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The inner shelf off the Nile Delta: sediment types and depositional environments

Continental shelf
Nile Delta
Grain size
Residual size
Plateau continental
Delta du Nil
Granulométrie
Sables reliques

M. Kh. El-Sayed
Department of Oceanography, Faculty of Science, University of Alexandria, Alexandria, Egypt.

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ABSTRACT

An analysis of grain size data, together with petrographical and morphological studies of the inner shelf sediments off the Nile Delta, were carried out with the aim of determining the major sediment types and depositional environments. Three sediment types were identified, each of which closely corresponds to a specific depositional environment.

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RÉSUMÉ

Le plateau continental interne devant le delta du Nil : types de sédiments et environnements sédimentaires.

L'analyse granulométrique comme l'étude pétrographique de sédiments recueillis en surface dans la zone interne du plateau continental qui s'étend devant le delta du Nil permettent de distinguer les types essentiels de sédiments et de définir l'environnement sédimentaire. Trois types de sédiments ont été identifiés, chacun d'eux se trouvant pratiquement déposé dans un environnement sédimentaire particulier.

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INTRODUCTION

The remarkable erosion of the shoreline of the Nile Delta has been intensively studied by sedimentologists and coastal engineers. The inner shelf area in front of the delta is believed to have undergone minor sedimentological changes, especially since the construction of the Aswan High Dam, which has prevented the Nile discharge.

Shelf sediments off the Nile Delta have been investigated by El-Wakeel *et al.* (1974), El-Wakeel and El-Sayed (1978) and El-Wakeel and Moussa (to be published). Detailed studies on the shelf and the Nile Cone sediments and structure have been carried out by Ross and Uchupi (1977) and Summerhayes *et al.* (1978).

The purpose of the present study is to distinguish the different sediment types and depositional environments along the inner shelf off the Nile Delta.

Area of study:

The inner shelf area extends from Alexandria to Port Said, and from the outer margin of the foreshore area up to a depth of some 50 m (Fig. 1).

EXPERIMENTAL BASIS FOR THE ANALYSIS OF DATA

A polarizing microscope was used to examine the particle morphology, petrography and the sediment constituents of a number of samples taken from the area under investigation.

The present work was based in part on the results of grain-size analysis of inner shelf samples already reported by Moussa (1973), El-Wakeel *et al.* (1974) and El-Wakeel and El-Sayed (1978). In their studies, however, the grain-size statistical parameters of Trask (1932) were applied, while in the present work, phi-notation rather than millimetre values was used as a size-scale.

The median diameter (M d φ), quartile deviation (QD φ), inclusive standard deviation (σ_I), inclusive skewness (S k_I) and kurtosis (K_G) were applied as statistical parameters following the equations of Folk and Ward (1957). Correlation coefficient values for these parameters were also determined according to Davis (1973).

Locations of bottom samples selected for this study are shown in Figure 1.

RESULTS AND DISCUSSION

Several investigations of the areal distribution of Nile shelf sediments (e. g. El-Wakeel *et al.*, 1974 and Summerhayes *et al.*, 1978) have revealed that terrigenous mud and sand are by far the major sediment constituents, in addition to bioclastic and carbonate deposits. The present paper has conveniently grouped the inner shelf sediments on the basis of petrographical and morphological investigation into three major types:

Nile deposits (terrigenous sediments)

Nile deposits constitute the major sediment type of the inner shelf area. Their origin was confirmed after a series of studies concerning their texture, chemistry and mineralogy (Emelyanov, 1972; El-Wakeel *et al.*, 1974; Summerhayes *et al.*, 1978; El-Wakeel, El-Sayed, 1978 and El-Wakeel, Moussa, to be published).

Residual sands

Terrigenous and/or relict types

Particle morphology revealed the coarse nearshore sand to consist of sub-rounded to rounded quartz grains coated by ferruginous materials. Similar sand is known to cover most of the nearshore area between Alexandria and Port Said. This sand has been clearly observed beyond the Lake of Burullus.

In the present study, this sand was identified as relict which was modified from ancient terrigenous sand. Summerhayes *et al.* (1978) noticed the occurrence of such sand and reported that it is probably of relict type.

Bioclastic sand

Shells of Molluscs and Echinoids were found to be dominant in the terrigenous deposits off the Nile Delta. Maerl covers much of the middle and outer shelves between Rosetta and Damietta (Summerhayes *et al.*, 1978). Accumulations of detrital branching coralline algae were recently observed by the author in the coastal and nearshore areas off El-Mex, west of Alexandria. Their occurrence is attributed to their transport from deeper areas and reflects the favourable conditions for their formation during the late Pleistocene.

Aeolianite-chemogenic deposits

Wind-laid carbonate oolitic deposits have recently been found to cover the inner shelf area off Alexandria (El-Wakeel, El-Sayed, 1978). It would be expected that when these oolitic deposits reach the sea bottom, they act as seeds for further carbonate sedimentation from the sea water. The term "aeolianite-chemogenic deposits" will be introduced to describe such deposits overgrown by chemical carbonate precipitation.

Grain-size parameters

Grain-size parameters were used to distinguish and confirm the sediment types, and consequently the depositional environments.

The plot of M d φ versus σ_I (Fig. 2) shows three fields of sediment population, each characterizing a definite sediment type. Field I represents the terrigenous sediments (type 1) and is characterized by the good to moderate sorting values. The residual sands (type 2) have well sorted values (field II). Field III represents the poorly sorted aeolianite-chemogenic deposits (type 3).

The relation between M d φ and S k_I (Fig. 2) shows that fields I and III have coarse skewed to strongly fine skewed values, while field II is of fine skewed to strongly coarse skewed values.

The relation between M d φ and K_G (Fig. 2) shows that a normal kurtosis type characterizes field I. Field II is of leptokurtic values, while field III represents both values.

Depositional environments

Previous attempts have been made to classify the shoreline of the Nile Delta, and hence the shelf beyond it,

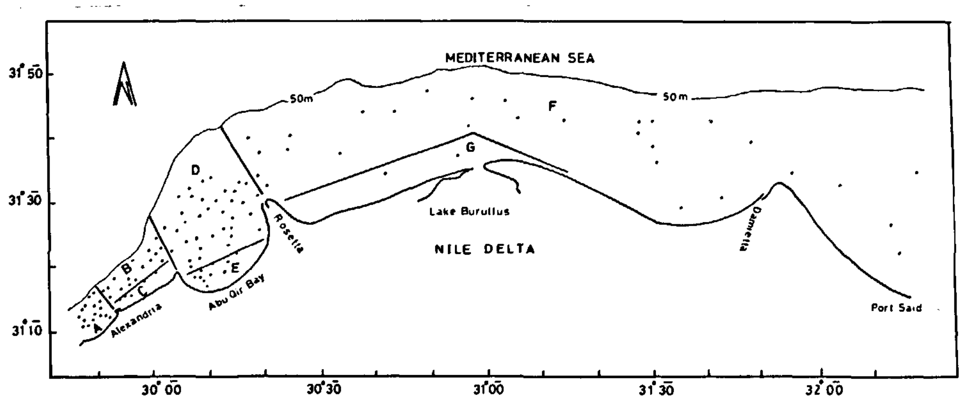


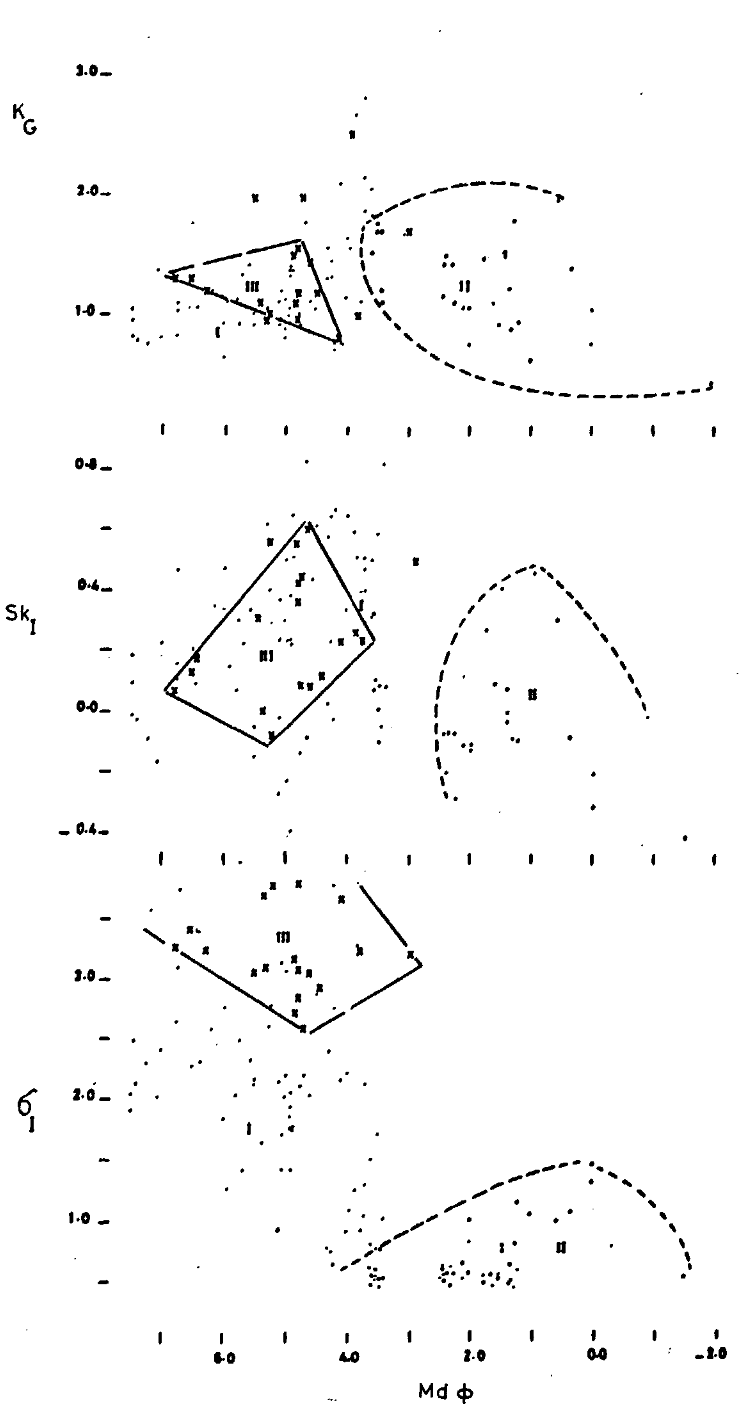
Figure 1
Area of study, locations of bottom samples and depositional environments.

Table 1
Depositional environments and sediment types.

			Depositional environments	Sediment types
3		A	Alexandria-west (marine)	Aeolianite-chemogenic deposits
2	1	B	Alexandria-northeast (deltaic-marine)	Nile deposits $(t+b)$
2	1	C	Alexandria-nearshore (shallow marine)	$t+b+r$
2	1	D	Abu Qir-north (deltaic-marine)	Nile deposits $(t+b)$
2	1	E	Abu Qir-nearshore (shallow marine)	$t+b+r$
2	1	F	Rosetta-Port Said-north (deltaic-marine)	Nile deposits $(t+b)$
2		G	Rosetta-Port Said-nearshore (shallow marine)	$t+b+r$

t, terrigenous sediments; *b*, bioclastic sand; *r*, relict sand.

Figure 2
Scatter diagrams of M *d* φ *versus* σ_I, S k_I *and* K_G *(small dots = terrigenous deposits from areas* B, D, F *and course dots = residual sands from areas* C, E, G *and* X = *aeolianite – chemogenic deposits from area* A).



into different sedimentary regions (Orlova, Zenkovich, 1974; El-Wakeel *et al.*, 1974; El-Wakeel, El-Sayed, 1978; Summerhayes *et al.*, 1978). A convenient classification for the depositional environments of the inner shelf is given in the present paper on the basis of sediment types and grain-size parameters (Fig. 1 and Table 1):

1) A deltaic-marine environment covered by terrigenous and bioclastic deposits (areas B, D and F in Fig. 1).

2) A shallow-marine environment covered by bioclastic and relict sands (areas C, E and G).

3) A marine environment, which is not directly affected by the Nile deposits, and is covered by the aeolianite-chemogenic deposits (area A).

Values of the correlation coefficient between M *d* φ and the other statistical parameters for the inner shelf sediments regarding their depositional environments are given in Table 2.

Residual sands as indices for the areas of erosion

The inner shelf area might be expected to have been continuously eroded since the construction of the Aswan High Dam. The exposed residual sands serve as indices to distinguish areas of erosion. The dominant eastward current would winnow up the fine deposits which are not recently compensated by modern Nile deposits, leaving the residual sands. Emery and Neev (1960) have observed that the easterly longshore drift has transported the Nile sands to the beaches of Israel. El-Wakeel *et al.* (1974) have reported that the near

Table 2
Values of correlation coefficient between the statistical parameters of the inner shelf sediments, with regard to their depositional environments.

Depositional environments			M *d* φ			
			QD φ	σ_I	S k_I	K_G
3		A	0.82	0.98	−0.49	−0.35
2	1	B	−0.30	−0.82	0.83	0.38
2	1	C	0.56	0.27	−0.26	−0.25
2	1	D	−0.32	0.20	0.30	0.38
2	1	E	0.20	0.27	0.20	−0.55
2	1	F	−0.15	0.16	0.32	0.10
2		G	0.80	0.72	−0.10	−0.48

bottom currents on the Nile shelf move eastwards at a velocity of less than 20 cm.sec^{-1}, while surface water moves in the same direction with an average velocity of about 25 cm.sec^{-1}. Hilaly (1971 *b*) noted that the area off Burullus is affected by a littoral current reaching a maximum speed of 100 cm.sec^{-1}. It was observed during the present study that residual sands existed in this particular area. Both observations could lead to the conclusion that the area off Burullus is being subjected to drastic erosion.

CONCLUSION

The inner shelf off the Nile Delta is believed to reflect minor sedimentological changes.

The present work revealed that the area is basically covered by terrigenous and bioclastic deposits, and is covered by aeolianite-chemogenic deposits off Alexandria. Residual sands are also observed in the nearshore area and could serve to distinguish areas of erosion.

Depositional environments have been classified on the bases of sediment types and grain-size parameters into: a deltaic marine, shallow marine and marine environments.

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