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# LATE QUATERNARY DEPOSITIONAL PHASES IN THE LAKE MANZALA REGION, EGYPT.

OMRAN E. FRIHY.
Coastal Research Institute, Alexandria, Egypt.

## ABSTRACT

Stratigraphic interpretation of petrological core data in the Lake Manzala region reveal four depositional phases during Late Pleistocene to Holocene, from base to top these phases are: 1- nonmarine alluvial phase, accumulated during the last major eustatic lowering sea-level which caused increasing in the alluviation process over the subaerially exposed Pleistocene deposits. This process produced an iron-stained, yellowish coarse grained sand and stiff oxidized brown clays. 2- erosional transgression phase, represented by late Pleistocene coastal medium sand unit. This phase was originally fluvial, deposited from the former Nile branches during maximum eustatic low-stand when the coastline had located at the edge of the Egyptian shelf. As the sea transgressed landward the fluvial sand is reworked, eroded and deposited again as a coastal sand. 3- depositional regression phase, made up of prodelta mud and delta front, accumulated from about 9,000 to 3,000 yr BP. This phase originated during the time when the rate of sea level rise had considerably diminished. At the same time the sholeline progarded seaward creating deltaic lobes due to a sediment supply resulted from discharge of the abandant former Nile branches. 4- erosional transgression phase (3,000 yr BP to present time) comprised of sand of coastal environment overlain by mud facies of littoral and marsh environments. This phase primarily deposited under conditions of erosion, slightly rising or stable sea level and negligible sediment supply.

## INTRODUCTION

The present study deals with the reconstruction of the sedimentary phases in the subsurface Late Pleistocene and Holocene deposits in Lake Manzala region extending from Damietta branch of the Nile to Tineh Plain in the northwesternmost Sinai, (Fig. 1).

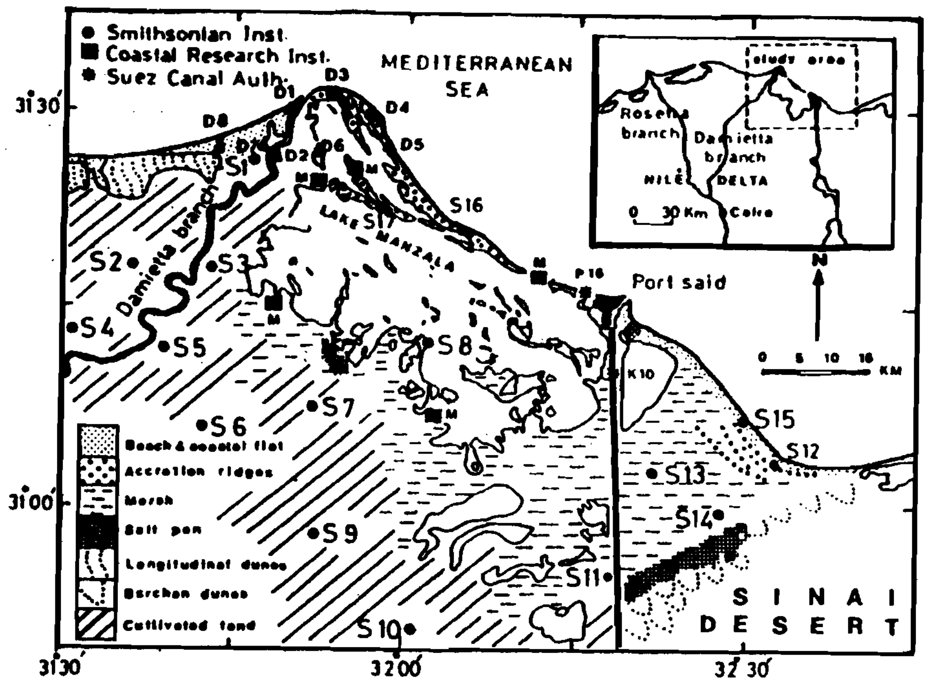


Fig. (1)

Map of the study area in the Lake Manzala region, showing the location of cores. S = Smithsonian Institution, D and M = Coastal Research Institute, Egypt and K and P = Suez Canal Authority.

In recent years, Nile Delta has been the subject of a number of sedimentological, archeological and geographical investigations. With respect to earlier research on the Nile Delta, numerous studies have considered various aspects, such as its morphology (Said, 1958; Butzer, 1975; Sestini, 1976; Frihy et al., 1987) and the general stratigraphic and tectonic history of Miocene to Quaternary sedimentary sequences (Said, 1962 and 1981; Zaghloul, et al., 1976; Rizzini et al., 1978). Description of the more general attributes of the Late Pleistocene to Holocene sediment facies and stratigraphy in the Nile Delta have been published by, among others, Fourteau (1915), Attia (1954) and Sneh et al. (1986). In respect to the Nile Delta Phases, Summerhayes et al. (1978) have proposed three evolutionary phases based on the surficial sediment textures of the continental shelf of Egypt: the classical phase (about 5000 to 500 yr BP), the channelized phase (about 500 yr BP to 1964) and the modern phase. Recently, El Askary and Frihy (1986) reconstructed three Holocene depositional phases in Rosetta and Damietta promontories: transgression, regression and erosional phases. Said (1981) described the entire different phases of the River Nile. They are, from the oldest to the youngest: the "Eonile" in the Upper Miocene, the "Paleonile" in the Upper Pliocene, and the "Proto-pre-and Neo-Nile" in the Pleistocene.

## DATA BASE

Numerous sediment cores and log engineering boreholes have been recovered in the study area by several institutions; Smithsonian Institution, Coastal Research Institute and Suez Canal Authority. These cores and boreholes range in depth from 16 to 48 meters. Earlier investigations on these cores and borehores were carried out by El-Askary and Frihy (1986); Stanley and Liyanage (1986); Coutellier and Stanley (1987); Frihy and Stanley (1987 a,b,c). A lithostratigraphic investigation of some of these cores has been published by Coutellier and Stanley (1987). They present a composite lithostratigraphic section based on two sections in the central part of Lake Manzala depicting eight major lithofacies (Fig. 2). In the present investigation, the author used these eight lithofacies and their petrological, sedimentary structures and carbon dates as a base to reconstruct the deltaic phases in the study area. Figure 2 illustrates a composite lithostratigraphic log depicting these facies (Coutellier and Stanley, 1987), their petrological components are represented by histograms. Data of histograms was obtained from Frihy and Stanley (1987 c). To some extent, the SEM survey of surface features of quartz grains has been also consulted, in conjuction with the other petrological data to interpret the subsurface deltaic phases. The SEM data is partially valuable with respect to compositionally mature sands where there are no diagnostic mineralogical, faunal or floral components to identify environments. The SEM information was obtained through published information by Frihy and Stanely (1987 b).

## DELTAIC PHASES

Herein, a discussion of the deltaic phases in Lake Manzala region is based on the available petrologic and SEM core data. The reconstructed sequence is equivalent to Said's (1981) Neo-Nile Delta phase which began accumulating with the rise in sea level at the end of the last glaciation. Analysis of the lithofacies relationships in the study area shows that the sediment facies can be grouped into the following vertical delatic phases (Fig. 3):

### 1- Non-marine Alluvial Phase:

This phase is represented by two depositional Pleistocene alluvial facies, coarse sand and stiff clays (Fig. 3), some dated as older than 30,000 yr BP. The lowermost part of this phase comprises iron-stained, yellowish

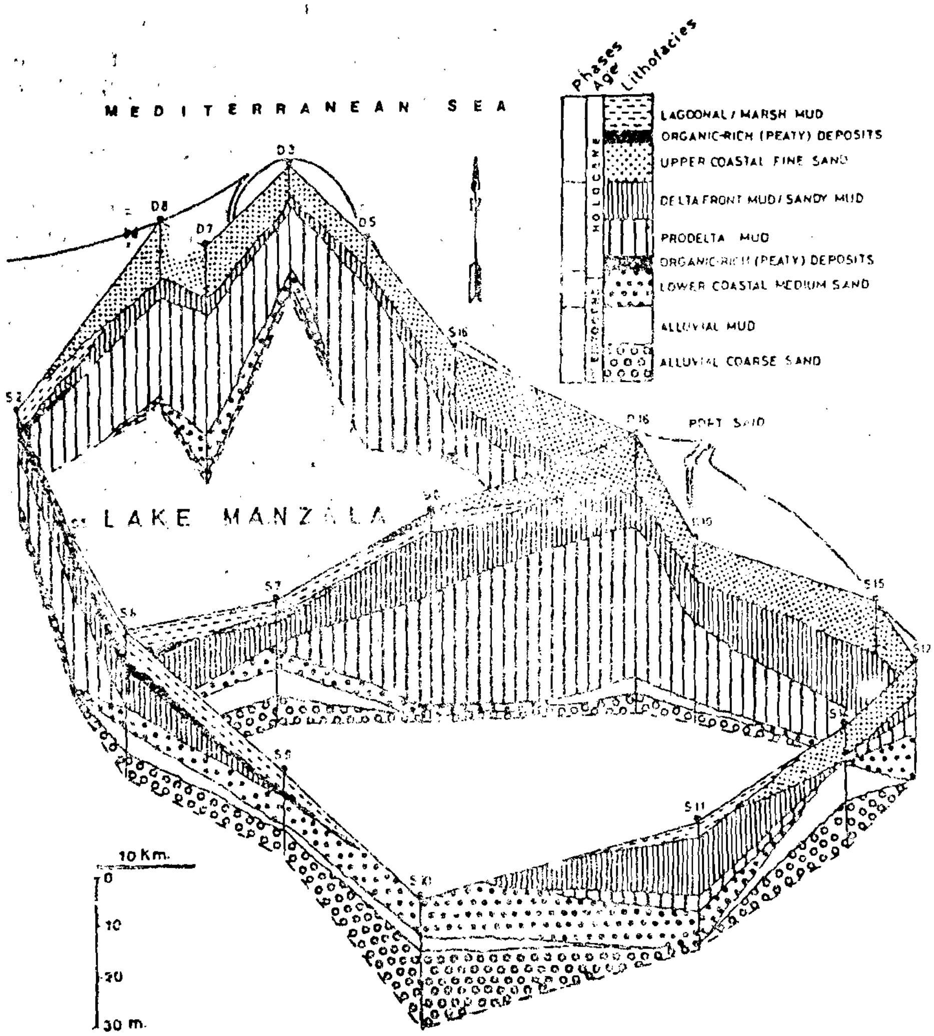


Fig. (2)

A composite lithostratigraphic log depicting the Late Pleistocene and Holocene facies in the study area, (modified after Coutellier and Stanley, 1987). Their petrological components represented by histograms (data after Frihy and Stanley, 1987 c). A = sand, B = silt, C = clay, D = light, E = heavy, F = mica, G = glauconite, H = pyrite, I = evaporite, J = lithic fragments, K = aggregates, L = plant fragments, M = foraminifera, N = shell fragments, O = ostracods, P = echinoids, Q = carbonate fragments.

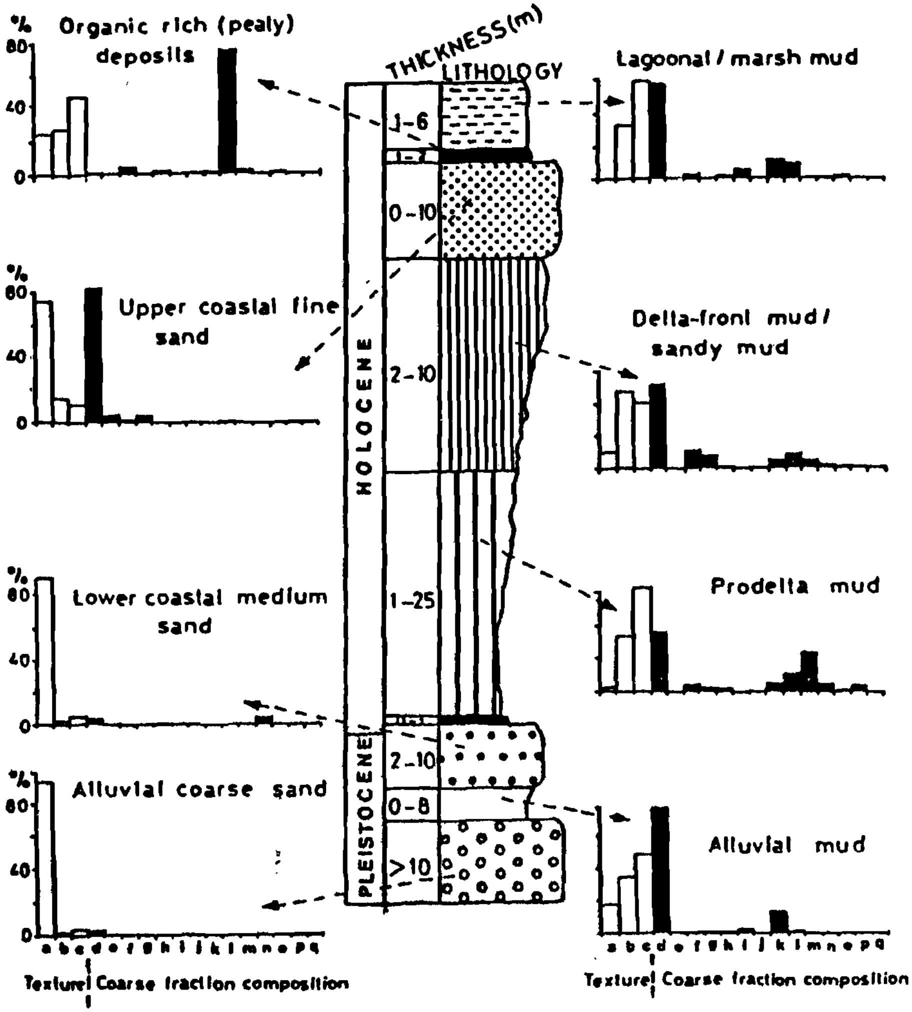


Fig. (3)

**Schematic fence diagram of the Lake Manzala region, illustrating the Late Pleistocene and Holocene deltaic Phases. 1 - non-marine alluvial phase. 2- erosional transgression Phase (coastal retreat). 3- depositional region phase. 4- erosional transgression phase ( retrograding shoreline).**

brown, and coarse grained subangular sand. This coarse sand is overlain by a unit of stiff brown clays, commonly display patches of oxidized stains, organic matter and gypsum crystals. The main characteristics of these two facies and their compositional and textural maturity are shown in Fig. 2. The biogenic components are absent in both the coarse sand and stiff clays. However, in such case the SEM survey of the surface texture of the coarse sand grains could be useful. Their chemical and mechanical features suggest a possible aeolian and subsqueous (river) regimes, i.e., when a river has flowed through a desert regime (Frihy and Stanley, 1987 b). As shown in the fence diagram (Fig.3) this phase has a wide lateral continuity and subaerially exposed southward (example core S 10). This non-marine alluvial phase, had been deposited during the last major eustatic sea level. At that time, the shoreline was located near the present outer edge of the continental shelf, when sea level stood about 120 meters lower than at present (Emery, 1968). As sea-level dropped, the Pleistocene deposits became subaerially exposed, subsequently subjected to oxidation, erosion and increased in weathering of sediments. In response to this lowered sea level, sediments of the deltaic plain were eroded, reworked and deposited by fluvial processes of the Nile distributaries. The presence of gypsum and oxidized lamination in these alluvial facies indicates the effects of arid climatic phase recorded during Late Pleistocene (cf. Said, 1981 and Adamson et al., 1980).

**2- Erosional Transgression Phase (Coastal Retreat):**

The above cited non-marine phase is overlain by a Late Pleistocene transgressive coastal clean medium-grained sand, dated as early as 20,000 to 15,000 yr BP. It generally shows thickening in a landward direction (Fig. 3). This sand unit, originally fluvial, originated from the former branches, and began to accumulate after the maximum eustatic low-stand when the coastline was located near the present outer margin of the continental shelf. As the sea transgressed landward (retrograding shoreline), these fluvial sands were eroded, reworked, winnowed and deposited again as coastal sands across the formerly exposed continental shelf and the deltaic plain region (cf. El Askary and Frihy, 1986; Coutellier and Stanley, 1987). Already by that time the shoreline had retreated to its landward position, about 15-20 Km south of its present location. The petrological components and the stratigraphic sequence of these coastal sands indicate their deposition in a coastal environment of beach or coastal dunes. This is generally consistent with the SEM survey which provides evidences of beach origin. The distribution pattern of the relict coarser sediments on the presentday continental shelf indicates that the coast of the delta was retreating throughout the Late Pleistocene to Holocene, and that the coastline was about 40-50 Km seaward from the present shore (Said, 1981). Similar coarse sediment pattern have been recorded by Misdorp and Sestini (1976) on the egyptian continental shelf, which concides with the three important axes of the Nile discharge in Late Pleistocene and Holocene time (Canopic, Saitic-Sebennitic and Athibic branches).

The rate of deposition of this coastal sand was probably moderate to high, partially receiving additional sediments to the shelf from the Nile distributaries. the deposition of this phase continued during the rapid eustatic rise in sea-level in the Late Pleistocene to Early Holocene. These processes of deposition were accompanied by wave action caused erosion and formation of coastal clean medium sand that overlies the Pleistocene non-marine phase.

**3- Depositional Regression Phase (Prograding Shoreline):**

This phase is represented by two marine lithological units, above the clean medium coastal sand phâse, accumulated from 9,000 to 3,000 yr BP. It comprised essentially prodelta mud (silt and clay admixture) at the base; delta front of mud to sandy mud, become sandier toward the top (Fig. 3). This phase tends to pinch-out landward, i.e., thickening in a seaward direction (Fig. 3). The mineralogical composition of the coarse fraction of this unit is much more diversed than the other units. Biogenic components, foraminifera, shell fragments and echinoids are dominated at the base of this phase, indicative of open marine conditions (Fig. 2). The same conclusion had been reached by El Askary and Frihy (1986) in the Holocene prodelta and delta front west of the study area. This phase is also markedly characterized by a distinct coarsening upward pattern, like any typical deltaic regression phase. The textural and faunal vertical pattern in a regressive phase reveal deeper water facies which are successively overlain by sediments deposited in progressively shallower water. the prodelta and delta front units were accumulated during the time when the rate of sea level rise had considerably diminished. This process was accompanied with conditions of abundant sediment supply resulting from discharge of the former Nile distributaries (seven or more) under slowly rising sea level (cf.El-Askary and Frihy, 1986, Coutellier and Stanley, 1987). According to Adamson et.al., (1980) the climate during this period was typical moisture condition, where there was major flooding along the Nile. All these conditions led to shoreline progradation and building up the deltaic lobes over the earlier Holocene and Late Pleistocene deposits cited above.

Some dark organic-rich 'peat' individual layers also occur locally at the base of the prodelta (Figs.2 and 3). This basal peaty deposits, appear to be formed of reworked organic matter deposited in sandy and muddy coastal environments, perhaps near delta mouths (cf. El-Askary and Frihy, 1987 b; and Coutellier and Stanley, 1987).

**4- Erosional Transgression Phase (Retrograding Shoreline)**

The above cited depositional regression phase is gradually succeeded by three lithological units, coastal sand, organic rich 'peat' deposits and lagoonal marsh facies near the top. Fig. 3 shows that the coastal sand is located in the seaward direction in the form of sand sheet, while the organic rich 'peat' deposits, and lagoonal marsh facies are distributed laterally in the landward side. They have been accumulated in a littoral, brakish and finally terrestrial environments. This can be interpreted on the basis of their coarsening upward pattern, which is accompanied by an upward decrease in both foraminiferal individuals and species number (El-Askary et al., 1984). The coastal sand environment in the lower part of this phase was probably deposited in littoral zone as sand barriers, accretionary ridges, nearshore bars, beach and coastal dunes. They are made up of well sorted, fine to very fine sand with considerable amount of heavy minerals. The SEM analysis of quartz grains of this unit shows that they were influenced by aeolian transport (coastal dunes); this is consistent with mineralogical and faunal content of sandsize components (Fig. 2). This sand unit is overlain by lagoonal and mud facies. The mud facies generally accumulated in littoral, brackish (such as coastal lakes or lagoons) and some terrestrial (marsh) environments (Coutellier and Stanely, 1987; Firhy and Stanley, 1987 b).

A dark organic rich facies, peat-like deposites, some with root structures occasionally occur between the coastal sand bodies and the upper lagoonal and / or marsh deposits. They probably accumulated in situ in marsh, swamps or lagoonal environments in depressions, behind the coastal and sand environments. The depositional condition of this phase is primarily due to the processes of erosion under condition of slightly rising or stable sea level and negligible sediment supply. the climate during this phase became markedly arid once again (Stanley and Maldonado, 1977; Murry, 1951).

## CONCLUSIONS

Based on the available core data including sedimentary structures, texture, composition, chronostratigraphy, lithofacies relationships, and SEM survey, four deltaic phases can be reconstructed in the Lake Manzala region during the Late Quaternary. From the oldest to youngest, these are: non-marine alluvial, erosional transgression, depositional regression and erosional transgression phases. These phases have shown that specific vertical sequences of lithological units are produced as a response to shoreline fluctuation, resulting a wide variety of deltaic environments in a desert-fluvial-coastal-marine system. They also consistent with the climatic oscillation during their accumulation, in cold-dry-moisture-arid conditions.

The nonmarine phase was originated during the alluviation of Late Pleistocene deltaic sediments which had been previously exposed to subaerial conditions as a result of the lowering sea level in the last glacial stage. At that time, the coastline was located somewhat seaward of its present position at the outer edge of the shelf. These processes produced an iron-stained, yellowish coarse grained sand and stiff oxidized dark brown clays. When the ice melted, sea level was raised, these deposits were submerged and subjected to reworking, erosion, winnowing by currents and waves and deposited as erosional transgerssion coastal sand phase. With subsequent slowly rising sea level, and abundant sediment supply resulting from the former Nile branches, a depositional regression phase (prograding shoreline) orginiated since 9,000 to 7,000 yr Bp. This phase comprised thick marine Holocene facies of prodelta mud grades upward into coarser sandy mud and sand of delta front. Finaliy on the top a younger lithofacies unit, deposited from 3,000 yr BP to present time, representing coastal sand and mud facies of littoral and marsh coastal environments accumulated in a condition of erosional transgression. This younger phase reflects condition of slightly rising or stable sea level and negligible sediment supply.

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