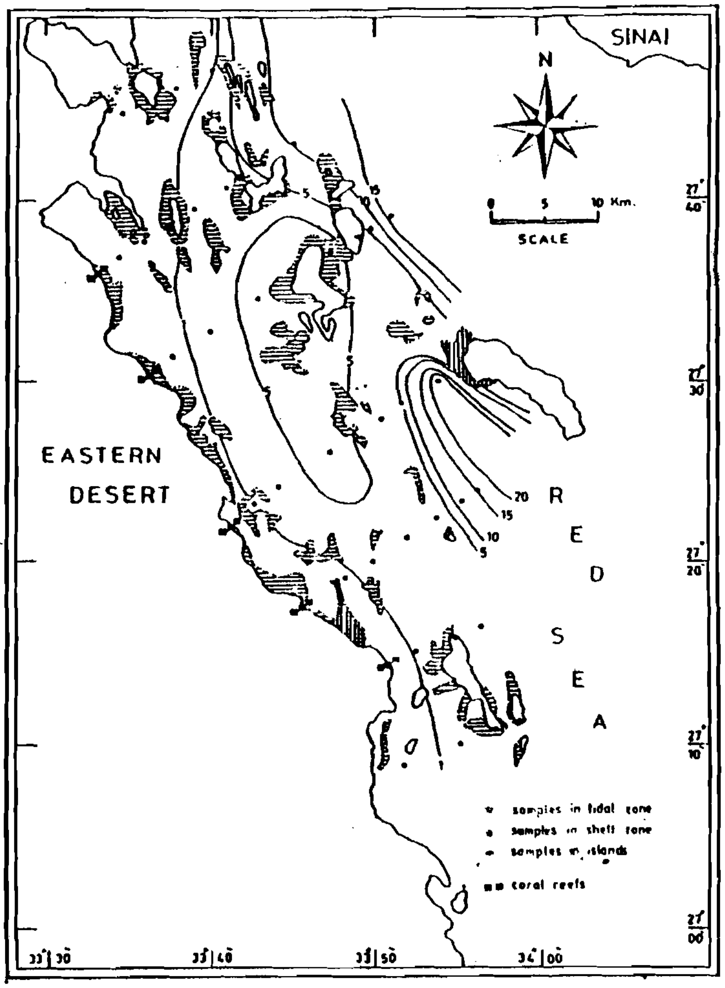

Fig. 9
Contour map showing the areal distribution of caly fraction in the area of study (clay %).

to poorly sorted and this change is related to a decrease in wave and current energy with increasing water depth.

Apart from being a useful descriptive term for a sediment sample, skewness is also a reflection of the depositional process. For example, beach sands tend to have a negative skewness, since fine components have been reworked by persistant wave action (Duane, 1964). The skewness of island and tidal sediments in this work proved to be negative i.e. coarsely skewed. But the skewness of shelf sediments have been found to be positive, i.e. finely skewed.

The areal distribution of the sand, silt and clay fractions, is affected by the distance from shore. The sand fraction decreases, the silt and clay fractions generally increase with increasing distance to the shore. These variations are probably controlled by one or more of the following factors:

1. The slope of the bottom and the depth of the sea, (Morelock, 1969; Almager and Wiseman , 1977; Benett et al., 1977; Keller et al., 1979; Busch and Keller, 1979, 1981 b and Inman, 1949) the greatest variation in properties with depth occurs in sediments of the upper continental slope. These sediments are also strongely affected by the distance from shore. Wherever depth increases, sand fraction tends to decrease, and silt and clay fractions tend to increase.

2. Waves and currents are responsible for the decrease of grain size (Scheidegger and Krissek, 1978). Thus, from the shoreline across the shelf, towards of shore, the grain size decreases. Thus, sand fractions decrease and silt and clay fraction increase seawards.

3. The geology of the coastal plains. The rock types that are found on the coasts of the Sea and the islands are different, both in nature and in age. Thus, the detrital supply to the western side of the study area contains and appreciable amount of silica sands when compared to the carbonates clastics found elsewhere (Shukry and Higazi, 1944 a & b). The percentage of sand fraction increases and that of clay and silt fraction decreases towrds the beach.

4- The presence of marine grass. Marine grass may cause the biochemical deposition of silt and clay sized aragonite (Powers and Kinsman, 1953). This tends to increase the silt and clay fraction in marine sediments rather than in beach sediments.

Use of the Discriminant Functions of Sahu for Environmental Interpretations.

Sahu (1964) established four descriminant functions using the previously calculated coefficients of Folk and Ward (1957), i.e. Mz, So, Sk & K. These functions would, according to Shau, enable the differentiation between sediment deposited under the conditions: eolian and beach, beach and shallow agitated marine, shallow agitated marine and deltaic, and deltaic and turbid.

The functions, represented by constants (calculated by Sahu after computing mechanical analysis data provided from several samples, represnting different know depositional environments) are as following:

$$Y_1 = -3.5688\ Mz + 3.7016\ So - 2.0766\ SK + 3.1135\ K$$
$$Y_2 = 15.0653\ Mz + 65.709\ So + 18.0101\ SK + 18.5043\ K$$
$$Y_3 = 0.2852\ Mz - 8.7604\ So - 4.8932\ SK + 0.0482\ K$$
$$Y_4 = 0.7215\ Mz - 0.4030\ So - 6.7322\ Sk + 5.2927\ K.$$

The function (Y_1) serves to differentiate between eolian and beach environments. Values for Y_1 <-2.7411 indicate eolian deposition, values of Y_1 >-2.7411 indicate beach deposition. The function (Y_2) serves to differentiate between beach and shallow agitated marine environments. Values for Y_2 <65.3650 indicate beach deposition, values of Y_2 >65.3650 indicate shallow agitated marine deposition. The function (Y_3) serves to differentiate between sallow agitated and deltaic environments. Values for Y_3 <-7.4190 indicate deltaic deposition, values of Y_3 >-7.4190 indicate shallow agitated marine deposition. The function (Y_4) serves to differentiate between deltaic and turbidity current deposition. Values of Y_4 <9.8433 indicate turbidity current, values of Y_4 > 9.8433 indicate deltaic environments. Table (8) gives the calculated values of Y_1, Y_2, Y_3 and Y_4 for the samples studied in the Ghardaqa area where the environment of deposition of the samples studied in the area is determined.

The application of the discriminant function of Sahu in the present study shows that 36 out of 51 samples give results compatible with field observations (i.e., 70.6% of samples) other samples give misleading results (29.4%). This shows that the method should be used with caution for invironmental interpretation in ancient sediments.

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