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# STUDY OF COASTAL SEDIMENTS, WEST OF ALEXANDRIA (EL-AGAMI - SIDI KREIR)

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## ABSTRACT

Although, the beaches west of Alexandria and their shorelines have been studied for geological and geomorphological aspects as part of the study of the northern coast of Egypt; but there were, little information on the coastal sediments and their cyclic changes between El-Agami and Sidi Kreir. The coast, extending along El-Agami and Sidi Kreir, is a part ofthe main seaside resort in Egypt, seasonally attracting millions of holiday makers. Complete modification of segments of the coastline extending from Alexandria to El-Agami, has resulted from rapid construction to house the fast-growing population and to accommodate industry and shipping at Egypt's principal port. Therefore, this study aims to provide baseline information on the sediment characterictics of this specific area. Allover the period, the beach and nearshore sediments of the study area have to be studied for the determinations of their texture, chemical and mineralogical characteristics during two major seasons (summer & winter). The conclusions expected from this study could be useful and applicable for further coastal zone management planning and development.

## 1. INTRODUCTION

Beaches are inherently unstable, as the beach sands are constantly shifted by the waves, nearshore currents and winds.At times the shoreline migrates landward, destroying homes built too close to the sea. Human reaction is to maintain the property in the face of the natural processes of shoreline erosion.The Mediterranean coast of Egypt of the Pleistocene age, extends about 900 km inlength from Sallum to Rafah and is cut by the two branches of the Nile river. Although Alexandria is not considered as part of the northern Nile delta proper from geomorphologic point of view, serious imlpications of the sea level rise on the city must be expected. Many problms are existing along Alexandria western coast including beach erosion, pollution and man-made coastal development. These problems affect coastal planing and management.

## 2. AREA OF STUDY

The area of study extends from El-Dekheila to Sidi Kreir (west of Alexandria) for about 24.5 km, between latitudes 31º. 08′. 19"N and 31º. 01′. 23"N and longitudes 29º. 49′. 23"E and 29º. 37′. 40"E (Fig. 1). The shoreline of this area is characterized by its straight extension with slight undulations and gentle slope. It is only truncated by the west Noubariya drain nearby Abu Talat beach. The shoreline is in most places sandy, with a relatively wider beaches which widen westwards except at El-Agami headland where the shoreline is rocky. The coast of this area is covered with fine sand, white carbonate sands are more distinguished westward. The sand of these beaches is generally packed hard on the foreshore, and these beaches having very gentle foreshore slopes. The shoreline of this area is exposed to erosion processes and therefore coastal protection is taken into consideration as in the nearshore area of $6^{th}$ October Beach. The general current regime off Alexandria was found to be parallel to the shoreline, and directed northeasterly or southwesterly (Abdallah, 1978 and Eid, 1979). Several geological studies of the northern part of Egypt including Alexandria region and its surroundings, started since the last two centuries. According to Warne & Stanley, (1993) Alexandria region can be subdivided into a series of distinct geomorphic units which are: beach, carbonate ridge, inland depression, drain and canal, low hill, semidesert, reclaimed lagoon and irrigated farmland.

## 3. MATERIALS AND METHODS

### 3.1 Collection and treatment of samples

Sampling was carried out along ten profiles perpendicular to the shoreline (Fig. 2a) to cover evenly the whole investigated area. Each profile was divided into several stations, the station spacing was at least ten meters, from a fixed point in the upper beach to the position where the nearshore core was taken at a depth from 0.5 to 1m in the sea. The period of the sampling has never exceeded one day for all the beaches to ensure uniform conditions. An overall 190 beach samples and 20 short cores were collected in summer and winter seasons. The collected sediment samples were left to dry in air, then disaggregated, and splitted by the cone and quarter technique. The quartered samples were divided into two portions for the different analysis. The first portion was used for grain size analysis and the second portion for the chemical analysis. The second portion was rewashed then dried at 105°C and pulverized to pass a 3ø sieve kept in dry for chemical analysis. The core samples were collected from the nearshore area for each profile from depths 0.5 to 1m (Fig. 2b). These cores were dissected at different levels according to bedding, if they are clearly layered., and were subjected to the same steps of the surface.

### 3.2 Laboratory study

The sieving technique was only applied on the sediments that lacking fractions smaller than 4.0Ø (0.063 mm). The four statistical parameters graphic mean size (MzØ), inclusive graphic standard deviation ($б_I$Ø), inclusive graphic skewness ($Sk_I$) and graphic kurtosis ($K_G$) were calculated according to Folk &Ward (1957). Calcium and magnesium were determined for carbonate analyses as described by Riley (1958). The total carbonate was determined by indirect method according to Vogel (1978). The organic carbon was estimated by the direct method described by El-Wakeel and Riley (1957). Twelve representative beach samples were used for X-ray diffraction analysis in order to identify the crystalline forms and the relative abundance of the carbonate minerals. A multivariate statistical technique used to identify a relatively small number of factors that can be used to represent relationships among sets of interrelated variables.

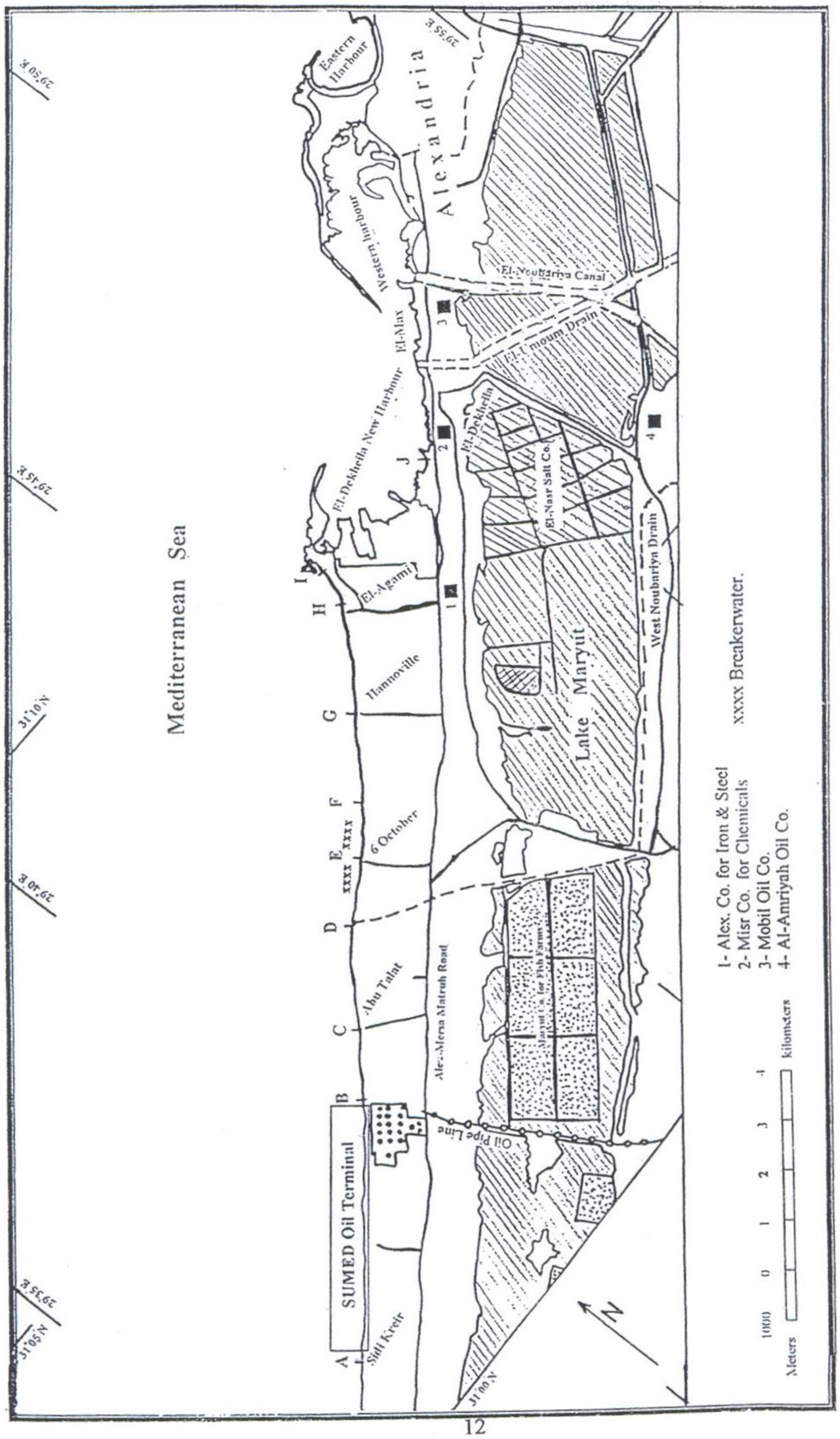


Fig. (1): Beaches west of Alexandria and locations of the profiles (A-J) from Sidi Kreir in the west to El-Dekheila in the east.

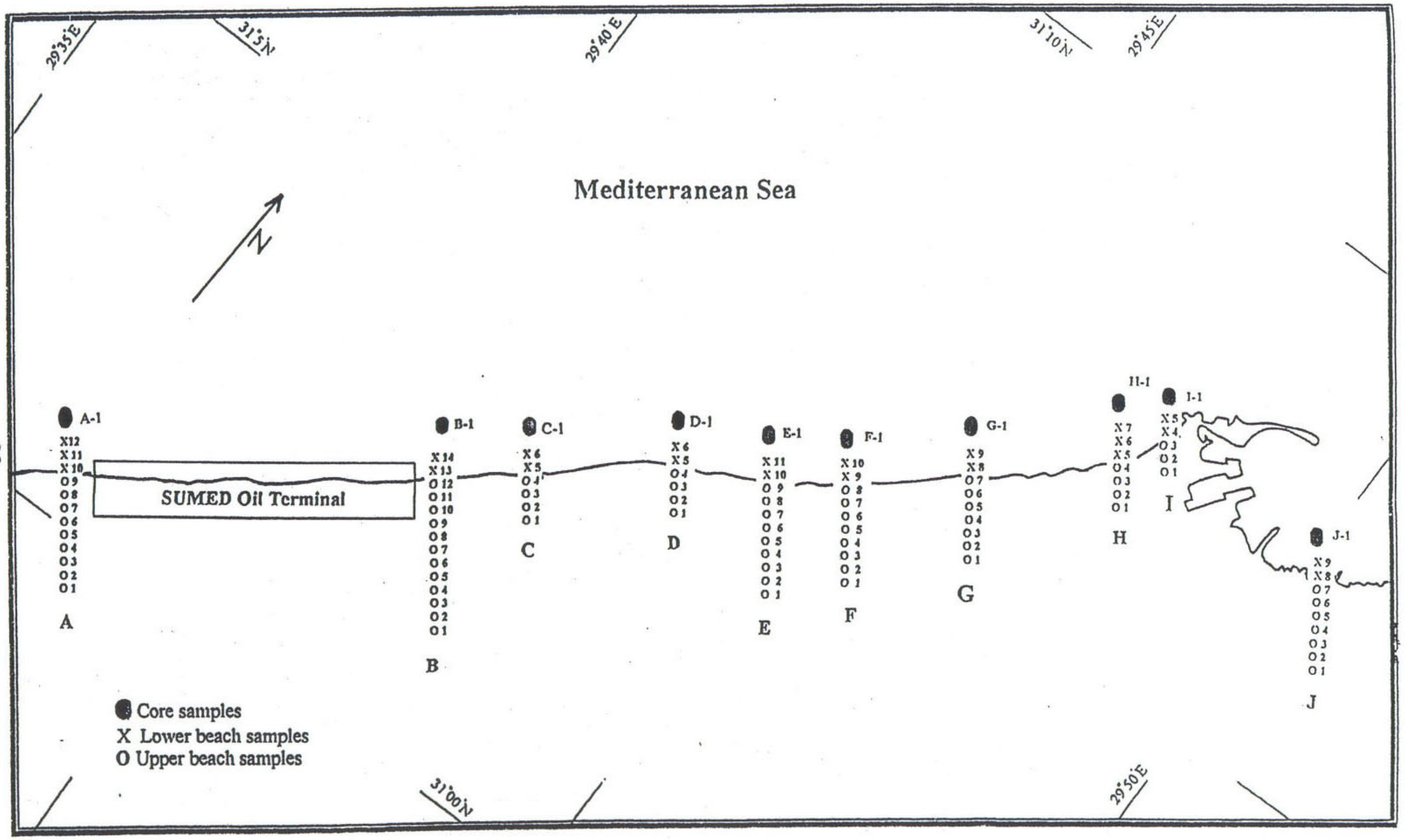


**Fig. (2a): Sampling locations in summer period 2000 / 2001.**

(Natural scale of beach sampling is 10m between the stations)

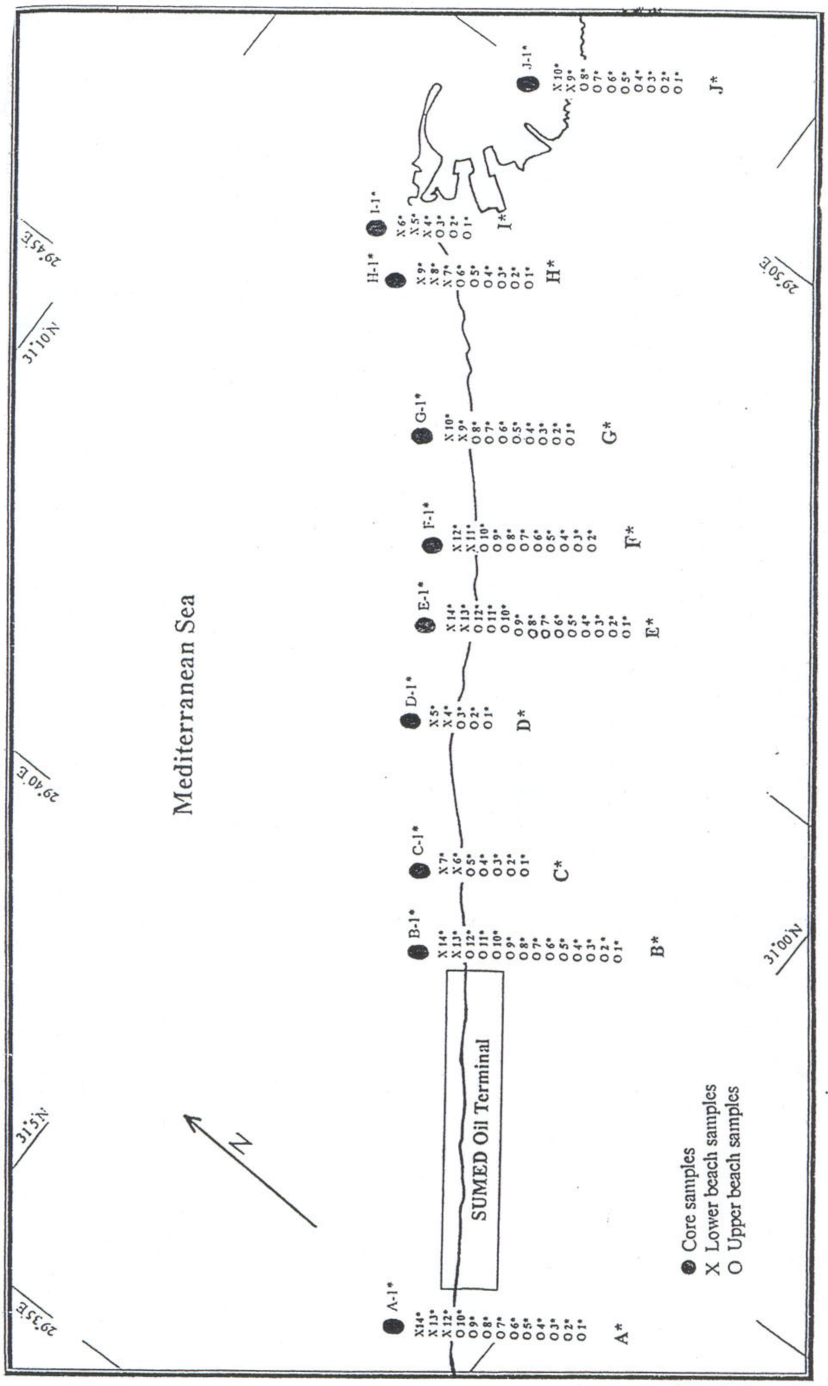


**Fig. (2b): Sampling locations in winter period 2000 / 2001.**
(Natural scale of beach sampling is 10m between the stations)

# 4. RESULTS AND DISCUSSION

## 4.1. Grain size analysis

### 4.1.1. Beach sediments

The beach sediments covering the study area extending from El-Dekheila to Sidi Kreir, were medium to fine sands with few coarse sand samples. In most profiles, the inclusive graphic mean size (MzØ) is decreasing seaward except in profiles (B and C) in winter and profile (G) in summer (Table 1). Thus, in the surf zone the undertow of backwash transports coarser sediment toward the breaker zone. In the mean time sediments are brought from the open sea into the breaker zone. Thus, in the breaker zone the coarse sediments are more abundant. If waves reach the beach at rather low angles, stronger longshore currents are produced which results in an active sediment transport parallel to the coast. This leads to sediment sorting, where only the sediment grains, which are in equilibrium in the surf zone and with longshore current are transported along the coast, while moving back and forth. The other grain sizes are transported to the breaker zone or swash zone. It was also noticed that the inclusive graphic mean size (MzØ) was increasing from west to east in the direction of the current regime of the area, in the same time there is a decrease in sorting ($б_I$Ø). This could be attributed to the effect of the prevailing longshore current having a general eastward direction, which winnows out the eroded finer sands leaving the coarser ones in the direction of wave driven sediments. The inclusive graphic standard deviation ($б_I$Ø) ranged from well sorted to poorly sorted and the major parts of the study area were covered by well and moderately sorted sediments. The inclusive graphic skewness ($Sk_I$) of sediments varied between very negatively and positively skewed and major parts of the study area were covered by negatively and very negatively skewed sediments. This indicates that this area is undergoing erosion according to Duane (1964).who mentioned that negative skewness characterized the environments undergoing erosion, while positive skewness for the depositional ones. He alsoconsidered that the negative skewness produced by winnowing action, whereas the positive skewness resulted from the accumulation of the fine sediments in sheltered environment. The inclusive graphic kurtosis ($K_G$) ranged between very platykurtic to very leptokurtic.

Thus we may conclude that in the present study, accretion occurring during the summer period where the surface sediments of most beaches of this area, were relatively finer, better sorted and more symmetrically skewed than they were during the erosion winter period. During this erosion winter period the sediments of the studied profiles tend to be coarser, poorly sorted and more negatively skewed, while there is no obvious trend of kurtosis between the two periods. The beach includes a wide variety of constituents, among which are the bioclastic constituents which contribute enormous quantity of fragments during the stormy periods. These constituents are the products of shoreward wave transport of the detached marine organisms living directly offshore and then carried shoreward. The change of the statistical parameters from one period to another is due to the presence or absence of these shell fragments. Frihy & Komar (1991) mentioned that the beach sand in the eroded areas of the Nile Delta are associated with finer grains rich in heavy minerals. They added that the greater rate of erosion, the finer the beach sand and the richness of its total heavy mineral content. Inversely, the areas of shoreline accretion are associated with coarser sands poor in heavy minerals, and richer in Quartz and Feldspar light minerals. These relationships result from the processes of selective grain sorting as the waves and longshore currents first erode the sand from the beach face, transport the sand along the shore, and finally deposited it in areas of accretion.. Therefore these variations may possibly be due to the differences in the energy conditions of the waves striking the coast at different angles depending upon their local configurations. Differences in textural characteristics and composition of the beach sands are due to local difference in energy conditions of waves, coastal configuration, degree of dominance of fluvial processes, and the lithology of the rocks in the hinterland.

It was also noticed that the inclusive graphic mean size (MzØ) values are negatively significant correlated with the inclusive graphic standard deviation ($б_I$Ø) values (r = -0.65 ;  r = -0.75 in summer and winter repectively). Folk (1974) suggested that the main factors controlling sorting are the size range of material supplied to the environment, type of deposition and current characteristics. Wigley (1961) proposed that poorly sorted sediments indicate a variable or turbulence during deposition. The relation of the mean size versus sorting, is the most sensitive measure for the delineation of the surface sediment types of study area during the two seasons of the study period. Accordingly, it was noticed that the sediments at most beach profiles were generally finer and better sorted during the summer than during winter period.

**4.1.2. Nearshore core sediments**

During summer period, the mean size (MzØ) of the nearshore core sediments showed a maximum value of 2.28Ø at $G_1$ and a minimum value of –0.21Ø at $C_5$ with an overall average of 1.09Ø. The highest average is shown in core (J-1) and the lower average in core (C-1) (Table 2). The trend of grain size tends to be finer with depth in cores (A-1, B-1, D-1, E-1, H-1 and I-1) and to coarser in the rest of cores. This is associated with a better sorting with depth for cores (A-1, B-1, D-1, H-1, I-1 and J-1) and poorly sorted in cores (C-1,   E-1 and G-1), while no variation was observed with depth in core (F-1). The inclusive graphic standard deviation ranged between a maximum value of 1.52 Ø at $E_4$ and a minimum value of 0.51 Ø at $G_1$ and $J_3$ with an overall average of 0.91 Ø. Therefore, the change of the mean size (MzØ) from top to bottom of the cores is attributed to the difference in the sorting values between erosion and accretion periods and to the admixture with shell fragments. It was found that the coarse sands tend to be poorly sorted and the finer grained to be well sorted during the two seasons. The inclusive graphic skewness ($SK_I$) varied between a maximum value of 0.22 at $F_2$ and a minimum value of –0.34 at $C_5$ with an overall average of –0.12. Skewness tends to be positive skewed with depth except in cores B-1, F-1 and I-1. The inclusive graphic kurtosis ($K_G$) ranged from a maximum value of 2.22 at $F_3$ and a minimum value of 0.40 at $E_3$ with an overall average of 1.04. Kurtosis tends to be platykurtic in cores A-1, B-1, G-1 and H-1 while in cores C-1, D-1, E-1 and I-1 tends to be leptokurtic with depth; and symmetrical or no variation in core (J-1).

During winter season (Table 3)., the mean size (MzØ) showed a maximum value of 2.59 Ø at $J_1$ and a minimum value of –0.15 Ø at $I_5$ with an average of 1.77 Ø (medium sand). The highest average is shown in core (J-1) and the lowest average in core (C-1). The grain size tends to be coarser with depth in cores B-1, C-1, D-1, E-1, G-1, H-1 and J-1. The trend of grain size of cores F-1 and I-1 shows that the lower sediments are relatively finer than those of the upper parts. The inclusive graphic standard deviation ranging between a maximum value 1.81 Ø at $I_3$ and a minimum value of 0.38 Ø at $J_1$ and $J_3$ with an overall average of 0.91 Ø. The sorting coefficient tends to be better with depth in cores F-1and I-1; while it is poorly sorted in other cores. The inclusive graphic skewness varied between a maximum of 0.09 at $J_2$ and a minimum of –0.51 at $I_1$ with an average of –0.22. The skewness is positive with depth in cores A-1, F-1, G-1, H-1 and I-1 and negatively skewed in other cores with small variation in core (J-1). The inclusive graphic kurtosis ranging from a maximum value of 1.59 at $E_2$ and a minimum value 0.43 at $D_3$ with an average of 1.17. The kurtosis is platykurtic in cores A-1, B-1, G-1, H-1 and I-1 and leptokurtic in other cores, while it is symmetrical or shows no variation with depth in core (J-1).

**Table (1): The minimum, maximum and average values of the grain size parameters of the beach sediments of the study area, summer and winter 2000/ 2001.**

| Profile. | Locality | Stat. Cons. | Summer 2000/ 2001 | | | Winter 2000/2001 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Aver. | Min. | Max. | Aver. |
| A | Sidi Kreir | MzØ | 0.91 | 1.99 | 1.44 | 0.91 | 1.79 | 1.37 |
| | | б$_I$Ø | 0.38 | 1.06 | 0.69 | 0.52 | 1.11 | 0.79 |
| | | Sk$_I$ | -0.3 | 0.18 | -0.1 | -0.34 | 0.27 | -0.11 |
| | | K$_G$ | 0.77 | 1.43 | 0.97 | 0.78 | 1.73 | 1.14 |
| B | SUMED Oil Terminal | MzØ | 0.71 | 1.72 | 1.12 | 1.03 | 2.41 | 1.41 |
| | | б$_I$Ø | 0.54 | 1.14 | 0.81 | 0.6 | 1.24 | 0.86 |
| | | Sk$_I$ | -0.21 | 0.22 | 0.02 | -0.24 | 0.33 | 0.05 |
| | | K$_G$ | 0.87 | 2.2 | 1.22 | 0.78 | 1.72 | 1.09 |
| C | Abu Talat | MzØ | 0.46 | 2.05 | 1.43 | 0.87 | 2.35 | 1.47 |
| | | б$_I$Ø | 0.46 | 0.8 | 0.61 | 0.45 | 0.95 | 0.97 |
| | | Sk$_I$ | -0.34 | 0.23 | -0.14 | 0.44 | 0.26 | -0.09 |
| | | K$_G$ | 0.85 | 2.46 | 1.26 | 0.93 | 1.84 | 1.19 |
| D | West Noubariya | MzØ | 1.02 | 1.75 | 1.48 | 0.39 | 1.75 | 1.37 |
| | | б$_I$Ø | 0.6 | 1.02 | 0.69 | 0.65 | 1.53 | 0.84 |
| | | Sk$_I$ | -0.56 | 0 | -0.23 | -0.31 | -0.11 | -0.22 |
| | | K$_G$ | 0.84 | 1.71 | 1.03 | 0.81 | 0.93 | 0.86 |
| E | 6$^{th}$ October | MzØ | 0.33 | 1.99 | 1.6 | 1.37 | 2.38 | 1.91 |
| | | б$_I$Ø | 0.53 | 1.42 | 0.72 | 0.31 | 1.19 | 0.66 |
| | | Sk$_I$ | -0.41 | -0.01 | -0.23 | -0.43 | -0.26 | -0.33 |
| | | K$_G$ | 0.42 | 1.17 | 0.86 | 0.82 | 1.84 | 1.08 |
| F | Abu Youssef | MzØ | 0.77 | 1.9 | 1.49 | 1.02 | 1.79 | 1.49 |
| | | б$_I$Ø | 0.61 | 0.86 | 0.75 | 0.66 | 1.14 | 0.81 |
| | | Sk$_I$ | -0.48 | 0.18 | -0.15 | -0.35 | 0.24 | -0.17 |
| | | K$_G$ | 0.41 | 2.06 | 0.91 | 0.73 | 1.28 | 0.85 |
| G | Hannoville | MzØ | 1.32 | 2.57 | 1.91 | 0.74 | 2.15 | 1.75 |
| | | б$_I$Ø | 0.34 | 0.77 | 0.6 | 0.47 | 1.12 | 0.67 |
| | | Sk$_I$ | -0.37 | 0.15 | -0.17 | 0.41 | 0.05 | -0.24 |
| | | K$_G$ | 0.76 | 1.27 | 0.97 | 0.91 | 2.07 | 1.27 |
| H | El-Agami Bittach | MzØ | 2.09 | 2.63 | 2.36 | 1.73 | 2.63 | 2.31 |
| | | б$_I$Ø | 0.34 | 0.72 | 0.52 | 0.29 | 1.24 | 0.6 |
| | | Sk$_I$ | -0.29 | 0.02 | -0.1 | -0.41 | 0.07 | -0.11 |
| | | K$_G$ | 1.06 | 1.8 | 1.24 | 0.81 | 2.27 | 1.37 |
| I | El-Agami Blace | MzØ | 1.81 | 2.49 | 2.27 | 1.03 | 2.6 | 2.13 |
| | | б$_I$Ø | 0.37 | 0.82 | 0.51 | 0.27 | 1.07 | 0.54 |
| | | Sk$_I$ | -0.36 | 0.17 | -0.1 | -0.1 | 0.03 | -0.06 |
| | | K$_G$ | 1.02 | 2.04 | 1.3 | 0.96 | 1.42 | 1.11 |
| J | El-Dekheila | MzØ | 1.77 | 2.26 | 1.99 | 1.85 | 2.55 | 2.23 |
| | | б$_I$Ø | 0.45 | 0.97 | 0.58 | 0.39 | 1.02 | 0.51 |
| | | Sk$_I$ | -0.46 | -0.06 | -0.18 | -0.52 | -0.02 | -0.16 |
| | | K$_G$ | 0.67 | 1.42 | 1.02 | 0.96 | 1.81 | 1.25 |

**Table (2 ): Statistical parameters of nearshore core sediments during summer period 2000.**

| Core No. | Sample level | Depth (cm) | MzØ | $\sigma_I$Ø | $Sk_I$ | $K_G$ | Core No. | Sample Level | Depth (cm) | MzØ | $\sigma_I$Ø | $Sk_I$ | $K_G$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A1** | 0-4 | 0.96 | 1.01 | -0.05 | 1.36 | | **F1** | 0-4 | 1 | 1 | -0.13 | 1.58 |
| **A-1** | **A2** | 8-Apr | 0.92 | 0.93 | -0.11 | 1.81 | | **F2** | 8-Apr | 1.02 | 0.72 | 0.22 | 0.94 |
| | **A3** | 12-Aug | 1.29 | 0.67 | 0.15 | 0.78 | **F-1** | **F3** | 12-Aug | 0.8 | 0.9 | -0.07 | 2.22 |
| | **B1** | 0-5 | 1.1 | 1.09 | -0.05 | 1.57 | | **F4** | 16-Dec | 0.69 | 0.86 | -0.02 | 1.73 |
| **B-1** | **B2** | 10-May | 1.67 | 0.83 | -0.1 | 0.88 | | **F5** | 16-18 | 0.81 | 0.93 | -0.09 | 1.71 |
| | **B3** | 15-Oct | 1.67 | 0.89 | -0.14 | 0.94 | | **G1** | 0-7 | 2.28 | 0.51 | -0.15 | 1.38 |
| | **B4** | 15-19 | 1.9 | 0.83 | -0.26 | 0.94 | | **G2** | 12-Jul | 1.78 | 0.7 | -0.23 | 0.92 |
| | **C1** | 0-5 | -0.19 | 0.98 | -0.22 | 0.44 | **G-1** | **G3** | 14-Dec | 2.04 | 0.59 | -0.22 | 1.64 |
| | **C2** | 10-May | 0 | 1.33 | -0.2 | 0.83 | | **G4** | 14-18 | 1.67 | 0.67 | -0.18 | 0.86 |
| **C-1** | **C3** | 15-Oct | -0.07 | 1.17 | -0.06 | 0.54 | | **G5** | 18-24 | 1.19 | 0.79 | 0.2 | 0.82 |
| | **C4** | 15-20 | -0.06 | 1.15 | -0.08 | 0.51 | | **H1** | 0-8 | 1.36 | 1.18 | -0.21 | 1.17 |
| | **C5** | 20-27 | -0.21 | 1.2 | -0.34 | 0.9 | **H-1** | **H2** | 14-Aug | 1.92 | 0.68 | -0.19 | 1.04 |
| | **D1** | 0-4 | -0.11 | 1.18 | -0.26 | 0.49 | | **H3** | 14-19 | 1.89 | 0.65 | -0.16 | 0.98 |
| **D-1** | **D2** | 8-Apr | 0.15 | 1.36 | -0.28 | 1.18 | | **H4** | 19-24 | 1.93 | 0.72 | -0.18 | 0.99 |
| | **D3** | 12-Aug | 1.48 | 0.7 | -0.1 | 0.92 | | **I1** | 0-6 | 1.58 | 0.8 | -0.07 | 0.92 |
| | **D4** | 16-Dec | 1.94 | 0.6 | -0.3 | 1.01 | **I-1** | **I2** | 11-Jun | 1.16 | 1.11 | -0.11 | 1.37 |
| | **E1** | 0-4 | -0.16 | 1.06 | -0.25 | 0.47 | | **I3** | 15-Nov | 2.23 | 0.65 | -0.21 | 1.2 |
| | **E2** | 8-Apr | -0.02 | 1.2 | -0.14 | 0.49 | | **I4** | 15-18.5 | 1.89 | 0.83 | -0.04 | 1.01 |
| **E-1** | **E3** | 12-Aug | 0.41 | 1.47 | -0.11 | 0.4 | | **J1** | 0-5 | 2.02 | 0.54 | -0.08 | 1.04 |
| | **E4** | 16-Dec | 0.31 | 1.52 | -0.17 | 1.06 | **J-1** | **J2** | 10-May | 2.08 | 0.56 | -0.09 | 1.07 |
| | **E5** | 16-18 | 0.03 | 1.22 | -0.13 | 0.48 | | **J3** | 15-Oct | 1.27 | 0.51 | 0.01 | 1.03 |

**Table. (3 ): Statistical parameters of nearshore core sediments during winter period 2000.**

| Core No. | Core Levels | Depth (cm) | MzØ | б$_i$ Ø | $Sk_I$ | $K_G$ | Core No. | Core Levels | Depth (cm) | MzØ | б$_I$Ø | $Sk_I$ | $K_G$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A-1* | $A_1$ | 0 – 5 | 1.51 | 0.77 | 0.22- | 0.96 | F-1* | $F_1$ | 0-2 | 1.76 | 0.82 | 0.48- | 0.95 |
| | $A_2$ | 5 – 10 | 1.57 | 0.67 | 0.23- | 0.92 | | $F_2$ | 8-Feb | 1.39 | 1.16 | 0.31- | 1.25 |
| | $A_3$ | 10 – 15 | 1.8 | 0.6 | 0.27- | 0.96 | | $F_3$ | 12-Aug | 1.97 | 0.69 | 0.33- | 1.15 |
| | $A_4$ | 15 – 17 | 1.46 | 0.74 | 0.11- | 0.79 | | $F_4$ | 12-15.5 | 1.92 | 0.69 | 0.33- | 1.11 |
| B-1* | $B_1$ | 0 – 4 | 2.38 | 0.63 | -0.131 | 1.23 | G-1* | $G_1$ | 0-5 | 2.26 | 0.54 | 0.20- | 1.28 |
| | $B_2$ | 4 – 8 | 2.15 | 0.73 | -0.153 | 1.22 | | $G_2$ | 10-May | 2.07 | 0.65 | 0.23- | 1.18 |
| | $B_3$ | 8 – 12 | 2.11 | 0.7 | -0.197 | 1.05 | | $G_3$ | 13-Oct | 1.74 | 0.74 | 0.21- | 0.96 |
| | $B_4$ | 12 – 17 | 2.01 | 0.78 | -0.183 | 1 | | $G_4$ | 13-16 | 1.47 | 0.7 | 0.11- | 0.74 |
| C-1* | $C_1$ | 0 – 4 | 2.53 | 0.43 | 0.0292 | 1.18 | H-1* | $H_1$ | 0-5 | 2.2 | 0.78 | 0.33- | 1.34 |
| | $C_2$ | 4 – 8 | 2.48 | 0.41 | -0.085 | 1.14 | | $H_2$ | 9-May | 1.72 | 1.25 | 0.42- | 1.5 |
| | $C_3$ | 8 – 12 | 2.42 | 0.42 | -0.079 | 1.23 | | $H_3$ | 12-Sep | 1.87 | 1.25 | 0.04- | 1.13 |
| | $C_4$ | 12 – 16 | 2.3 | 0.52 | -0.118 | 1.24 | | $H_4$ | 14-Dec | 1.55 | 1.27 | 0.29- | 1.24 |
| | $C_5$ | 16 – 19 | 2.39 | 0.56 | -0.037 | 1.32 | I-1* | $I_1$ | 0-5 | 0.19 | 1.81 | -0.46 | 1.56 |
| D-1* | $D_1$ | 0 – 8 | 0.27 | 1.41 | 0.18- | 0.43 | | $I_2$ | 10-May | 0.16 | 1.54 | -0.51 | 1.34 |
| | $D_2$ | 8 – 12 | 1.3 | 1.13 | 0.33- | 1.16 | | $I_3$ | 13-Oct | 0.15 | 1.43 | 0.26- | 1.28 |
| | $D_3$ | 12 –18.5 | 0.2 | 1.48 | 0.19- | 1.29 | | $I_4$ | 13-18.5 | 1.72 | 0.84 | 0.19- | 0.99 |
| E-1* | $E_1$ | 0 – 5 | 2.36 | 0.47 | 0.29- | 1.39 | J-1* | $J_1$ | 0-5 | 2.59 | 0.38 | 0.08- | 1.26 |
| | $E_2$ | 5 – 10 | 2.24 | 0.51 | 0.27- | 1.59 | | $J_2$ | 10-May | 2.52 | 0.4 | 0.09 | 1.34 |
| | $E_3$ | 10 – 14 | 2.07 | 0.75 | 0.41- | 1.5 | | $J_3$ | 10-15.5 | 2.5 | 0.48 | 0.09- | 1.31 |

It appears that the difference or similarity in the grain size parameters from top to bottom of the cores is attributed to the physical conditions of the nearshore area. It was found that the coarse sands tend to be poorly sorted and the finer grains to be well sorted in both summer and winter. In addition, the beaches include a wide variety of constituents, among which are the bioclastic constituents, which contribute high quantity of fragments during the stormy periods. The change of the statistical parameters from one period to another may be due to the presence or absence of these shell fragments.

## 4. 2 CHEMICAL ANALYSIS

### 4.2.1 Beach sediments

In summer, the organic carbon content in the beach sediments ranged from 0.03 to 0.54% with an average of 0.33%, while in winter the organic carbon content ranged from 0.03 to 0.46% with an average 0.22%. Allover the study period, it was noticed that the trend of the organic carbon content in most profiles was decreasing seaward and increasing eastward. The organic carbon content was higher in summer than in winter (Table 4). The relatively lower values of organic carbon in the beach sediments of the study area can be the result of: a) the position of this area further away from the riverine input or terrestrial discharge which is regarded as the main contributer of the organic detritus; b) the remarkable increase of carbonate; and c) waves and longshore and rip currents may remove the fine particles and the associated organic carbon away from the beach. The present work findings are agreeable with Revelle and Shepard (1938), who mentioned that the decrease in the organic carbon seaward is explained by the increase of the grain size and the carbonate content. The lower values of organic carbon in winter period are attributed to the coarsening of sediments than in summer period. The correlation between the organic carbon content and the mean size (MzØ) of the beach sediments shows a significant positive correlation in summer and a weak positive correlation in winter. According to Trask (1932), the main cause of the increase of organic matter in fine particles is the similarity in the settling velocity of both organic constituents and fine particles. The correlation between the organic carbon and the determined total carbonate content showed significant negatively correlation in summer and insignificant negatively correlation in winter. This may be attributed to the uniform chemical composition of the beach sediments of the study area.

In summer period, the $CaCO_3$ % varied from 68.64 to 82.40% with an average 77.55% while the $MgCO_3$% from 8.10 to 23.50% with an average 14.76%. The determined total carbonate ranged between 85.60% and 99.40% with an average of 95.06% while in winter, the $CaCO_3$ % varied from 70.93 to 81.49% with an average 77.80% and the $MgCO_3$% from 9.32 to 20.73% with an average of 14.85%. The determined total carbonate was ranging between 87.40% and 98.60% with an average 95.02%. It was noticed that the trend of calcium carbonate tends to increase seaward in profiles A, C, E, G and I and decrease in other profiles while the trend of magnesium carbonate is different in these profiles in summer. The trend of magnesium carbonate is decreasing seaward in profiles A, C, D, F and I and increasing in other profiles while the calculated calcium carbonate is increasing seaward in most profiles except profile (I) in winter. The trend of determined total carbonate is increasing seaward in most profiles except A and E in summer and A, C and H in winter. It is noticed that there is no sharp difference in the distribution of the latter parameters from west to east and between the two seasons. Most of the beach sands have total carbonate values exceeding 85% and are homogenous in distribution. The correlation between the total carbonate content and the mean size (MzØ) values in this study showed insignificant correlation in summer and winter (Table 5). The calculated calcium carbonate is negatively significant correlated in the two seasons with the magnesium carbonate. This may be attributed to the uniformity of chemical as well as physical composition, of sediments of the study area which are composed almost of pure carbonates of sand-sized grains. The non-arrival of riverine muds or terrestrial discharge also plays a leading role in keeping the sediments of the western part of the Egyptian shelf as highly carbonate content.

**Table (4): The minimum, maximum and average values of the chemical parameters (in %) of the beach sediments during periods 2000 / 2001.**

| Profile. | Locality | Chemical parameters (%). | Summer | | | Winter | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Max. | Aver. | Min. | Max. | Aver. |
| A | Sidi Kreir | Org. C. % | 0.03 | 0.42 | 0.27 | 0.12 | 0.31 | 0.23 |
| | | $CaCO_3$ % | 75.21 | 81.96 | 79.27 | 76.58 | 79.71 | 78.44 |
| | | $MgCO_3$ % | 9.05 | 20.73 | 14.09 | 12.42 | 18.2 | 15.42 |
| | | Tot.Carbonate % | 92.8 | 99 | 96.18 | 93 | 98.2 | 96.13 |
| B | SUMED Oil Terminal | Org.C. % | 0.17 | 0.33 | 0.24 | 0.18 | 0.35 | 0.24 |
| | | $CaCO_3$ % | 76.84 | 81.04 | 79.26 | 77.5 | 81.49 | 79.46 |
| | | $MgCO_3$ % | 8.11 | 15.64 | 13.25 | 10.91 | 16.04 | 13.76 |
| | | Tot.Carbonate % | 90.6 | 97.6 | 95.2 | 93.2 | 98.2 | 95.54 |
| C | Abu Talat | Org. C. % | 0.21 | 0.3 | 0.25 | 0.12 | 0.33 | 0.23 |
| | | $CaCO_3$ % | 77.28 | 82.15 | 79.26 | 76.06 | 81.38 | 79.19 |
| | | $MgCO_3$ % | 11.39 | 13.85 | 12.82 | 10.88 | 15.9 | 13.57 |
| | | Tot.Carbonate % | 92.4 | 97.8 | 95.01 | 93.2 | 97.5 | 95.04 |
| D | West Noubariya | Org. C. % | 0.2 | 0.53 | 0.38 | 0.2 | 0.32 | 0.27 |
| | | $CaCO_3$ % | 71.41 | 76.95 | 74.17 | 73.71 | 77.79 | 75.39 |
| | | $MgCO_3$ % | 8.1 | 21.61 | 16.34 | 12.3 | 17.53 | 14.74 |
| | | Tot.Carbonate % | 85.6 | 97 | 93.33 | 90 | 96.4 | 92.56 |
| E | $6^{th}$ October | Org. C. % | 0.31 | 0.54 | 0.46 | 0.14 | 0.46 | 0.23 |
| | | $CaCO_3$ % | 68.64 | 76.2 | 72.79 | 74.14 | 79.93 | 77.64 |
| | | $MgCO_3$ % | 13.59 | 23.5 | 17.69 | 10.6 | 20.73 | 14.66 |
| | | Tot.Carbonate % | 91.65 | 96.6 | 93.36 | 87.4 | 98.2 | 95.54 |
| F | Abu Youssef | Org. C. % | 0.24 | 0.43 | 0.33 | 0.03 | 0.36 | 0.14 |
| | | $CaCO_3$ % | 73.44 | 81.04 | 76.32 | 72.86 | 79.18 | 75.95 |
| | | $MgCO_3$ % | 12.05 | 19.91 | 15.26 | 14.41 | 19.95 | 16.9 |
| | | Tot.Carbonate % | 90.6 | 96.2 | 94.34 | 92.4 | 98.2 | 95.54 |
| G | Hannoville | Org. C. % | 0.27 | 0.43 | 0.37 | 0.03 | 0.26 | 0.15 |
| | | $CaCO_3$ % | 75.1 | 81.71 | 78.36 | 75.43 | 79.93 | 77.85 |
| | | $MgCO_3$ % | 11.33 | 18.9 | 14.06 | 9.32 | 15.93 | 13.68 |
| | | Tot.Carbonate % | 92.8 | 96.9 | 95.03 | 88 | 97.8 | 93.98 |
| H | El-Agami Bittach | Org. C. % | 0.3 | 0.37 | 0.33 | 0.03 | 0.39 | 0.22 |
| | | $CaCO_3$ % | 75.4 | 79.08 | 77.76 | 74.14 | 79.82 | 77.83 |
| | | $MgCO_3$ % | 14.07 | 18.25 | 16.99 | 10.07 | 16.89 | 14.83 |
| | | Tot.Carbonate % | 94.2 | 99.4 | 97.43 | 92.6 | 98.4 | 94.78 |
| I | El-Agami Blace | Org. C. % | 0.32 | 0.4 | 0.36 | 0.25 | 0.42 | 0.34 |
| | | $CaCO_3$ % | 75.21 | 81.24 | 78.03 | 70.93 | 79.07 | 76.23 |
| | | $MgCO_3$ % | 12.01 | 15.49 | 13.44 | 12.71 | 19.4 | 17.07 |
| | | Tot.Carbonate % | 90.6 | 96.2 | 94.24 | 92.8 | 98.6 | 95.97 |
| J | El-Dekheila | Org. C. % | 0.3 | 0.4 | 0.35 | 0.14 | 0.37 | 0.29 |
| | | $CaCO_3$ % | 77.5 | 82.4 | 79.59 | 73.82 | 80.36 | 78.12 |
| | | $MgCO_3$ % | 10.52 | 17.85 | 13.83 | 12.69 | 16.48 | 14.22 |
| | | Tot.Carbonate % | 94 | 98.2 | 96.02 | 87.8 | 97.8 | 94.36 |

**Table (5): Correlation coefficient values between the chemical parameters of the beach sediments during summer period 2000.**

| | Summer | | | | | Winter | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MzØ | Org. C% | $CaCO_3$% | $MgCO_3$% | $TCO_3$ % | MzØ | Org. C% | $CaCO_3$% | $MgCO_3$% | $TCO_3$ % |
| MzØ | 1 | | | | | 1 | | | | |
| Org. C% | 0.311** | 1 | | | | 0.089 | 1 | | | |
| $CaCO_3$% | -0.046 | -0.448** | 1 | | | -0.014 | -0.087 | 1 | | |
| $MgCO_3$% | 0.108 | 0.201 | -0.733** | 1 | | 0.037 | -0.066 | -0.478** | 1 | |
| $TCO_3$ % | 0.08 | -0.319** | 0.325** | 0.398** | 1 | 0.069 | -0.14 | 0.419** | 0.562** | 1 |

** Correlation is significant at 0.01level.
* Correlation is significant at 0.05 level.

### 4.2.2. Nearshore core sediments

During summer period (Table6), the organic carbon content varied between 0.03 and 0.60% with an average of 0.26%. Core (D-1) is characterized by sediments rich in organic carbon with an average content of 0.42%, and a minimum of 0.06% is found in core (G-1). The surface layers are rich in organic carbon than the lower parts of cores C-1, E-1, H-1 and J-1 and the opposite is shown in the other cores. This is due to the difference in the accumulation of solid organic particles to the surface sediments of the cores and the reduction or absence of the shell fragments. The $CaCO_3$ % ranged between 73.67% and 81.6% with an average 77.58%. The $MgCO_3$% varied from 11.02% to 20.5% with an average of 15.91%. Core (C-1) is characterized by the highest average of calcium carbonate (80.53%) and lowest of magnesium carbonate (12.69%) and the inverse pattern (74.34%, 20.06% respectively) was shown in core (H-1). The determined total carbonate content varied between 91% and 98.6% with an average of 96.12%, whereas the highest average of 97.25% was shown in core (B-1) and the lowest average of 94% in core (A-1). The surface sediments have higher values of carbonates than the lower parts of the cores B-1, C-1 and J-1 and the inverse pattern in the other cores. This resulted from to the marked increase of the shell fragments in the upper parts than the lower parts and the opposite pattern for the other cores. This downward increase in carbonates is attributed to the marked increase of shell fragments in the lower parts of the cores. The rapid accumulation of the recent organic carbon rich deposits in such a reducing environment would prevent the decomposition of the buried shell fragments.

During winter (Table 7), the organic carbon content ranged between 0.18% and 0.54%, with an average of 0.37%. The sediments of core (J-1) were characterized by the highest average of 0.46% of the organic carbon content and the lower average of 0.24% in core (B-1). The surface layers are richer in organic carbon than the lower parts of cores D-1, F-1, G-1 and H-1; and it shows opposite pattern in the other cores. The $CaCO_3$% ranged between 74.36% and 82.15% with an average of 78.73% whereas the highest average is 80.54% as shown in core (J-1) and the lower average is 76.66% in core (I-1) which shows that the trend of the $CaCO_3$ content tends to decrease with depth in cores E-1, F-1 and G-1 and increase in the reset of cores. The $MgCO_3$% varied from 10.44% to 19.21% with an average of 14.82%; the highest average of 16.79% is in core (H-1) and the lower average of 13.05% is in core (C-1), and increasing with depth in cores A-1, F-1, G-1 and H-1and decreasing in the reset of cores. The determined total carbonate content varied between 91% and 99.8% with an average of 96.12%. Thus it is clear that the surface layers are richer in carbonate than the lower parts of cores B-1, D-1, E-1, G-1 and J-1, and an opposite trend was observed in the other cores. Core (D-1) is characterized by higher values and lower values in core (G-1) which averages 97.87%, 94.3% respectively. The nearshore core sediments, similar to the beach sediments, are characterized by a high content of carbonates. It seams that the richness in the carbonate content resulted from two factors: the eroded carbonate-rich coastal materials and the mixing of sediments with shell fragments of gastropods, lamellibranchs and other calcareous debris (El-Wakeel and El-Sayed, 1978).

### 4.3 Carbonate mineralogy

X–ray diffraction analysis of representative beach samples revealed that aragonite is the main constituent of these carbonate sediments; followed by Mg-calcite. Minor amounts of calcite and dolomite were recorded (Fig. 3). In general, along the study area, the aragonite ranges between 28 and 92% with an average of 73.42%. Mg-calcite varied from 5.33 to 64.56% with an average of 21.28% and calcite ranged from 0.53 to 9.54% with an average of 3.06% while dolomite ranged between 0.19 and 7.64% with an average of 1.55%. The aragonite content decreases eastward while the other minerals tend to increase eastward. This could be attributed to the decrease of the oolitic carbonates eastward and admixture of sediments with shell fragments.

The richness in the carbonate content is attributed to materials derived from the inland carbonate ridges and to the calcareous skeletons in the sediments of this area. It has been reported that the contribution of biogenic clastics to Alexandria beach sediments reaches values up to 75% from the bulk sand fraction, and they are the primary sources of carbonates to Alexandria coast and the calcium and magnesium are rather a good expression for the biogenic origin of sediments in the different beaches, or the oolitic sands (El-Sayed & Khalil, 1980). It is worthy to mention that the marine calcareous skeletal remains are not only the source responsible for the relatively high content of calcium and magnesium but the oolitic carbonate sediments derived from the inland ridges; beside the oolitic grains already occurring on the continental shelf contribute to the rise of the calcium and magnesium carbonate content in the sediments of this area. Emelyanov (1972) showed that the oolites of the Mediterranean African shelf sediments are composed mainly of aragonite with lesser content of calcite. Alexandersson (1972), in his work on the cementation of Mediterranean beach rocks, suggested that the precipitation of aragonite appears to be a “subordinate” process in the Mediterranean at the present time and he regarded the aragonite ooids off the Gulf of Gabes, southern Tunisia, as reworked material, derived from the coastal Holocene oolites. The high content of aragonite in the area of study could be attributed to the presence of ooids (non-skeletal), which was formed mostly during the Pleistocene (Anwar *et al.*, 1981), where the environmental conditions at present do not favor its precipitation. The favorable environmental conditions such as the presence of magnesium ions and suitable seawater temperature that are conductive for the precipitation of aragonite rather than calcite. In addition, aragonite could be also derived from the relict oolitic carbonate sediments, forming the ridges. The relatively low Mg-calcite content recorded in the study area sediments could be attributed to the biogenic carbonate debris as in the beaches of Agami and El-Dekheila.

**Table ( 6 ): Chemical parameters (in %) of the nearshore core sediments, summer period 2000.**

| Core No. | Sample Level | Org.C % | CaO % | MgO % | $CaCO_3$ % | $MgCO_3$ % | Determined T.Carbonate % | Core No. | Sample Level | Org.C % | CaO % | MgO % | $CaCO_3$ % | $MgCO_3$ % | Determined T.Carbonate % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | 0.31 | 43.6 | 6.76 | 77.87 | 14.2 | 94.8 | | $F_1$ | 0.15 | 43.11 | 7.19 | 76.98 | 15.1 | 95 |
| A-1 | $A_2$ | 0.29 | 42.88 | 5.9 | 76.57 | 12.38 | 91 | | $F_2$ | 0.18 | 41.82 | 9.65 | 74.68 | 20.27 | 97 |
| | $A_3$ | 0.41 | 43.89 | 7.15 | 78.38 | 15.02 | 96.2 | F-1 | $F_3$ | 0.31 | 43.04 | 8.63 | 76.85 | 18.12 | 96 |
| | $B_1$ | 0.21 | 44.95 | 7.03 | 80.27 | 14.76 | 98 | | $F_4$ | 0.33 | 43.09 | 7.89 | 76.95 | 16.57 | 96.2 |
| B-1 | $B_2$ | 0.32 | 43.9 | 6.78 | 78.39 | 14.25 | 95.6 | | $F_5$ | 0.41 | 42.69 | 9.22 | 76.23 | 19.36 | 97 |
| | $B_3$ | 0.26 | 45.69 | 6.67 | 81.6 | 14 | 98.6 | | $G_1$ | 0.03 | 41.98 | 8.26 | 74.97 | 17.35 | 95.2 |
| | $B_4$ | 0.35 | 45.32 | 6.19 | 80.93 | 13 | 96.8 | | $G_2$ | 0.05 | 41.62 | 8.53 | 74.31 | 17.91 | 95 |
| | $C_1$ | 0.32 | 45.26 | 6.23 | 80.82 | 13.07 | 96.8 | G-1 | $G_3$ | 0.04 | 42.34 | 8.45 | 75.61 | 17.74 | 96.2 |
| | $C_2$ | 0.29 | 44.83 | 6.31 | 80.05 | 13.25 | 96 | | $G_4$ | 0.15 | 41.99 | 8.32 | 74.99 | 17.47 | 95.4 |
| C-1 | $C_3$ | 0.26 | 45.26 | 5.79 | 80.82 | 12.15 | 94.4 | | $G_5$ | 0.03 | 42.59 | 8.6 | 76.05 | 18.06 | 97.1 |
| | $C_4$ | 0.23 | 44.58 | 6.64 | 79.6 | 13.94 | 96.4 | | $H_1$ | 0.21 | 41.57 | 9.76 | 74.24 | 20.5 | 97 |
| | $C_5$ | 0.32 | 45.57 | 5.25 | 81.38 | 11.02 | 95 | H-1 | $H_2$ | 0.14 | 41.26 | 9.74 | 73.67 | 20.46 | 97.2 |
| | $D_1$ | 0.33 | 43.41 | 6.55 | 77.52 | 13.75 | 94.2 | | $H_3$ | 0.12 | 41.47 | 9.46 | 74.05 | 19.86 | 96.85 |
| D-1 | $D_2$ | 0.39 | 45.5 | 6.75 | 81.25 | 14.18 | 98.2 | | $H_4$ | 0.13 | 42.22 | 9.24 | 75.4 | 19.41 | 97.8 |
| | $D_3$ | 0.7 | 44.08 | 7.1 | 78.71 | 14.91 | 96.4 | | $I_1$ | 0.04 | 42.46 | 8.74 | 75.81 | 18.35 | 96.6 |
| | $D_4$ | 0.34 | 45.18 | 5.78 | 80.68 | 12.15 | 95.4 | I-1 | $I_2$ | 0.22 | 42.22 | 8.29 | 75.4 | 17.41 | 95.8 |
| | $E_1$ | 0.47 | 41.3 | 8.34 | 73.74 | 17.52 | 93.2 | | $I_3$ | 0.29 | 42.86 | 8.46 | 76.54 | 17.77 | 97.3 |
| | $E_2$ | 0.51 | 43.65 | 8.08 | 77.94 | 16.97 | 97.8 | | $I_4$ | 0.2 | 43.56 | 8.31 | 77.78 | 17.44 | 98.2 |
| E-1 | $E_3$ | 0.25 | 43.94 | 6.97 | 78.46 | 14.64 | 96 | | $J_1$ | 0.38 | 42.46 | 8.94 | 75.81 | 18.78 | 97.4 |
| | $E_4$ | 0.26 | 42.71 | 7.26 | 76.26 | 15.25 | 94.4 | J-1 | $J_2$ | 0.41 | 43.79 | 7.8 | 78.2 | 16.38 | 96.2 |
| | $E_5$ | 0.28 | 44.01 | 6.63 | 78.59 | 13.91 | 94.9 | | $J_3$ | 0.09 | 43.58 | 8.15 | 77.81 | 17.12 | 96.5 |
| **Mean** | | 0.34 | 44.26 | 6.67 | 79.04 | 14.02 | 95.72 | **Mean** | | 0.19 | 42.46 | 8.65 | 75.83 | 18.16 | 96.52 |

**Table (7 ): Chemical parameters (in %) of the nearshore core sediments, winter period 2000.**

| Core No. | Sample Level | Org.C % | CaO % | MgO % | $CaCO_3$ % | $MgCO_3$ % | Determined T.Carbonate % | Core No. | Sample Level | Org.C % | CaO % | MgO % | $CaCO_3$ % | $MgCO_3$ % | Determined T.Carbonate % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | 0.34 | 43.26 | 5.99 | 77.25 | 12.58 | 92.8 | | $F_1$ | 0.46 | 44.7 | 6.01 | 79.82 | 12.62 | 95.4 |
| A-1* | $A_2$ | 0.48 | 42.3 | 8.72 | 75.5 | 18.3 | 96.8 | F-1* | $F_2$ | 0.39 | 45 | 6.48 | 80.36 | 13.61 | 96.8 |
| | $A_3$ | 0.41 | 43.86 | 7.61 | 78.32 | 15.99 | 97.2 | | $F_3$ | 0.42 | 44.64 | 7.41 | 79.71 | 15.55 | 98.2 |
| | $A_4$ | 0.46 | 44.64 | 6.8 | 79.71 | 14.27 | 96 | | $F_4$ | 0.39 | 43.32 | 7.75 | 77.36 | 16.27 | 96.4 |
| | $B_1$ | 0.18 | 44.39 | 7.63 | 79.27 | 16.02 | 97.8 | | $G_1$ | 0.37 | 44.58 | 6.83 | 79.61 | 14.33 | 96.4 |
| B-1* | $B_2$ | 0.29 | 43.09 | 7.54 | 76.95 | 15.82 | 95.4 | G-1* | $G_2$ | 0.54 | 43.32 | 5.89 | 77.36 | 12.36 | 91 |
| | $B_3$ | 0.22 | 46 | 6.66 | 82.15 | 13.98 | 99.1 | | $G_3$ | 0.31 | 43.44 | 7.2 | 77.57 | 15.12 | 95.6 |
| | $B_4$ | 0.27 | 45.51 | 6.6 | 81.26 | 13.87 | 95.7 | | $G_4$ | 0.41 | 44.76 | 5.98 | 79.9 | 12.56 | 94.2 |
| | $C_1$ | 0.25 | 45.2 | 6.53 | 80.71 | 13.71 | 96.1 | | $H_1$ | 0.34 | 42.9 | 6.69 | 76.61 | 14.05 | 93.6 |
| | $C_2$ | 0.21 | 44.33 | 6.61 | 79.16 | 13.88 | 95.8 | H-1* | $H_2$ | 0.54 | 42.24 | 7.83 | 75.43 | 16.45 | 94.8 |
| C-1* | $C_3$ | 0.31 | 43.59 | 6.18 | 77.83 | 12.98 | 93.4 | | $H_3$ | 0.44 | 43.5 | 9.15 | 77.68 | 19.21 | 99.8 |
| | $C_4$ | 0.24 | 45.01 | 7.08 | 80.38 | 14.87 | 98.1 | | $H_4$ | 0.34 | 43.32 | 8.32 | 77.36 | 17.47 | 97.6 |
| | $C_5$ | 0.28 | 46 | 4.99 | 82.15 | 10.47 | 95.3 | | $I_1$ | 0.34 | 41.64 | 8.03 | 74.36 | 16.87 | 94.2 |
| | $D_1$ | 0.42 | 44.7 | 7.83 | 79.82 | 16.45 | 99.2 | I-1* | $I_2$ | 0.33 | 42.54 | 7.24 | 75.96 | 15.2 | 93.5 |
| D-1* | $D_2$ | 0.51 | 44.34 | 6.94 | 79.18 | 14.57 | 96.6 | | $I_3$ | 0.34 | 43.62 | 8.18 | 77.89 | 17.18 | 98 |
| | $D_3$ | 0.34 | 45.12 | 6.8 | 80.57 | 14.29 | 97.8 | | $I_4$ | 0.37 | 43.92 | 7.66 | 78.43 | 16.09 | 98.4 |
| | $E_1$ | 0.34 | 43.74 | 8.2 | 78.11 | 17.22 | 98.2 | | $J_1$ | 0.48 | 44.88 | 7.45 | 80.14 | 15.64 | 97 |
| E-1* | $E_2$ | 0.41 | 44.28 | 7.57 | 79.07 | 15.9 | 98.2 | J-1* | $J_2$ | 0.41 | 45.12 | 6.88 | 80.57 | 14.45 | 96.8 |
| | $E_3$ | 0.44 | 43.26 | 6.52 | 77.25 | 13.7 | 94.4 | | $J_3$ | 0.48 | 45.3 | 4.97 | 80.89 | 10.44 | 92.6 |
| **Mean** | | 0.34 | 44.35 | 6.99 | 79.19 | 14.68 | 96.52 | **Mean** | | 0.41 | 43.83 | 7.16 | 78.26 | 15.02 | 95.81 |

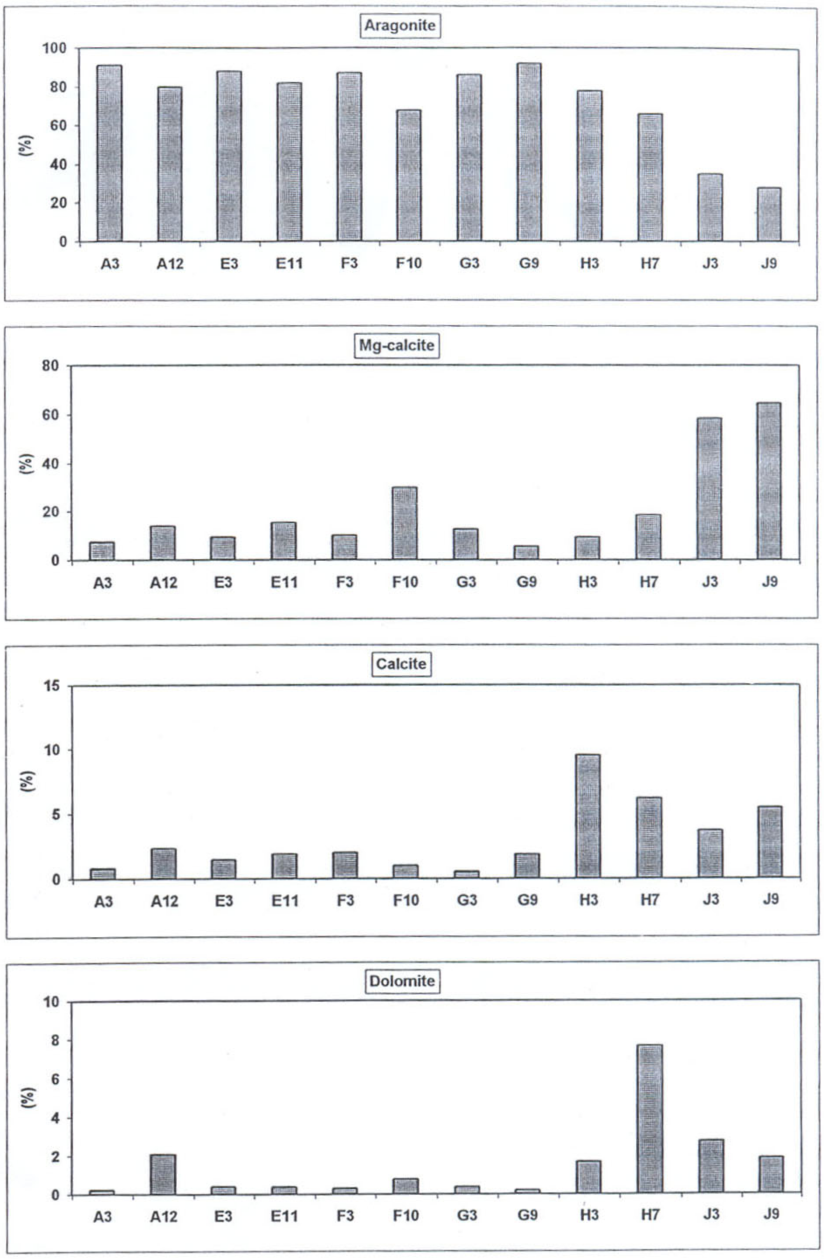


**Fig. (3): The variations of carbonate minerals of the selected beach samples from west to east of study area.**

## 5-CONCLUSION

To conclude, the coastal area between El-Agami and Sidi Kreir bears typical characteristics of the western Mediterranean coasts of Egypt as confirmed from their grain size, chemical and mineralogical features. The shoreline of this area is characterized by its straight extension with slight undulations and gentle slope. It is only truncated by the west Noubariya drain nearby Abu Talat beach. The shoreline is in most places sandy, with a relatively wider beaches which widen westwards except at El-Agami headland where the shoreline is rocky. The coast of this area is covered with fine sand, white carbonate sands are more distinguished westward. The sand of these beaches is generally packed hard on the foreshore, and these beaches having very gentle foreshore slopes. The shoreline of this area is exposed to erosion processes and therefore coastal protection is taken into consideration

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