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Preliminary marine geological studies on recent sediments of Kuwait Bay

MAMDOUH A. MOHAMED

Department of Geology, University of Kuwait

ABSTRACT

The purpose of the present work is to provide information on the recent sediments in this area and to construct a map showing the nature of the bottom topography and the factors controlling the sediment distribution.

The inorganic material (carbonate sediment) that constitutes the major part of the Kuwait Bay sediments is attributed to the deposits falling out from the duststorms caused by the northwest winds, locally known as 'shamal'. The organic sedimentary materials are partly supplied by the sewage which is pumped into the Bay and partly from plants and animals which live in this area. These plants and animals occur in small quantities due to abnormally high salinity.

Among the more important factors controlling the distribution of recent sediments in this Bay are the wind and bottom currents, in addition to biological interference. Thus, this area is characterized by an interplay of marine and terrestrial influences.

INTRODUCTION

This survey was carried out in June 1976. Twenty-two stations were selected (Fig. 1) at depths ranging from 3 to 20 m. The position of the stations was determined by navigational methods using admiralty charts. The samples were collected by means of bottom grab (Peterson type) which was found to be the most suitable type for the present work. It is to be noted that the samples collected were obtained from the upper 20 cm of the bottom deposits.

TECHNIQUE USED

The bottom samples were mechanically analysed using wet sieving for coarse fractions (sand). The samples were screened through a set of standard sieves with mesh openings of 0·50, 0·25, 0·125 and 0·063 mm. For the fine fractions (silt and clay), the pipette method was used as described by Krumbien & Pettijohn (1938).

The weight percentage of different fractions was calculated and the data obtained were represented by histograms as shown in Fig. 2. The cumulative percentages were also graphically drawn on probability paper (Fig. 3). The statistical parameters were calculated following the equation used by Inman (1952).

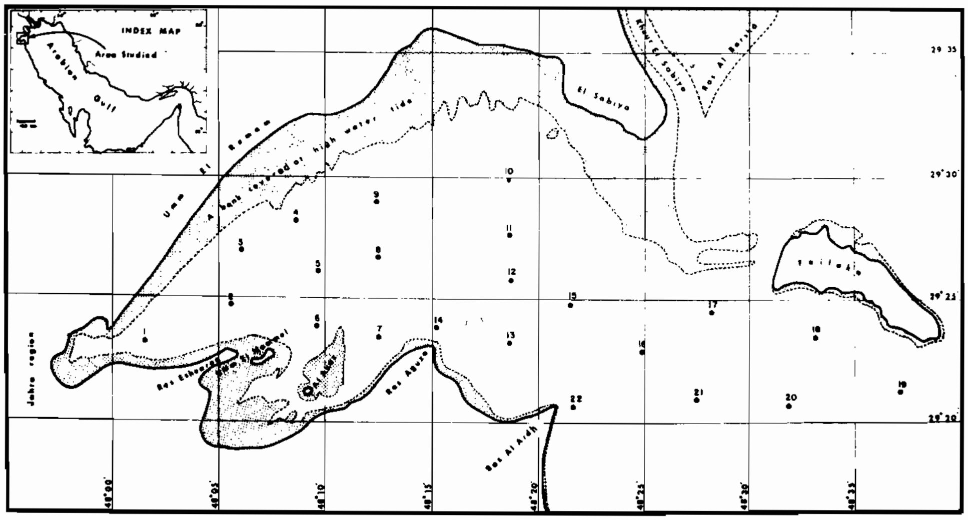

Fig. 1. The area of study and the location of samples.

RESULTS

The data derived from mechanical analysis and the calculated statistical parameters are listed in Table 1. From this table, it is found that the sorting ($\sigma\phi$) of the samples ranges from 0·50 to 1·60 with an average sorting of 1·21. This means that the samples are well sorted. Their skewness ($\alpha\phi$) ranges from −0·19 to +0·76. Eighteen samples are skewed towards the fine fractions and two samples are skewed towards the coarse fractions, while one sample is neutral and is located at the middle of the Bay near the southern coast (station no. 7). The median diameter (Mdϕ) ranges from 3·2 to 6·3ϕ with an average of 5·53ϕ. From the histograms, it is clear that the chief ingredient was medium sand (2·0ϕ) in two samples only, and very coarse silt (5·0ϕ) in the rest of the samples.

Interrelations of statistical parameters

Scatter diagrams were made to find out the relations between:
(a) Depth and sorting (Fig. 4).
(b) Skewness and median diameter (Fig. 5).
(c) Sorting and median diameter (Fig. 6).
(d) Depth and median diameter (Fig. 7).

From scatter diagrams, it is found that the sorting increases with decrease of median diameter while there is no relation between sorting and depth. The median diameter increases with increasing depth, up to a depth of 7 m and then decreases. The relation between median diameter and skewness shows that skewness increases slightly with decrease of median diameter.

Bottom configuration

Kuwait Bay takes the shape of a broad inclined V. It extends for about 42 km in length

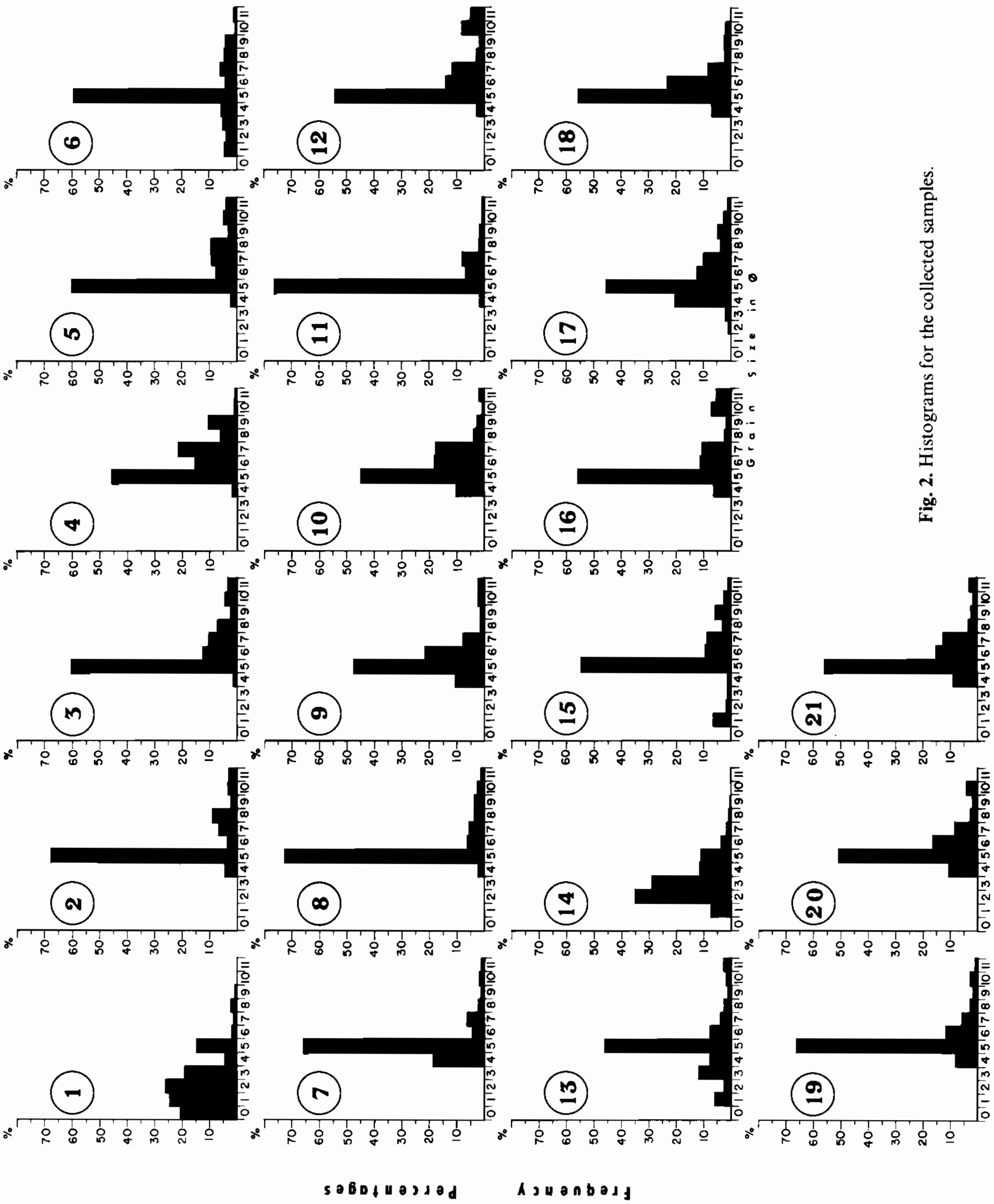

Fig. 2. Histograms for the collected samples.

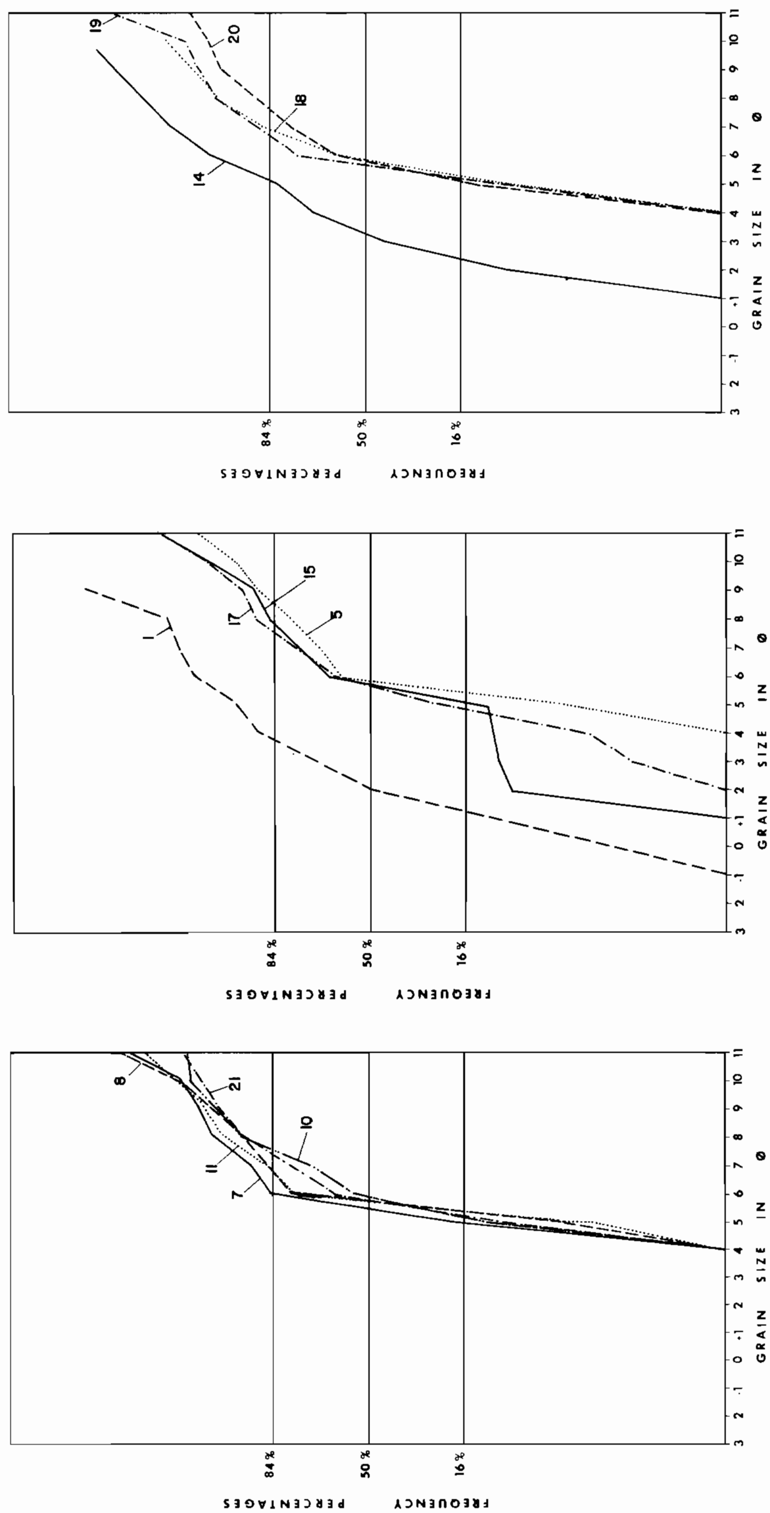

Fig. 3. Cumulative curves for the collected samples.

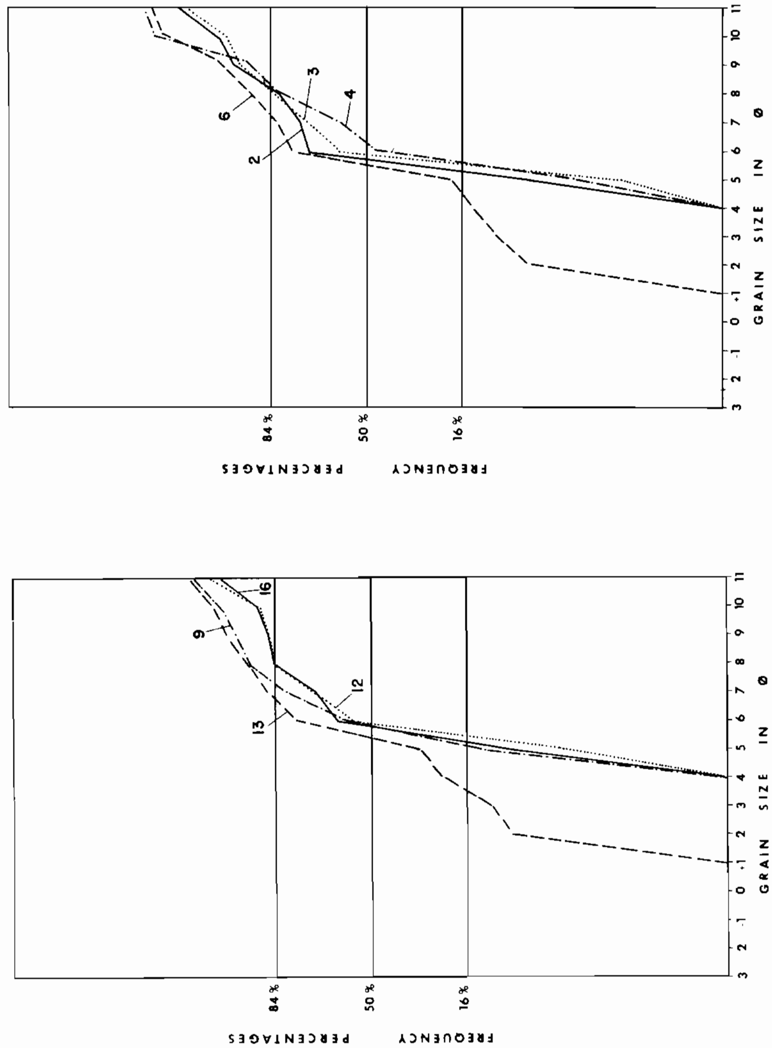

Fig. 3 (cont.). Cumulative curves for the collected samples.

Table 1. Data derived from mechanical analysis and the calculated statistical parameters

Sample no.	Depth (m)	Sand (%)	Silt (%)	Clay (%)	Statistical parameter Mean	Median	Sorting	Skewness	Sediment type
1	4·20	91·92	6·36	1·72	2·55	3·20	1·25	−0·52	Sand
2	13·70	4·52	78·40	17·08	6·73	5·90	1·48	+0·56	Clayey silt
3	3·30	0·40	83·44	16·16	6·78	5·58	1·23	0·76	Silt
4	2·90	1·44	81·44	17·12	6·90	6·30	1·30	0·46	Silt
5	9·80	2·04	76·76	21·20	6·85	5·90	1·50	0·70	Clayey silt
6	10·00	19·12	70·32	10·56	5·80	5·50	1·30	0·23	Sandy silt
7	9·25	18·60	76·12	5·28	5·50	0·50	0·50	0·00	Sandy silt
8	9·10	2·00	89·44	8·56	6·05	5·70	0·65	0·54	Silt
9	3·00	9·60	70·90	9·50	6·20	5·80	1·10	0·36	Silt
10	3·80	10·40	80·24	9·36	6·35	5·90	1·20	0·38	Silt
11	11·60	1·20	92·72	6·08	6·05	5·70	0·65	0·54	Silt
12	16·00	2·30	81·45	16·25	6·60	6·10	1·20	0·44	Silt
13	9·50	30·32	59·70	9·98	5·10	5·40	1·60	−0·19	Sandy silt
14	4·40	82·20	16·76	1·04	3·75	3·30	1·35	+0·33	Sand
15	20·00	10·60	78·64	13·56	6·45	5·70	1·35	0·56	Silt
16	6·70	6·70	77·12	16·18	6·55	5·80	1·45	0·52	Clayey silt
17	6·70	21·24	66·72	12·04	6·20	5·60	1·30	0·46	Sandy silt
18	5·50	7·04	87·28	5·68	6·10	5·80	0·80	0·36	Silt
19	6·45	8·00	85·60	6·40	5·95	5·65	0·75	0·40	Silt
20	5·30	9·40	80·12	10·48	6·40	5·80	1·30	0·46	Silt
21	5·00	7·80	83·04	9·16	6·30	5·70	1·10	0·55	Silt
22	19·00	—	—	—	—	—	—	—	Rock

and about 29 km in width with an entrance of about 21 km. The shoreline is bordered by sands while the tidal zone is characterized by beach rocks more or less covered with mud flats.

Six profiles were made perpendicular to the coastline in order to show the features that may be present in the bottom (Fig. 8). From this figure, it is found that the area near the entrance is a kidney-shaped basin with depth of about 25 m. The basin is called colk and is about 9 km long and about 2·5 km wide. Its trend is NW–SE and occurs near to the coastline of Ras El-Ardh. Except for the colk, the bottom of the Bay is nearly flat. The depth generally decreases rapidly from the colk to the shoreline on both sides of the Bay, while it decreases slowly towards the west of the Bay as shown in Fig. 9. The colk may be formed by the currents generated by the wind and tide. These are strong enough to move superficial sediments on the sea bottom and this prevents deposition or even erodes channels or colk where water is driven through narrow straits (Benson 1963).

The distribution of the sediments

A generalized sediment map (Fig. 10) has been constructed to show the relationship between the principal type of sediments and the topography of Kuwait Bay. This map,

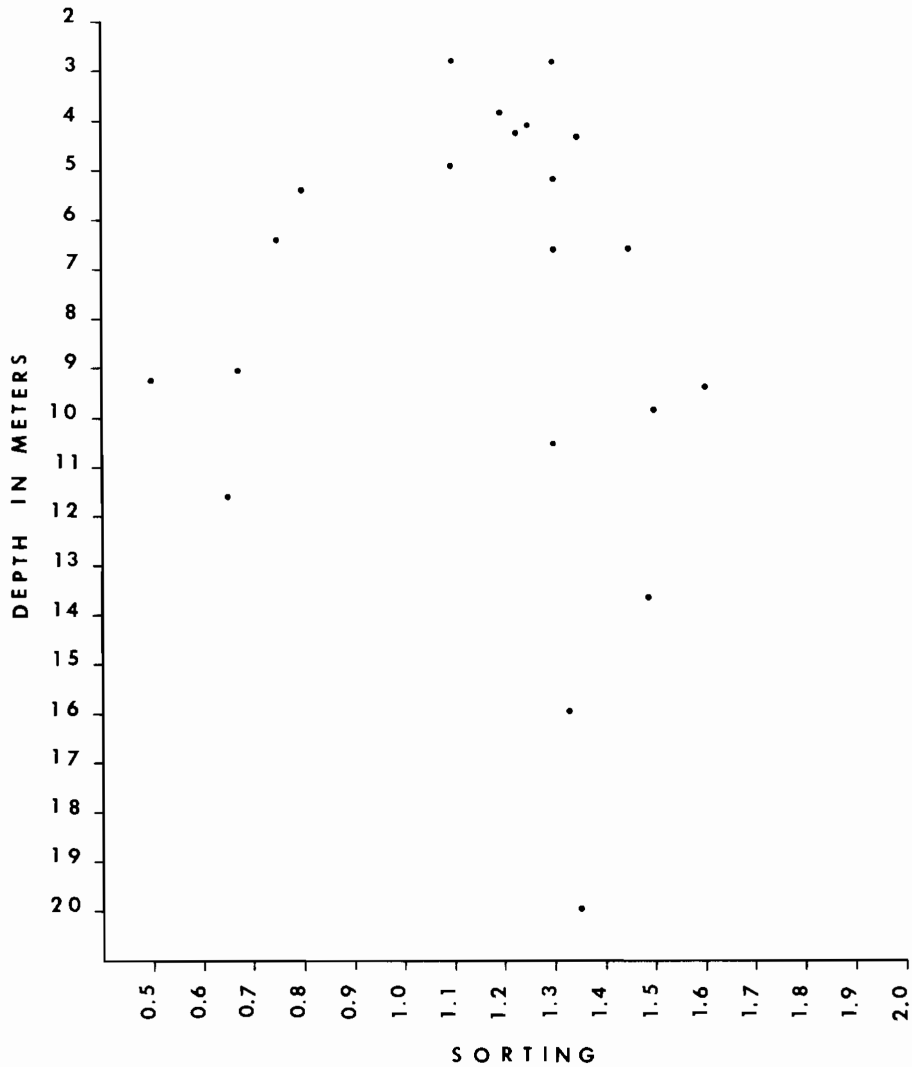

Fig. 4. The relation between depth and sorting.

which is based on the sand–silt–clay ratio, is prepared in accordance with the nomenclature used by Trefethen (1950). Owing to the difficulty encountered in accurately placing the boundary lines between the different types of sediments, these lines should be regarded with due reservation. The bottom was classified into the following types of sediments: rock, sand, silty sand, sandy silt, silt, and clayey silt. In some parts of the shoreline (especially the breaker zone located in the southern side) the rock (beach rock) was covered with mud flats. From the sediment distribution map (Fig. 10) it is found that the texture of the sediments changes irregularly along the shoreline. There are actually more areas where coarse sediments exist. This observation is best seen in front of Ras Aguza and off Jahra region, where sand and silty sand are directly

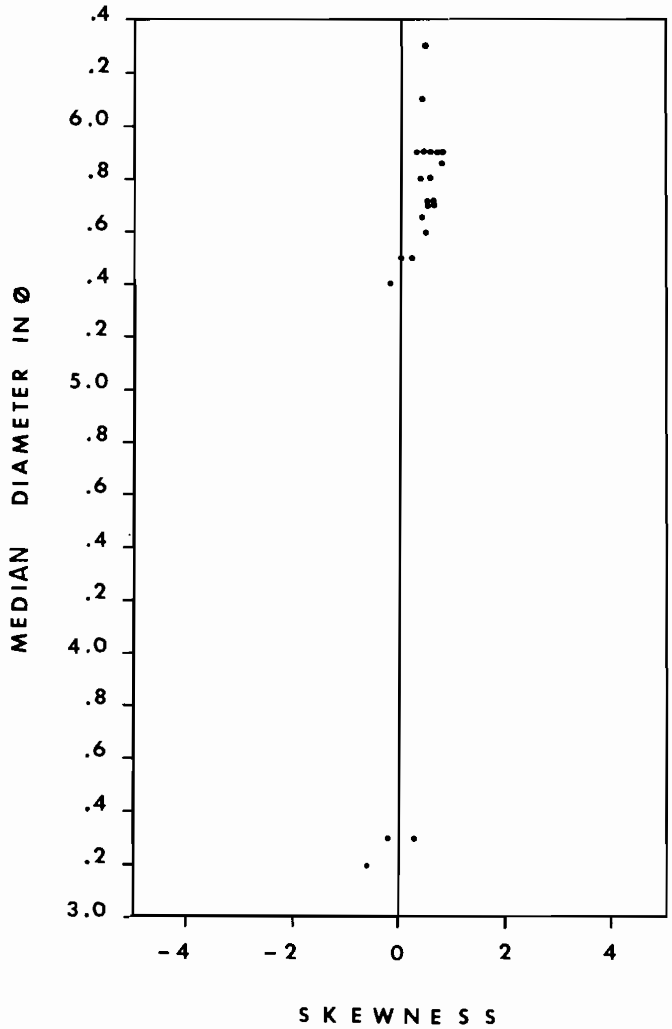

Fig. 5. The relation between skewness and median diameter.

reported. Sandy silt is reported at the southern side of the Bay and at the northeast entrance near Failaka island at a depth of about 6·70 m. The rest of the Bay is covered with silt including three patches of clayey silt: two located near the entrance of the Bay and the third in the western part of the Bay. Rocky bottom is reported directly off Ras El Ardh near to the shoreline at the entrance of the Bay (station no. 22).

Generally, the coarse sediments (sand and silty sand) are present in the southern side of the Bay, with a relatively larger median diameter (up to 3·2ϕ). This coarse sediment gradually decreases in size towards the northeastern side of the Bay where the fine fractions (sandy silt, silt and clayey silt) are present with relatively smaller median diameter (up to 6·3ϕ) as shown in Fig. 11.

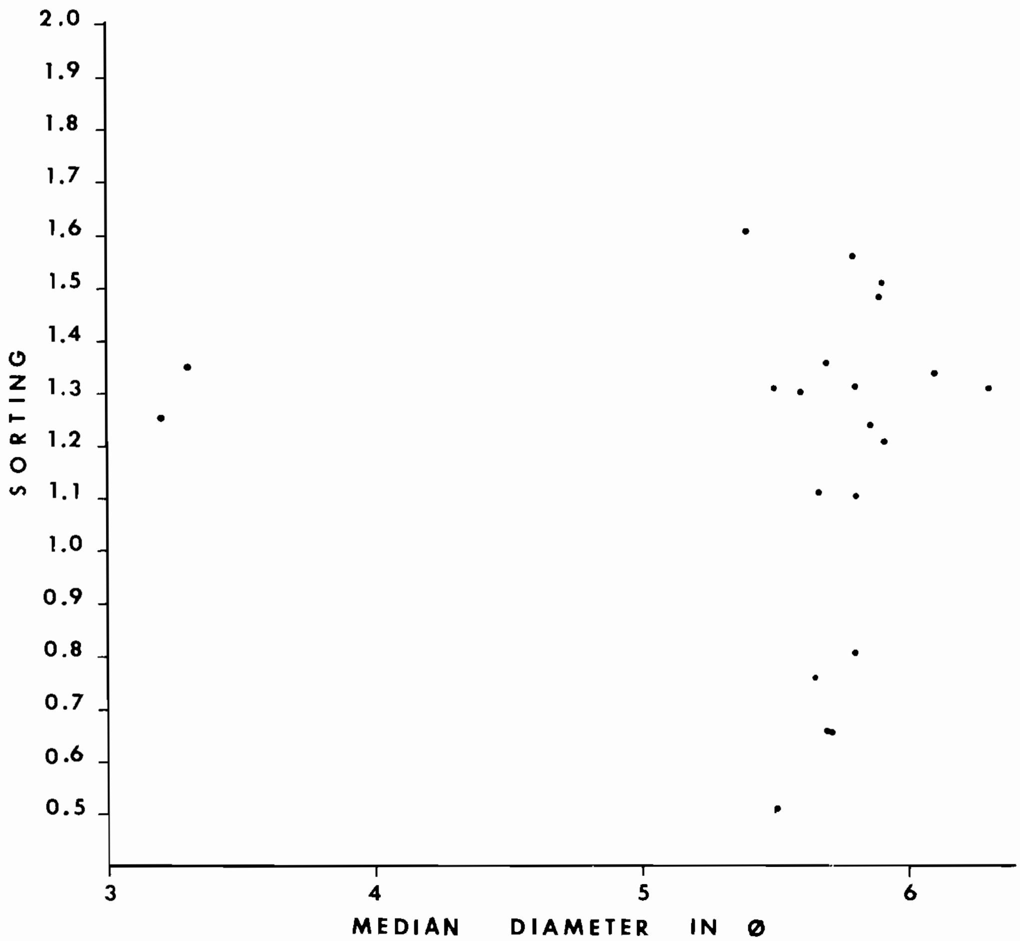

Fig. 6. The relation between sorting and median diameter.

Salinity

Twenty samples of sea water were collected 1 m above the bottom. The total salts for each sample were determined and expressed as g/l. The data are presented in Table 2.

From the values of salinity at corresponding stations, a salinity distribution map was drawn with 1‰ contour intervals (Fig. 12). From this map it was found that salinity increased rapidly from the northeastern to the southern parts of the Bay. The maximum values were recorded near Jahra and in the area located between Ras Aguza and Ras El-Ardh, where salinity values reached more than 50‰. Its minimum values were recorded near the northeastern part of the Bay where salinity reached 40‰ (at the entrance).

Carbonate content

The carbonate content (including both calcium and magnesium carbonate) was determined in twenty washed, dried, samples using the method described by USDA (1954)

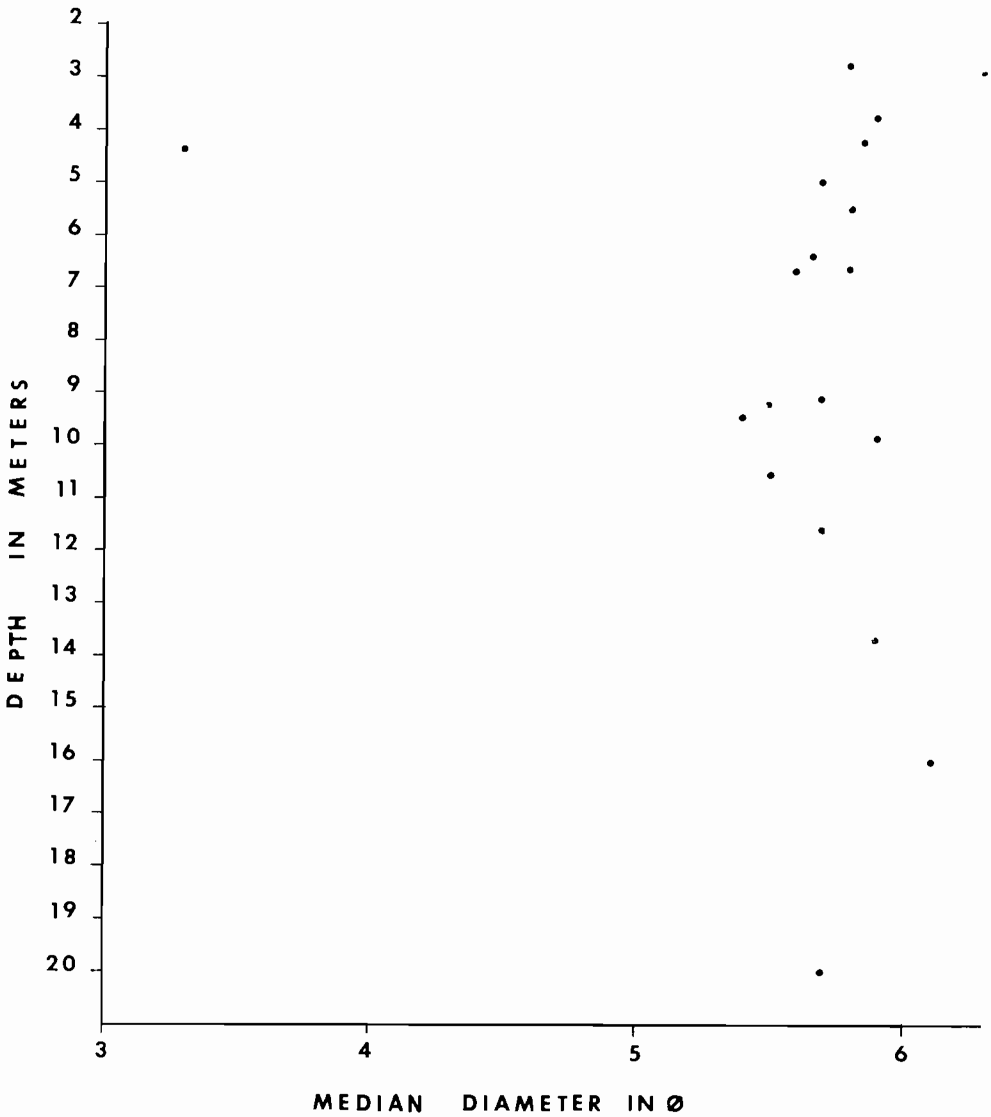

Fig. 7. The relation between depth and median diameter.

and modified by Anwar & Mohamed (1970). The average carbonate content for the Bay is 61·2%. The maximum value (94·5%) was secured off Jahra while the minimum value (50·9%) occurred at Al-Akaz island. Most samples had a carbonate content between 50·9% and 72·7%.

Organic matter

The organic matter content was determined in twenty washed, dried, samples and expressed as organic carbon using the method described by El-Wakeel & Riley (1957). The values of organic matter content were listed in Table 2. It was found that the lowest

Table 2. Some chemical characteristics of water and sediments of Kuwait Bay

Sample no.	Salinity‰ 1 m above the bottom	Carbonate in sediments (%)	Organic matter in sediments (%)
1	52·35	94·5	0·058
2	50·13	56·3	0·652
3	—	69·1	0·397
4	46·00	54·5	0·177
5	48·10	50·9	0·475
6	47·01	52·7	0·533
7	45·82	58·9	0·889
8	—	56·3	0·770
9	45·50	54·5	0·635
10	45·13	52·7	0·475
11	46·17	56·3	0·770
12	47·19	63·6	—
13	48·01	65·4	1·601
14	50·19	72·7	1·127
15	47·00	58·9	0·832
16	—	63·6	0·295
17	40·00	54·5	0·397
18	47·41	60·0	1·008
19	44·24	70·1	1·127
20	41·27	67·2	0·771
21	40·37	52·7	1·008
22	51·95	—	—
Average	47·95	61·2	0·700

— = Not determined.

organic matter content is present near the western side of the Bay where it reached 0·058% and the northern and northeastern parts of the Bay, where the organic matter is below 0·5%. The highest amount of organic matter content is present near Umm-Al-Nammel island and in the area located between Ras Aguza and the entrance of the Bay (Fig. 14).

Generally, the amount of organic matter decreases from the southern side to the northwestern and northeastern sides of the Bay where the organic matter content reaches an amount less than 0·5%. Thus, the areas which have highest organic matter content are situated near the places of greatest human production of organic matter. However, this area is characterized by low organic matter content as compared to the calculated world average for nearshore sediments (i.e. 2·5% organic carbon (Trask 1939).

DISCUSSION AND CONCLUSION

In order to interpret the distribution of the bottom sediments in Kuwait Bay, it is necessary to know the sources and the factors under which the bottom sediments were

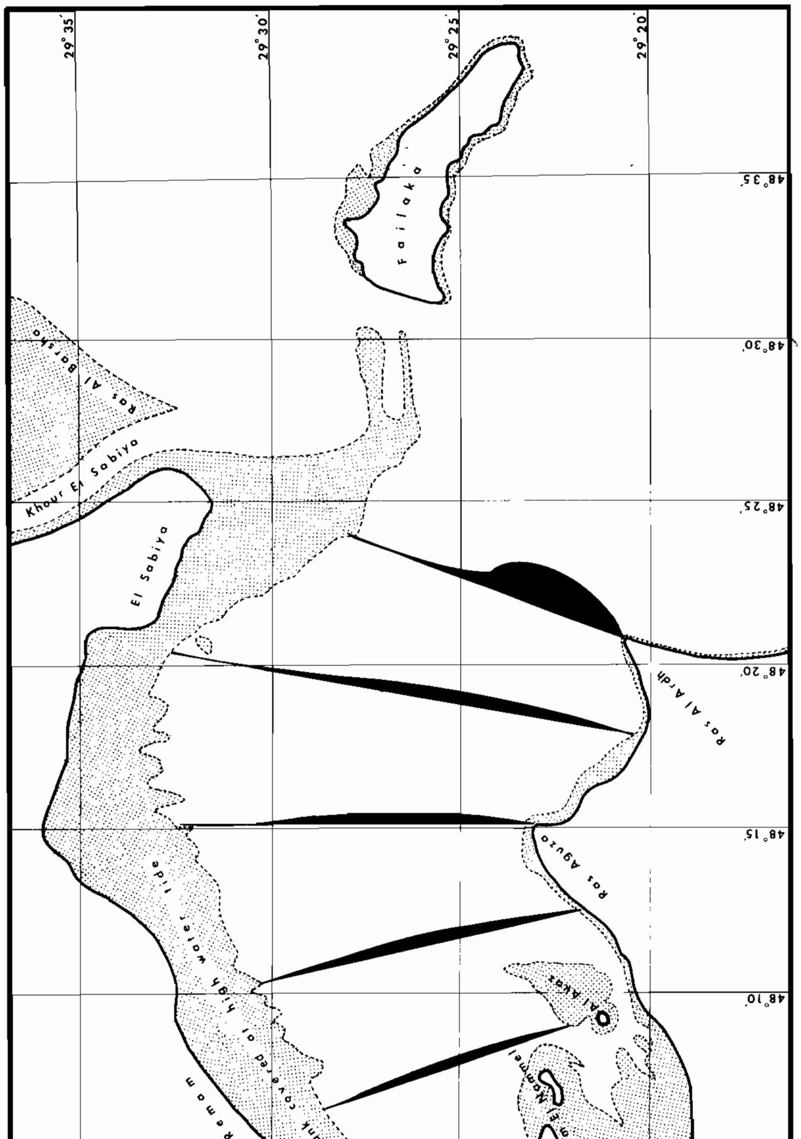

Fig. 8. The profiles showing the bottom configuration.

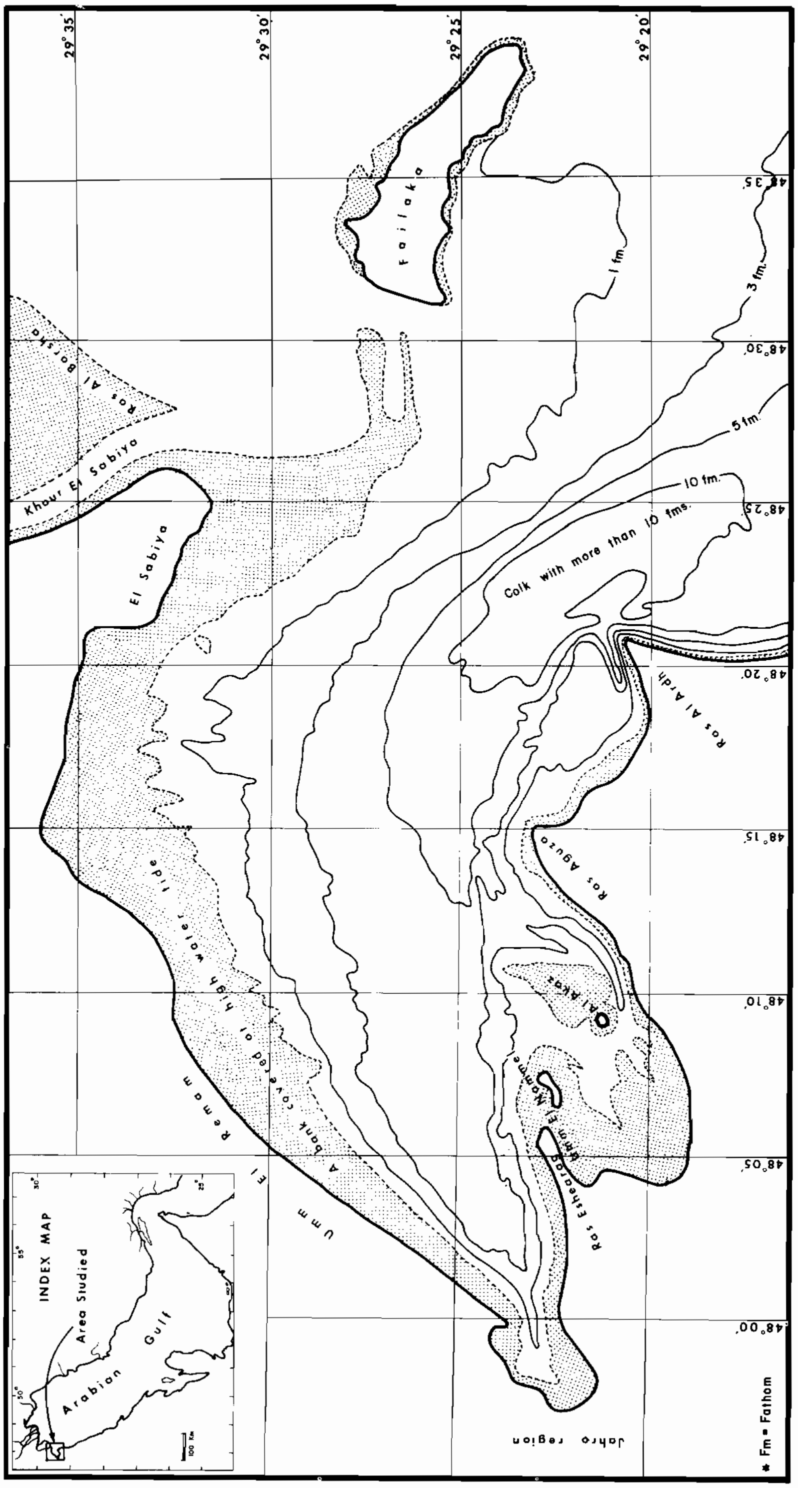

Fig. 9. Contour map showing the bottom configuration.

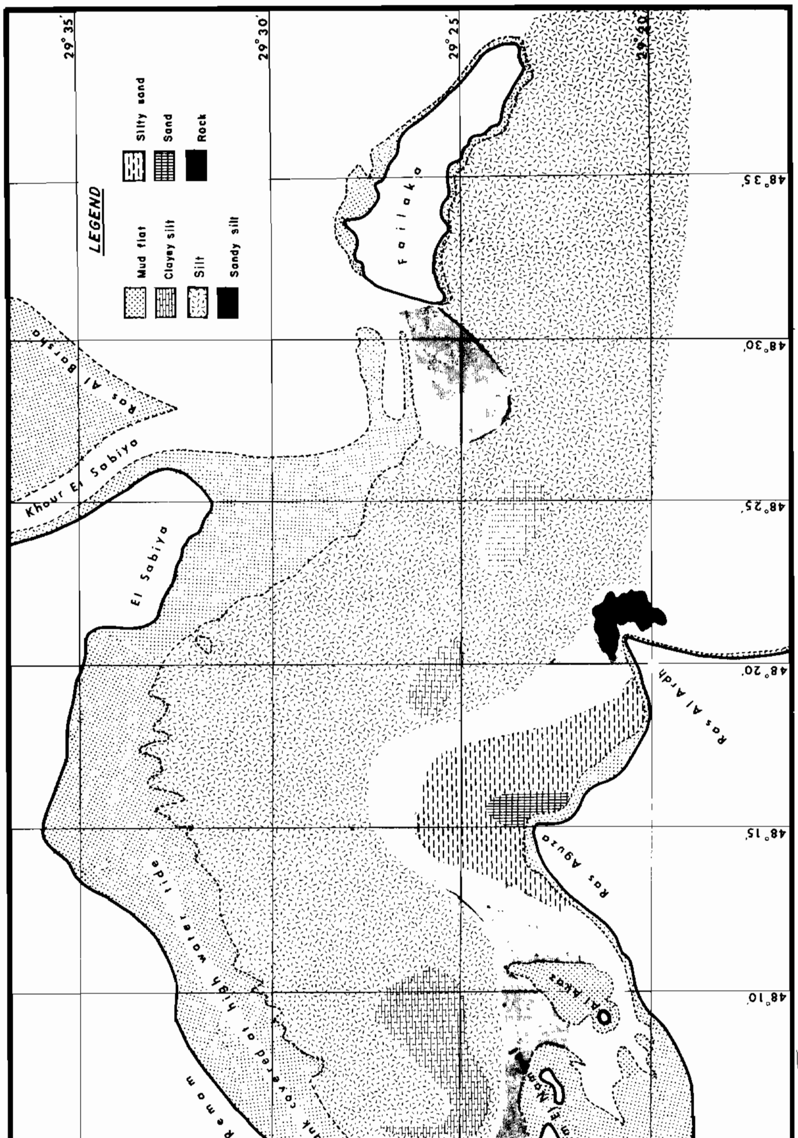

Fig. 10. Sediment distribution map.

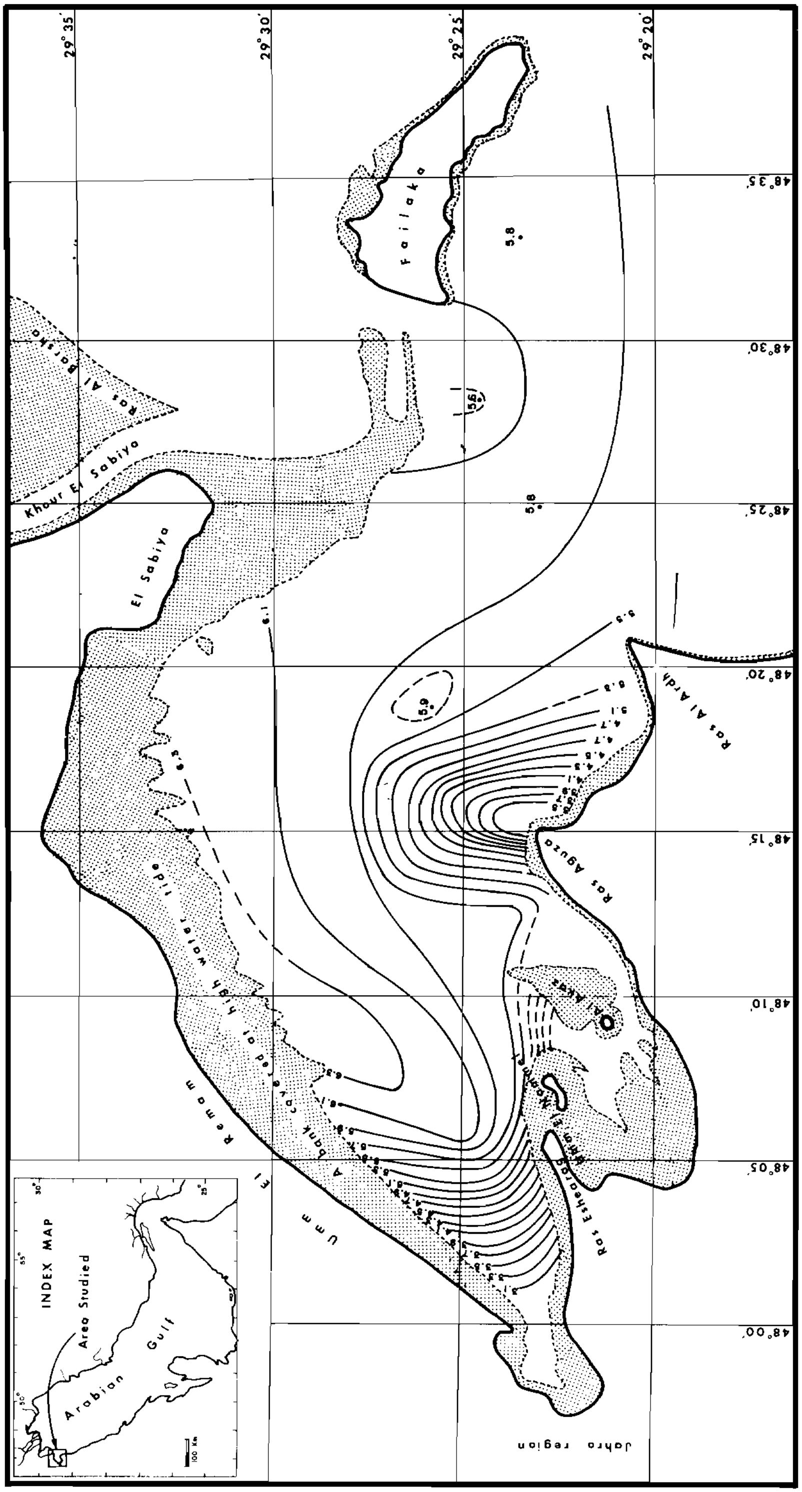

Fig. 11. The distribution of median diameter.

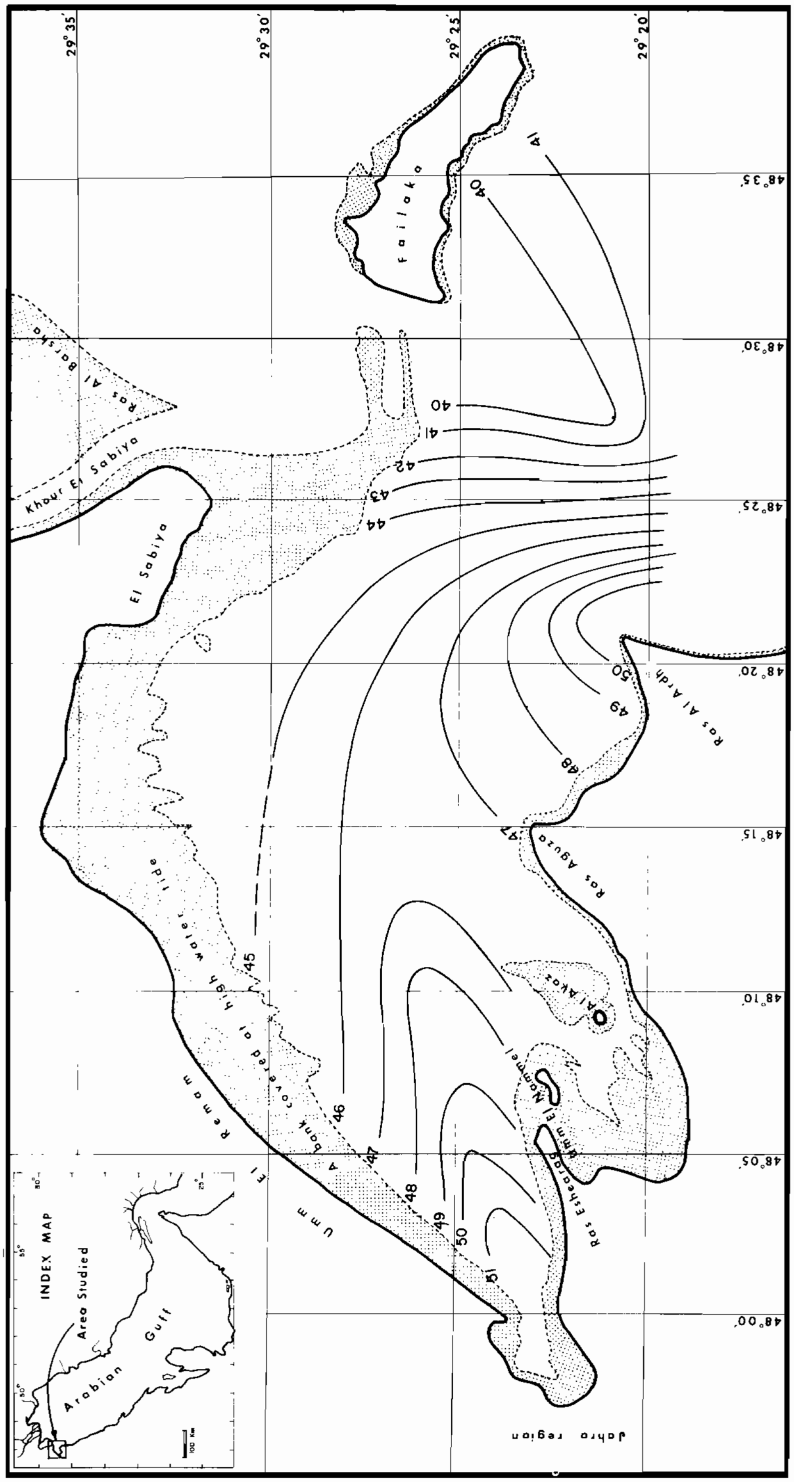

Fig. 12. Salinity of waters near the bottom of Kuwait Bay (samples taken 1 m above the bottom).

deposited. The bottom of Kuwait Bay is more or less covered with silt, especially in the northern half of the Bay. According to Knappen, Tippetto, Abbett & McCarty (1953), the average amount of suspended load of the Tigris river near Baghdad is 800 g/m^3. Philip (1968) stated that most of the load derived from the Tigris and Euphrates rivers is deposited north of Qurna and only the clay size detrital material remains in suspension, while Berry, Brophy & Naqash (1970) maintain that most of the suspended load is deposited before the river reaches Fao, approximately 10 km north of the Arabian Gulf. Emery (1956) stated that more than 90% of the deposits carried by the Tigris and Euphrates rivers are deposited in Iraqi territory whilst the rest of the sediments is deposited in the northern part of the Arabian Gulf. Therefore, very little detrital material comes out of the Shatt Al-Arab river, with an average carbonate content of 55% (recorded near Fao by Saadallah & Kukal (1969)). However, the major part of detrital material comes from the deposits that fall out from the duststorms in the northern parts of the Arabian Gulf. So the detrital material may originate from two sources: the load of sediments that comes from Shatt Al-Arab in suspension and the fallout dust brought by the northwest winds (shamal). The salinity recorded in Kuwait Bay in June is high, averaging about 47·95% in contrast to 39% and 40% for the Arabian Gulf in the same period. The average carbonate content in Kuwait Bay sediments is about 61·2% which is nearly the same as that in the Arabian Gulf sediments. However, the organic matter content in Kuwait Bay sediments is low, averaging about 0·7% in contrast to 1·7% for the Arabian Gulf sediments. From the foregoing discussion, it appears that the properties of the sediments and their distribution seem to have been controlled by the various factors of the environment, essentially wind, bottom topography, transporting influence of current and waves and biological interference. The only feature recorded in the bottom of the Bay is the colk. The inorganic material is almost entirely supplied from land by the northwest winds that carry dust in silt size from the desert regions. The organic sedimentary material is supplied partly from the sewage pumped into the Bay and partly from plants and animals which live in this area. Accordingly, we can conclude that Kuwaït Bay is characterized by an interplay of marine and terrestrial influences.

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الرواسب الحديثة لخليج الكويت

ممدوح عبد المقصود محمد
قسم الجيولوجيا بجامعة الكويت

خلاصة

الغرض من هذه الدراسة هو القاء الضوء على كيفية توزيع الرسوبيات البحرية الحديثة على قاع خليج الكويت والعوامل المتحكمة في ذلك ، مع رسم خريطة لتضاريس القاع . ولتحقيق ذلك تم جمع اثنتين وعشرين عينة من رسوبيات القاع تمثل منطقة مساحتها ٩٠٠كم^{٢} تقريبا ، واتضح من البحث أن رسوبيات تلك المنطقة تأتي من مصدرين رئيسيين الاول هو رسوبيات شط العرب التي تحملها التيارات البحرية الى خليج الكويت وهي في الغالب التيارات الناشئة عن المد والجزر ، والمصدر الثاني هو رسوبيات المناطق الصحراوية المجاورة والتي تحمل بواسطة الرياح وهي في الغالب الرياح الشمالية الغربية المسماة برياح « الشمال » ، هذا بالاضافة إلى بعض المصادر العضوية كبقايا النباتات والحيوانات التي تعيش في المنطقة . والعوامل المتحكمة في توزيع هذه الرواسب هي غالبا التيارات البحرية والرياح وتضاريس القاع . وعلى ذلك يمكننا القول بأن رسوبيات المنطقة عبارة عن خليط من أصل بحري وأصل أرضي .