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LITHOFACIES CHARACTERISTICS OF SUBSURFACE SEDIMENTS OF LAKE EDKU

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Key Words: Geology, Sediments, Limnology, Lake Edku, Egypt.

ABSTRACT

Lithological and petrographical study of sediment borings identifies late Pleistocene and Holocene sedimentary environments in Lake Edku area on the northwestern Nile delta. These sedimentary environments. starting from the top. are: soft lagoon muds extends downward to about 3-13 m. thin layers of marsh lagoon peat-rich muds appeared at depths ranging between 3 and 10 m followed by interbedded Pleistocene alluvial plain silty clay (hard muds). channel sands and stiff fluvial-terrestrial muds extending downward up to 40 m depth from the lake seabed surface. The flood plain muds are embedded with carbonate rock granules between 16 and 35m depth. The lithological and petrographical characteristics of the study subsurface sedimentary facies are attributed to different sedimentary provenances including sediment discharged from the Rosetta branch and former Canopic channel. and transport carbonate rocks derived from the adjacent Pleistocene carbonate ridges at Abu Quir headland.

INTRODUCTION

Earlier discussions of the Sedimentologic and lithostratigraphic history of the Late Quaternary subsurface deposits of the Nile delta was made by, among others, Attia (1954), Butzer (1976), Sneh *et al.* (1986), Said (1981), Anwar *et. al.* (1984), El Askary and Frihy (1986), Sneh *et al.*(1986), Coutellier and Stanley (1987), Frihy (1992), Frihy and Stanley (1987 & 1988) and Arbouille and Stanley (1991), Stanley *et al.* (1992). Generally, Quaternary subsurface stratigraphy of the northern Nile delta consists of, from bottom to top, alluvial sand and stiff mud (older than ~12.000) unconformably overlain by shallow marine to coastal transgressive sand (~12,000 to 8.000). This sand is, in turn, unconformably overlain by a variable sequence of Holocene deltaic sand, silt, and mud as old as ~7.500 yr (Warne and Stanley, 1993).

Lake Edku is one of the four brackish water coastal lagoons of the Nile Delta having communication with the Mediterranean Sea. Limnologically, lake Edku belongs to the open- lake system. Lake Edku lies about 30 km northeast of Alexandria, south of the shoreline of Abu- Qir Bay. It extends east west for a distance of about 19km and has an average width of about 6km and a maximum width is 11 km. The depth of the lake varies between 40 and 150 cm, with an average of about 1m; the deepest parts are restricted to the central and eastern sides of the lake. The lake covers a total area of about 126 km^2, most of it, particularly its eastern side is densely vegetated. Major sediment discharges in this region are the Rosetta branch and the former Canopic channel. The Canopic channel was most from about 3000 to 6000 years B. P., when relative sea level was lower than at present (Chen *et.al.*,1992). During this period, the distributor flowed into what is now the western part of the bay. i.e. between the inlet of Edku Lake and the sector just to the east of Abu Quir headland (Frihy *et. al.*, 1994).

This paper focuses on the reconstruction of the subsurface sedimentary environments in the Lake Edku area based on petrological analysis of engineering borehole samples. As a base the reconstruction was interpreted on the basis of earlier petrological and carbon dates published by others (e.g. Stanley, 1987, 1988; Arbouille & Stanley 1991; Stanley et al. 1992 and Warne & Stanley 1993). Incorporated with this study also the sedimentary provinces contributed in the formation of the constructed environments.

METHODOLOGY

Six undisturbed engineering boreholes namely BH I to BH VI were sampled using trailer -mounted combination rotary percussion machines to a depth of about 40-m by the Arab Foundation Company (Fig. 1).

A total of 80 sediment samples were selected from the 6 boreholes, described and subjected to mechanical analysis to delineate the sedimentological and petrographic characteristics in order to determine the paleoenvironmental conditions under which they were deposited. The texture

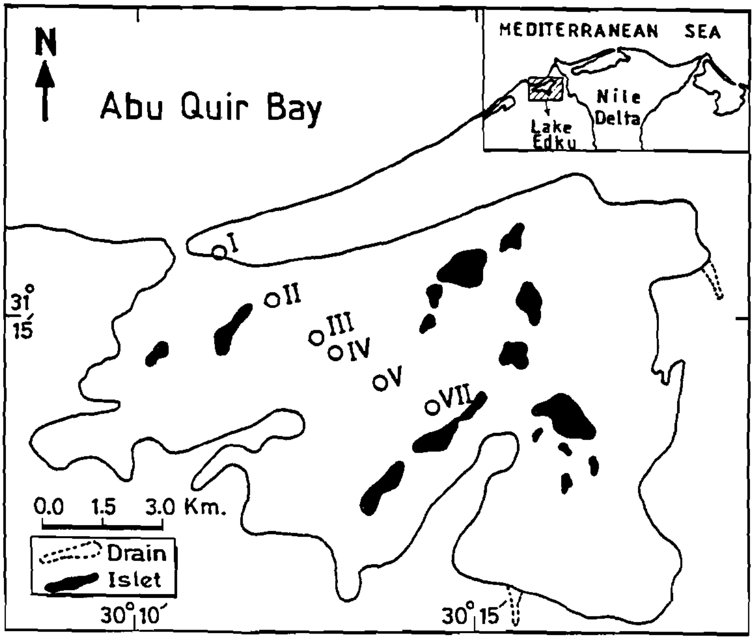

Fig. 1 Map of Lake Edku showing sites of boreholes examined in this study.

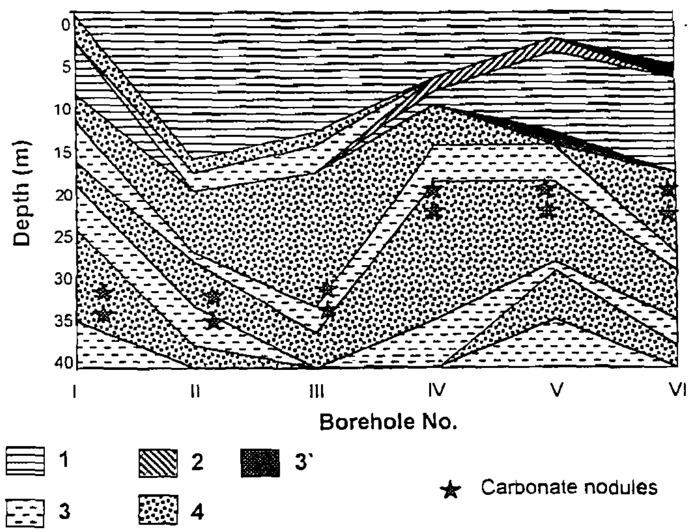

Fig. 2. NW-SE cross-section showing sedimentary environments, starting from the top, are: (1) Soft lagoon muds, (2) thin layers of marsh/ lagoon peat-rich muds, (3) Pleistocene alluvial plain hard muds (3'), channel sands and (4) stiff fluvial-terrestrial muds.

parameters were computed according to Folk and Ward (1957). The composition of sand-size fractions (> 63 microns) in some selected samples was examined under a reflected microscope. This composition includes light and heavy minerals, mica, lithic fragments, aggregates, faunal and floral components. Mineralogical analysis was carried out on selected borehole samples. For X-ray analysis, the samples were ground in mortar to pass through a 44 μ-mesh sieve (nominal diameter) then sprinkled on Vaseline on a glass slide to ensure random orientation. A Philips X-ray diffractometer Model 1060/80 with copper target tube and nickel filter was used. Diffraction was made at 40 Kv, 25 M.A., chart speed 1°/min in the range of 2 °~60° (2 θ), the operating sensitivity was 4x100 counts/sec and the chart speed at 1cm/min. The relative abundance of the minerals was determined by peak height analysis (GRIFFIN, 1971). Scanning electron microscope investigation (SEM) was also done on selected samples. Samples were mounted on aluminum stubs and left to dry then coated with gold and then investigated using Joel (JSM5300) electron microscope. Scanning was carried out at 25-30 Kv.

RESULTS & DISCUSSIONS

Description and interpretation of Late Quaternary facies

The NW-SE section depicting the main subsurface lithofacies units from oldest to youngest is illustrated in Fig. (2). Most of these lithofacies have been described in previous Nile delta investigations (Coutellier and Stanley, 1987; Arbouille and Stanley, 1991, Chen et al., 1992).

Late Pleistocene non-marine facies
Stiff muds

The stiff brown muds lie in the lower most part of some boreholes (I & VI) is equivalent to the Pleistocene fluvial-terrestrial environment rather than marine environments (Abu-Zed and Stanley, 1990). They are accumulated from earlier than ~30,000 years to 18,000 years BP, during the last Pleistocene sea-level high stand and last major eustatic lowering (Chen *et al.*, 1992). They contain iron-stained coarse-grained sand composed largely of quartz grains with feldspar, mica and lithic components. Biogenic components are absent.

Channel sands and flood plain muds

Fine- to coarse-grained, poorly sorted sands occur in the lower portion of most the study boreholes, mostly exceed 10-m thickness. These sands are primarily composed of iron-stained quartz, feldspar mica, lithic fragments and aggregates. Fauna is absent. Sands are interpreted to have been deposited in a major river channel in proximity to the coastline. These sands are interbedded with stiff muds, ranges in thickness from 2 to 4m. The coarse grain fraction composed of quartz, feldspar, iron-stained grains and calcareous nodules. Fauna and flora are scarse to absent in this facies. The sand and mud facies were deposited from 18,000 years BP to 11,000 years BP, during the last major low-stand and the early phases of the subsequent, very rapid sea-level rise. They are interpreted to have been deposited along the flanks of a river channel near the coastline (Chen *et al.*, 1992). The flood plain muds contain limestone granules imbedded in the clay matrix. The higher values of carbonate content were determined by Shata and Okbah (2001) in their geochemical study of the studied cores at depth level range from 16-18m in the southern part and at depth range from 33-36 in northern part of the investigated area. These limestone granules were derived from the adjacent Abu Quir carbonate ridge. They were probably eroded from the ridge into the Lake during heavy storms.

Delta front Holocene facies

Marsh Peat muds

According to Coutellier and Stanley (1987) the Nile delta sediments of Holocene age began to accumulate ~8,000 – 7,000 years BP as the rate of sea-level rise began to decrease (Chen *et al.*, 1992). Peat-rich dark mud layers occur in boreholes V and VI. This marsh facies range in thickness from 0.5 to about 4.5 m (Fig. 2). They are deposited between ~7.500 and 3,000 years B.P., Coutellier and Stanley (1987).

Lagoon Muds

Olive gray to grayish black soft, massive muds occurs in the upper portion of all boreholes of the study area. The thickness of the lagoon deposits ranges from 4 to 12 m. Common components include light and heavy minerals, mica and plant debris. Fauna and flora include foraminifera and ostracods. Equivalent deposits indicated that they were accumulated from ~5,000 years BP to the present (Chen *et al.*, 1992). The delta front deposits of the marsh and lagoon muds accumulated when sea level rose from about –5m to the present position.

Textural characteristics:

The vertical variations of the textural parameters show a general coarsening downward trend (Fig. 3). Generally, the textural trend reveals two main groups of sediment grain sizes; the first comprises of medium to fine sand (1 to 3 Ø) starting from 20m to the base. This group represents the channel sand. The second group includes silty clay (mud) layers (mud) (6to 8 Ø) characterizes the mud environments including the upper lagoon soft muds and the stiff fluvial-terrestrial muds. The vertical variation of mean grain size reflects the variability of their hydrodynamic depositional processes (Wilgey, 1961). This also is confirmed by the vertical variation in their grain sorting (standard deviation) Fig. (3). The minimum values of standard deviation (range of moderately to very well sorted) are found in the lower and middle parts of most boreholes. A wide range of standard deviation values is noticed in the mud unit on the upper parts of the boreholes indicating poorly sorted components.

The discrimination of the depositional environments under which the sediments were deposited was determined by drawing scatter diagrams between the different parameter Fig. (4). The diagram shows that the silty clay layers were deposited in a different depositional environment. These environments are originally related to sediment deposited in the western most part of Abu Quir Bay including Lake Edku.

The mineralogical characteristics:

The X-ray charts revealed the presence of well-crystallized minerals throughout the investigated borhole (Fig.5). Silicate minerals are represented by quartz, which increases downwards. Feldspars exist as accessories mineral at some depth intervals. Clay minerals in the form of Kaolinite are dominated near the surface layer, whereas smectite was dominated at depth intervals of about 37 m (Fig.6). Abu-Zied & Stanley (1990) suggested that the higher proportions of smectite and lower concentrations of kaolinite and illite be recorded in the northeastern than in north-central delta region during Late Pleistocene and Holocene. They also postulated that Late Pleistocene mud accumulated on the subaerially exposed northern delta plain surface during the time of low eustatic stands prior to 10000 years BP. At depth interval of 16m-sediment matrix composed of inorganic limestone granules intercalated and surrounded by clay matrix. Figure 6 illustrates that the carbonate minerals include aragonite, calcite and Mg-calcite. It is interesting to note that both quartz and carbonate minerals were determined also in the clay fraction indicating their authogenic origin (Fig.7).

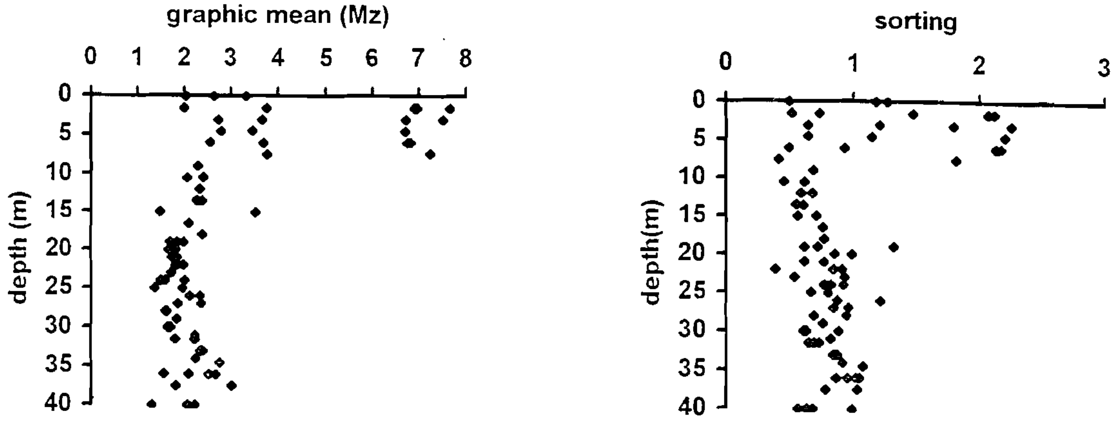

Fig.(3): Variations of statistical parmeters in subsurface sediments of Lake Edku with depth.

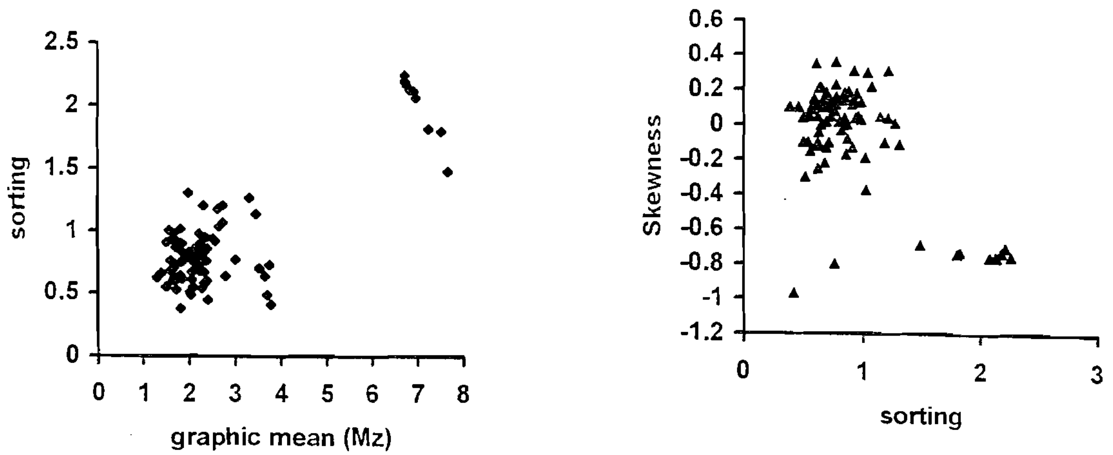

Fig.(4): Discrimination of depositional environments in subsurface sediments of Lake Edku.

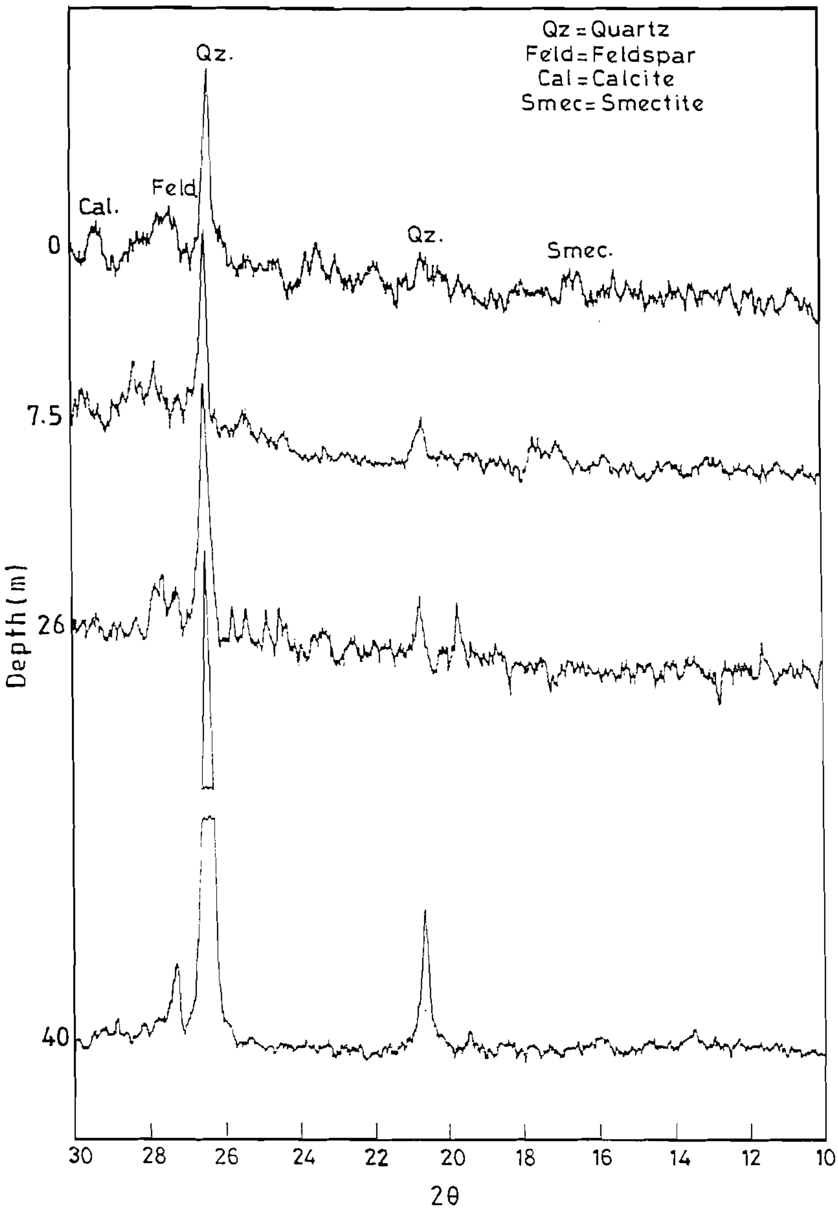

Fig. (5): X-ray patterns for mineralogical composition of subsurface sediments of Lake Edku.

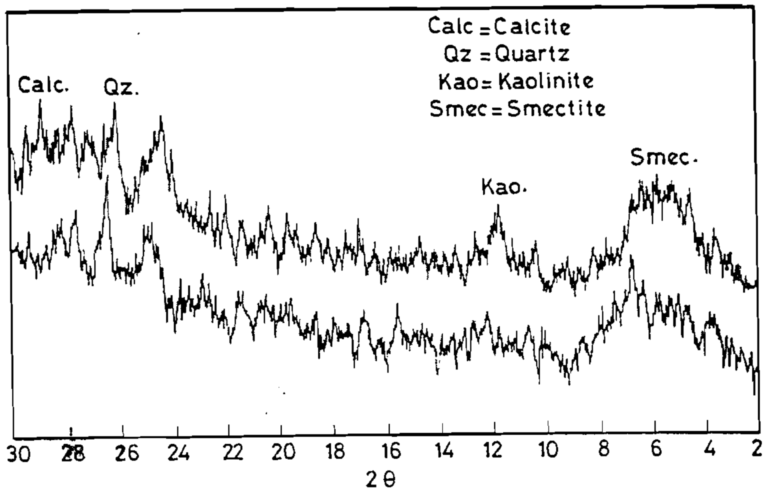

Fig. (6): Mineralogical composition of clay fraction in subsurface sediments of Lake Edku.

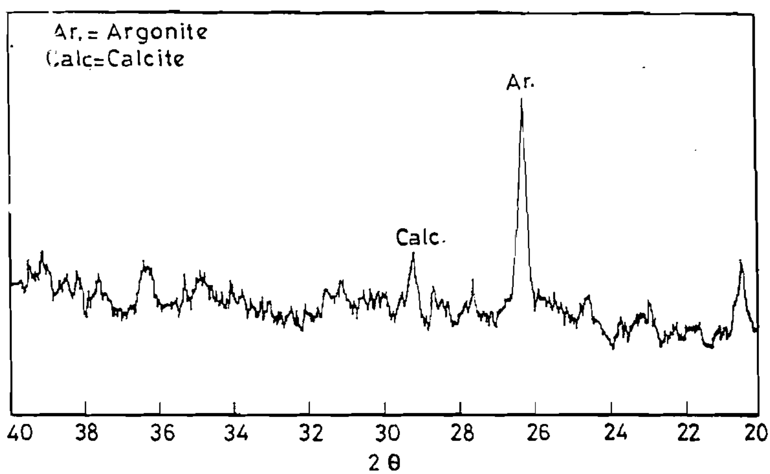

Fig. (7): Mineralogical composition of carbonate sediments of submerged ridge.

The petrographical characteristics:

Study of scanning electron microscopy illustrates that the sediment matrix is clastic enriched with organic matter and reworked authigenic carbonate grains formed inside the basin of deposition. The study reveals that different form of carbonate minerals range from rhomhedral to micritic calcite, as well as, needles of aragonite. Well-cemented grainstoes occur at deeper depth intervals within poorly cemented ridge (plate 1). The petrographical analysis reveals the presence of more than two generations of cement (plate 2 & 4). Moreover, the study shows that clay matrix composed of kaolinite and smectite (plate 3).

A comparison between the study of Warne & Stanley (1993). (Fig. 8) with the present investigation ensures transport of carbonate rocks derived from the adjacent Pleistocene carbonate ridges at Abu Quir headland. It was recorded at depth of about 16m at northeastern side and at depth interval of 33m. It was suggested that these limestone granules were derived from the adjacent Abu Quir carbonate ridge. They were probably eroded from the ridge into the Lake during heavy storms. However, Warne & Stanley (1993) suggested that, during the late Pleistocene prior to 35000 years BP (Sicilian to Late Monasterian) a series of prominent nearshore marine to coastal dune ridges were deposited. These carbonate rich sands accumulated during a series of sea-level highstands. Minor sea-level fluctuations affected the development of each ridge and resulted in intermittent subarial exposure and subsequent caliche and paleosol development

CONCLUSIONS

The late Quaternary deposits in lake Edku have been interpreted on the basis of petrological analysis (texture and mineralogical analysis) of boring sediments. From oldest to youngest, theses are: stiff alluvial Pleistocene mud, Pleistocene channel sand and flood plain mud, Holocene marsh peat muds and lagoon muds. The reconstructed sedimentary facies is equivalent to Said's (1981) Neo-Nile delta phase that began accumulating with the rise in sea level at the end of the last glaciation.

Results of this study indicated that three primary sediment sources have been contributed to the depositional processes of Edku lake region, these include;

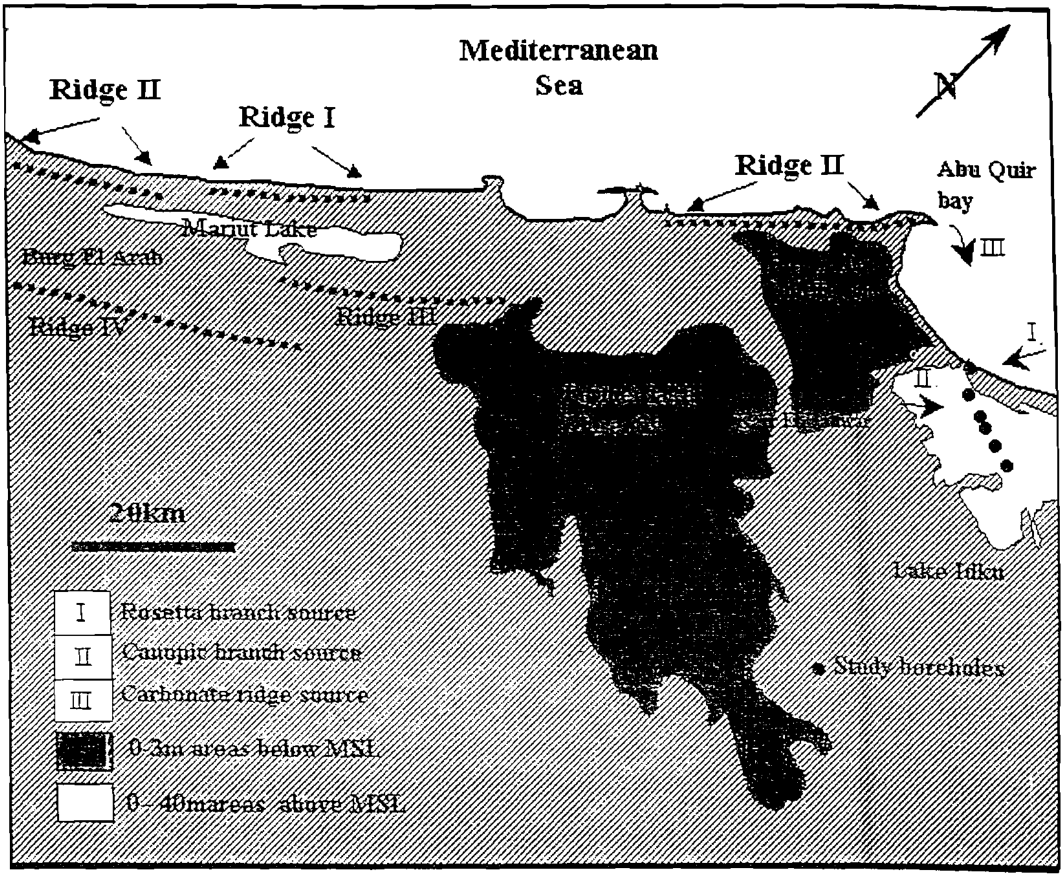

Fig. (8): Topographic map of Alexandria region (modified from Warne and Stanley, 1993). Arrows depict major depositional sources contributed in the formation of the subsurface sedimentary facies identified in this study.

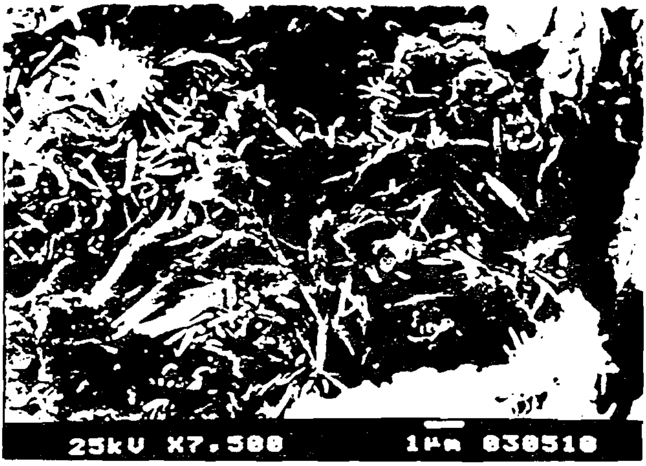

Plate (1): Needle structure of aragonite crystal surrounded and intercalated by smectite at depth of 16m.

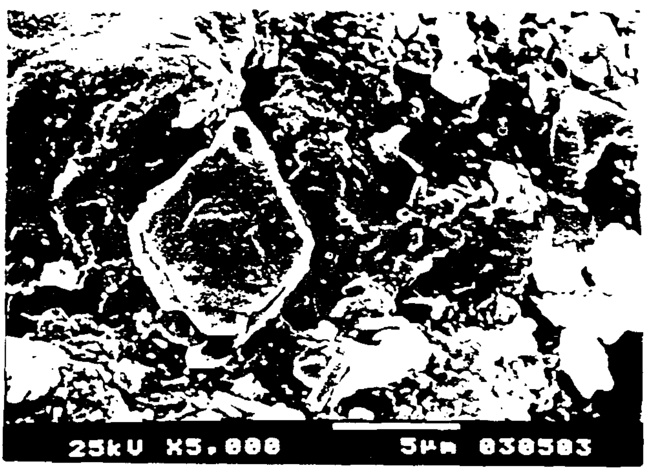

Plate (2): Rhomhedral crystals of calcite in carbonate matrix at depth 33m.

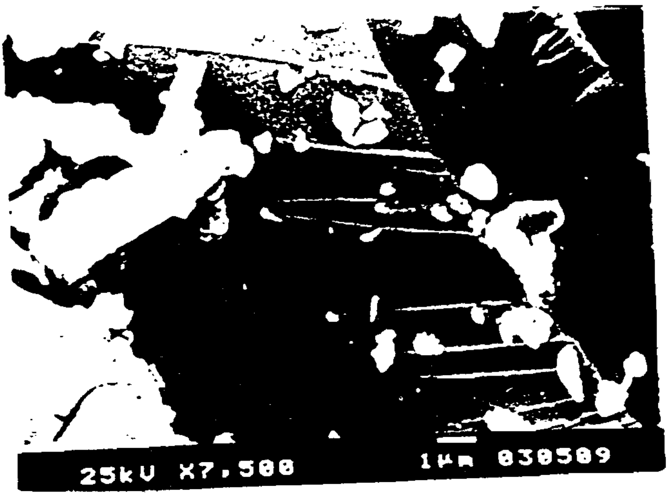

Plate (3): Kaolinite crystals with their distinct cleavage as matrix for the carbonate granules.

Plate (4): micritic calcite cement.

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1. Sediment discharged from the ancient distributaries of the Nile, the Canopic and Rosetta channels.
2. Calcareous- rich sediments derived from the adjacent carbonate ridge at Abu Quir headland and carbonate.
3. Terrigenous sediments derived from erosion of the Rosetta branch and its promontory in the eastern part of the bay.

Reworking of clastic sediment from the former Canopic distributors and relict channel and delta lobe deposits took place on the southwest bay floor.

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