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GEOMORPHOLOGICAL FEATURES OF THE NILE DELTA COASTAL PLAIN: A REVIEW

GEOMORFOLOŠKA OBILJEŽJA DELTE NILA OBALNA RAVNICA: PREGLED

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The study of the coastal plain features of the Nile Delta coast from Alexandria to Tineh Bay, east of Port Said reveals remarkable geomorphological units. Running landward from the Mediterranean coast, these units are: 1— the nearshore zone, up to 6—7 m water depth, generally shows texture distribution fining seaward across the surf-zone, breaker zone and sand bar. 2— beach and coastal flat, made up of fine and very fine sand with limited patches of medium and coarse sand. 3— coastal accretion sand ridges represent a tracer of old beaches fringing the coastal deltaic plain in some localities. Older carbonate ridges (Pleistocene) extend westward from Alexandria towards the Lybian border. 4— coastal dunes; barchan and longitudinal belts of fine and very fine sand usually located at the southern margins of the backshore flat parallel to the coast. Other inactive accumulation of sand and silt old dunes are lying further inland south of the recent ones and south of the coastal lakes. 5 — coastal lakes; the distribution pattern of the bottom sediments of Burullus and Manzala Lakes is similar, where the relict sediments in both lakes are surrounded by modern sedimentation. On the other hand, the pattern is mainly modern in case of Idku Lake.

INTRODUCTION

The northern coast of Egypt is generally considered as consisting of three different units:

1- The western part of the Egyptian coast extends westward from Alexandria towards the Libyan border. It is formed of a series of coastal dunes mainly composed of oolitic and biogenic carbonate sand. Parallel to them and lying further inland (to the south) there are a series of older indurated Pleistocene beach-dune ridges. These ridges are separated by depressions filled with lagoonal-sebkha deposits (Hassouba, 1980).

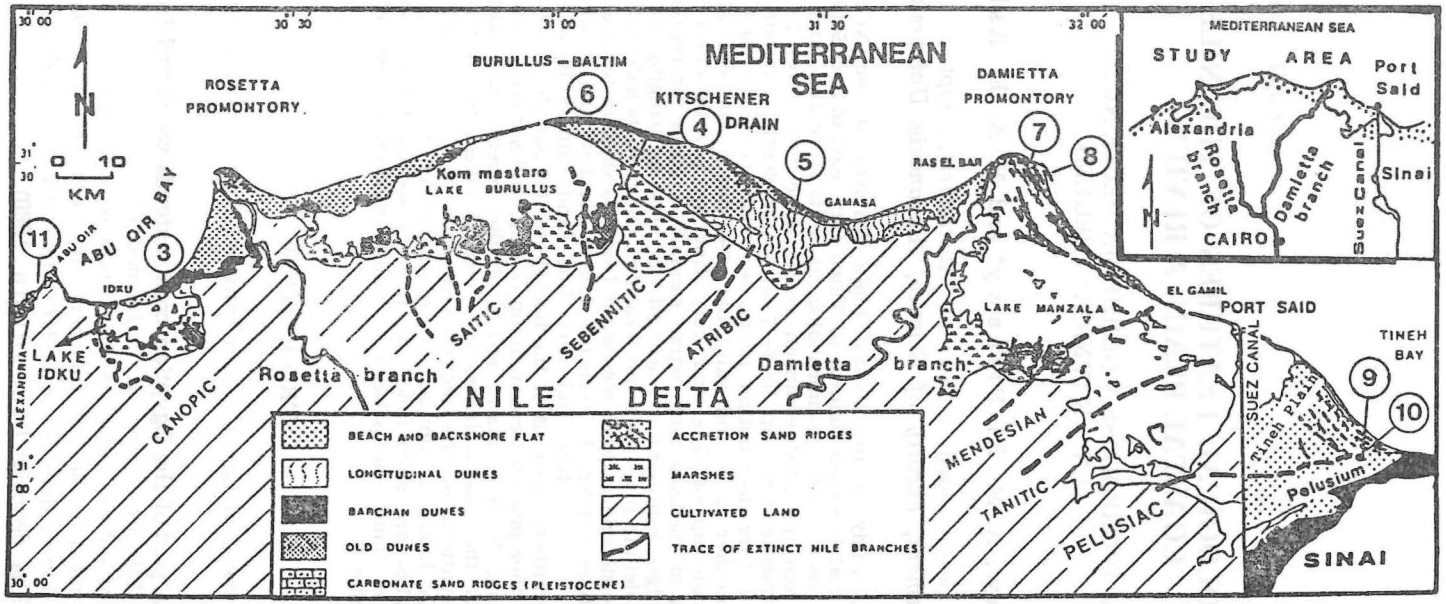


Fig. 1. Geomorphological units along the Nile Delta Coastal zone. Numbers in circles denote positions of photographs cited in the text

2- The central part of the coast of the Nile Delta extending from Alexandria to the easternmost edge of the delta east of Port Said at Tineh Plain. It is formed of quartz sand beach-dune belt and deltaic deposits.

3- The third unit is the coastal plain of Sinai Peninsula which represents the easternmost part of the Egyptain coast. This unit consists mainly of a quartz sand-beach-dune belt which was formed by influences of both deltaic and wind-blown deposits.

Many workers studied the geomorphology of the Egyptian coast (Shukri *et al.*, 1955; Said, 1958; Sestini, 1976; Hassouba, 1980 and El Fishawi and El Askary, 1981). According to Said (1981) the Nile Delta coastal zone is related to the Neonile sediments in the early stage of Late Pleistocene up to the present time (modern Nile). The coast was probably lying 50 Km to the north of the modern coast and the distributaries of the delta of the Neonile were numerous. At least, seven major branches of the delta are mentioned in various historical documents and in ancient maps (Fig. 1). These are from west to east, Canopic, Saitic, Sebennitic, Atribic, Mendesian, Tanitic, and Pelusiac branches. Five of them degenerated and silted up, whereas two, the present-day Damietta and Rosetta branches, remian active (Said, 1981). Additional knowledge on these branches published by, among others, Toussson (1913), Ball (1942), Sneh and Weissbrod (1973), Coutellier and Stanley (1987) and Tharwat and Frihy (1988).

The present study was initiated to define more precisely the major geomorphological units in the coastal zone north of the Nile Delta (Fig. 1). This investigation is based largely on the field trips, air photos of 1955 & 1983 and satellite photos of 1976. The geomorphological analysis also enters herein with earlier geomorphological, sedimentological and archeological studies in the region published by others.

MAIN GEOMORPHOLOGICAL UNITS

Nearshore Area

The investigated nearshore area includes the surfzone, breaker zone and the area beyond breaker zone up to 6—7m water depth. The general morphological features of the nearshore profiles vary in a somewhat regular manner along the coast. A summer bar (2—3m depth) and one or two storm bars (5—6m depth) with maximum of 1.2m height exist along most of the Nile Delta coast (Manohar, 1976). The sand of bar crest is coarser than that of the bar trough (El Fishawi, 1977).

The distribution of mean grain size diameter within the nearshore zone along the coast is shown in Fig. 2. Generally, the mean diameter tends to decrease gradually from shoreline towards the sea. Medium and fine sand occur near the beach while very fine sand and silt occur up to 6m depth. Local patches of coarse sand are found off Idku and Burullus outlets which coincide with the positions of the extinct Nile branches. The nearshore zone off Alexandria is characterized by an interplay of biogenic and terrestrial agencies with total carbonate content of less than 80% (El Wakeel and El Sayed, 1978).

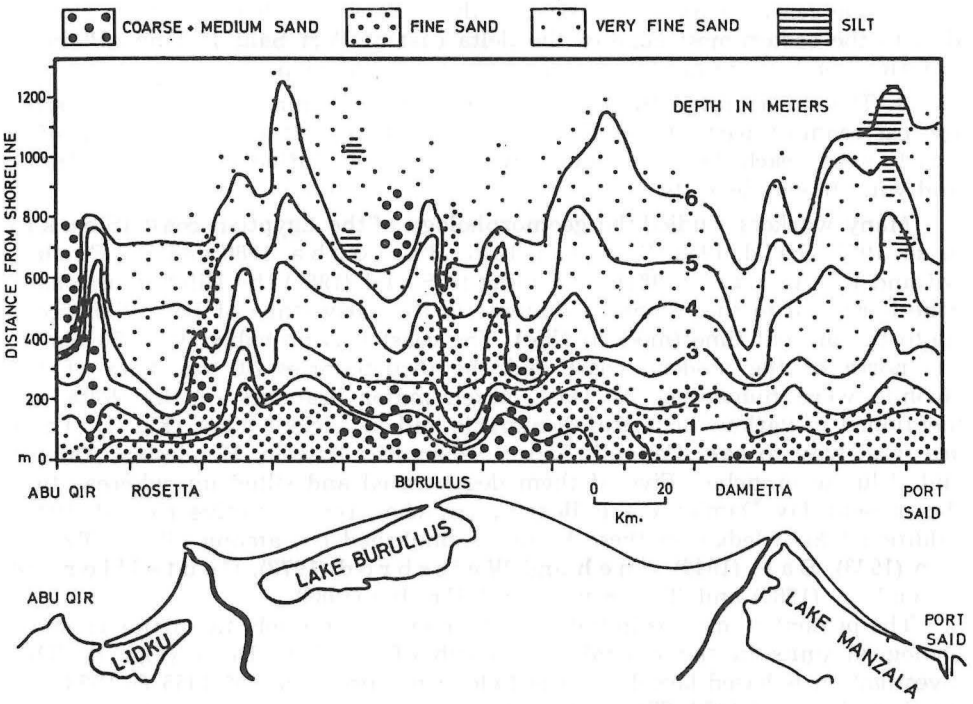


Fig. 2. Bathymetry and distribution of mean grain diameter over the nearshore area off the Nile Delta coast

Beach and Backshore Flat

The shoreline of the Nile Delta coast is sandy, slightly undulating and smooth in some localities. Abu Qir, Rosetta, Burullus and Damietta are the more developed headlands along the coast. The coastline is interrupted by the present-day Rosetta and Damietta branches of the Nile as well as by some outlets and drains. The beach is mainly made up of loose deposits of quartz mixed with small amounts of shell fragments and heavy minerals. The slope of the beach face ranges between few degrees and 18 degrees. To the west of Alexandria the beach sediments are rich in carbonate oolitic sand which eroded from the limestone ridges skirting the shore in that area. The grain size variation of the beach sand along the delta shows fluctuation of both coarser sand (coarse to medium sand) and finer one (fine to very fine sand). The coarser sand is present in three stretches; the western part of Abu Qir Bay, in the central part of the delta coast, and also it appears in small amounts on the beach between Ras El Bar and El Gamil outlet. On the other hand, the finer sediments are distributed on the beaches of the distributary mouths of Rosetta and Damietta as well as the outlets and drains. During the winter seasons the mean diameter of beach sand lies between 0.70 O and 2.60 O with an average of 1.98 O. On the other hand, it varies between 1.15 O and 2.90 O

with an average of 2.4 O in summer seasons (El Fishawi and Molnar, 1983). The abundance of coarser sands in winter and the finer ones in summer may be related to the fact that the beach receives more energy in winter than in summer.

At some stretches the beach is covered by pebbles, the sediment textures and the origin of which was discussed by El Fishawi and Molnar (1981). Beach pebbles have the greatest continuity and largest areal extent west of Burullus outlet and 12Km east of Gamasa. They consist mostly of mudstone and silty sandstone, containing shell fragments. The Nile Delta beach pebbles can be derived from the submarine banks of old Nile branches. Based on sea level rise variation diagram, Misdorp (1977) tentatively dated these banks on the continental shelf at some time between 7000—9000 years B. P.

The most significant development of beach is the cuspate nature of the shoreline along the eastern Burullus coast. The large cusps were observed from east of the Burullus outlet to Kitschener drain. The cusps have a mean spacing of 1.2 Km and a mean height between 40—60 cm. Generally the cusps tend to move laterally eastwards with a rate of 340m per month (El Fishawi, 1977). A 4.5 km-long spit has been also documented east of the Damietta mouth. The Damietta spit (Fig. 8) depicted on 1983 aerial photos was not present in 1955 (Fig. 7).

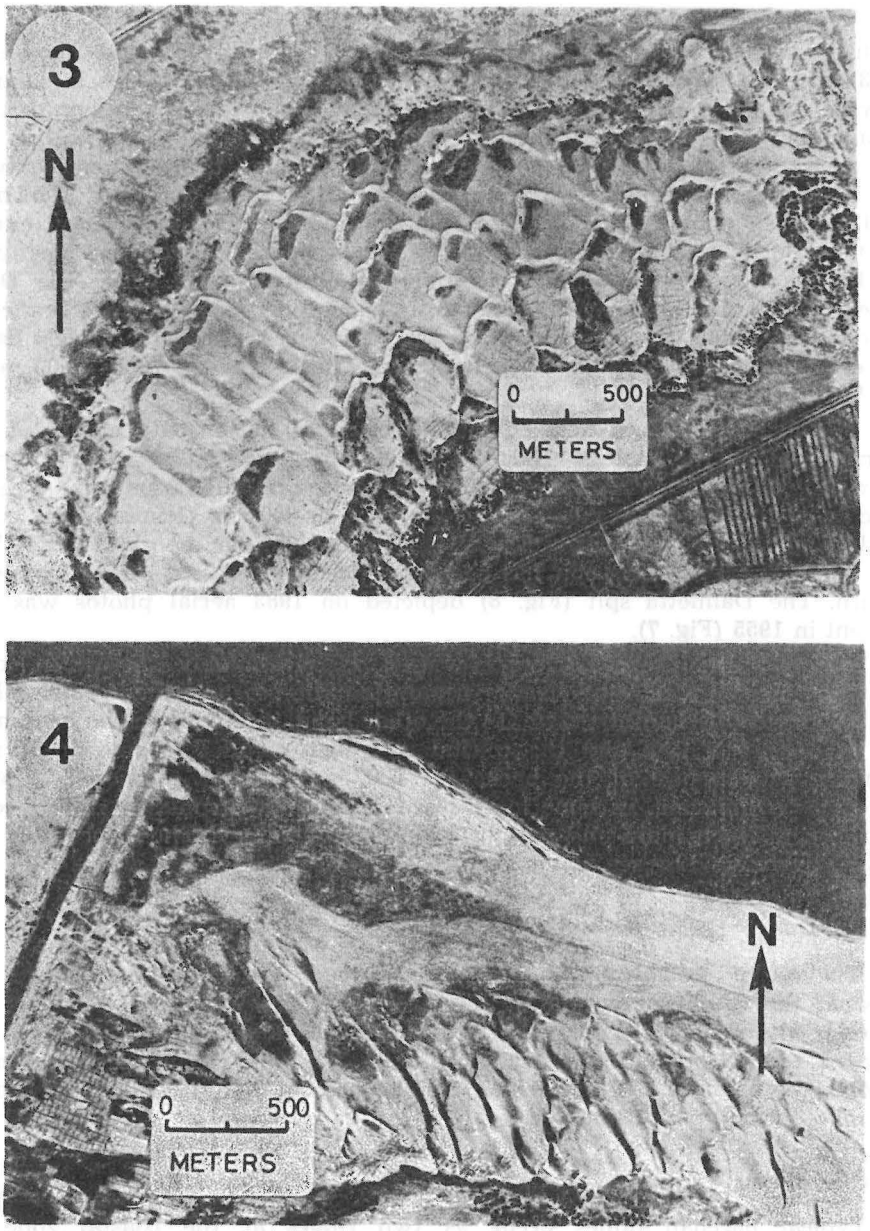
The width of the backshore is varied, it is relatively narrow in some places in the form of sand barrier separating the sea and the coastal lakes, e. g., Damietta El Gamil barrier. On the other hand, it is wide in the backshore flat of Abu Qir Bay and the coastal zone between Kitschener drain and Gamasa. The surface of the backshore flat is generally composed of well sorted very fine sand, in some localities it is mixed with muddy deltaic sediments, e. g. Tineh plain and east of Rosetta promontory. These localities are usually submerged by sea water during stormy seasons.

Coastal Dunes

The recent coastal dunes are located usually near and parallel to the coast at the southern margin of the backshore flat. The sand forming the dunes is ultimately derived from the beach bearm and coastal flat which are exposed to the prevailing wind. Eventually the used term »recent dunes« denotes those dunes still reworking by the present hydraulic regime. There are three main types of these dunes:

Barchan dunes

Typical barchan dunes occur as two ridges at the coastal zone of Abu Qir Bay and east Burullus (Figs. 3&4). They are also present in few isolated forms east of Rosetta promontory and among the longitudinal dunes west of Gamasa (Fig. 1). Abu Qir Rosetta ridge is represented by two belts located at right angle to each other on the backshore flat of Abu Qir Bay. Their width ranges between 1 and 3Km with maximum height of 10m. The first barchan belt (Idku dunes) extends 10 Km parallel to Rosetta branch. The windward side of these barchans is directed to the northwest direction



Figs. 3 & 4. Areal photographs showing different varieties of barchan dunes; their locations are shown in Fig. 1.

of the prevailing summer wind, where it mostly blows from the NW quadrant. Further to the east the Burullus-Kitschener drain ridge there is a complex barchan ridge found parallel to the coast between Burullus outlet and east of Kitschener drain for about 30Km. Its height is up to 40m and width ranges

between 1—2Km (Figs. 1&4). At the eastern edge of the delta a deformed barchan dune belt has been recorded south of Tineh Plain (Fig. 1&9).

Longitudinal dunes

Longitudinal dunes of 15—30m height and 2—12 Km width are recorded to the west and east of Gamasa and extend for about 35 Km parallel to shoreline (Fig. 5). These dunes extend to the south in the form of elongated sand bodies (1.2—1.4Km) more or less straight or serrated with their long axes lying parallel to the prevailing wind direction.

Glennie (1970) belives that during Pleistocene glaciation and because of stronger winds, longitudinal dunes were produced in abundance. Today some of them are undergoing modification to barchan dunes because wind velocities are not strong enough to maintain them. On the other hand, Bagnold (1971) mentioned that barchans can be formed in the longitudinal troughs between multiple seif chains where the effect of cross-winds is excluded. West of Gamasa, it is observed that the southern parts of longitudinal dunes tend to be modified to series of isolated barchans (Fig. 5). Such modifications took place with the direction of prevailing wind and consequently the barchan dunes occur together with the longitudinal ones in the same series. These features may support the opinions of Glennie (1970) and Bagnold (1971).

Old dunes

A complex series of sandy old dunes present underneath the recent ones have been recorded in different localities, e. g., Kom. Mastaro, Burullus-Baltim stretch, Gamasa, and south of Lake Idku (Fig. 6). Silty old dunes have been also observed south of Burullus and Manzala lakes. The archeological sites scattered in lake Manzala; at Abu Omar, Tanis and Daphnae had been built on these dunes. The origin of these silty dunes is still uncertain. Generally the elevation of the old dunes ranges from 2—5m, it is usually vegetated and the sand grains are of reddish color. The geographic distribution of the old dunes along the coast is generally associated with the position of the former Nile distributaries.

Coastal Ridges

Numerous traces of accretional old beaches in the form of sand ridges fringing the coastal deltaic plain have been recorded east of Rosetta promontory, west of Gamasa, east of Damietta promontory and on the backshore of Tineh plain (Fig. 1). The nature and origin of these ridges are directly related to the processes that have taken place in shaping the delta morphology. The beach ridges to the east of Damietta promontory are the most extensive, complex and well developed ones along the delta coast. In general, these ridges run parallel or subparallel to the present shoreline (Figs. 1&7). Most of these ridges are enclosed in water bodies and so appear as islands in the Manzala Lake. These islands are formed of fine moderately well-sorted sand. They are good indicators as a relict deltaic featuers: some delineate the position of reworked shoreline and, others record the remains of river banks of former

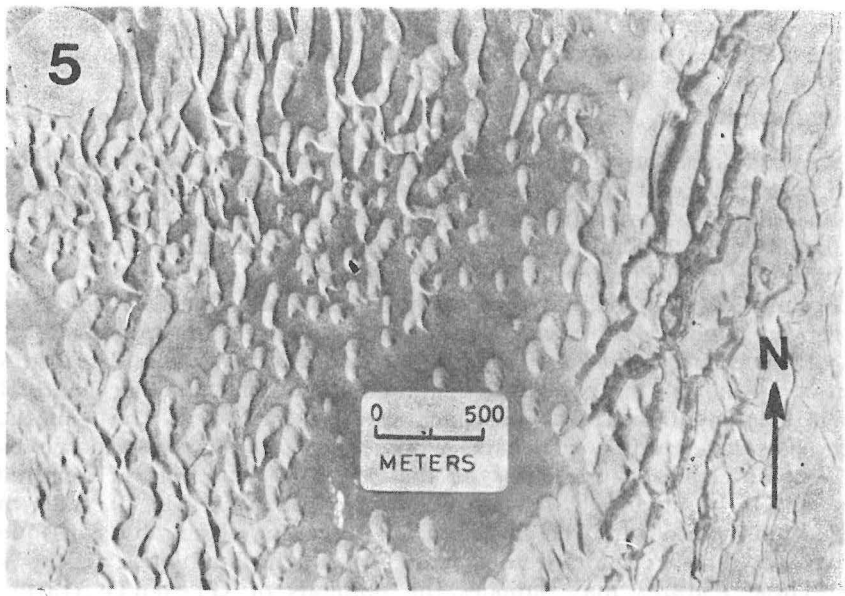


Fig. 5. Areal photograph showing longitudinal dunes with some modification to isolated barchan dunes.

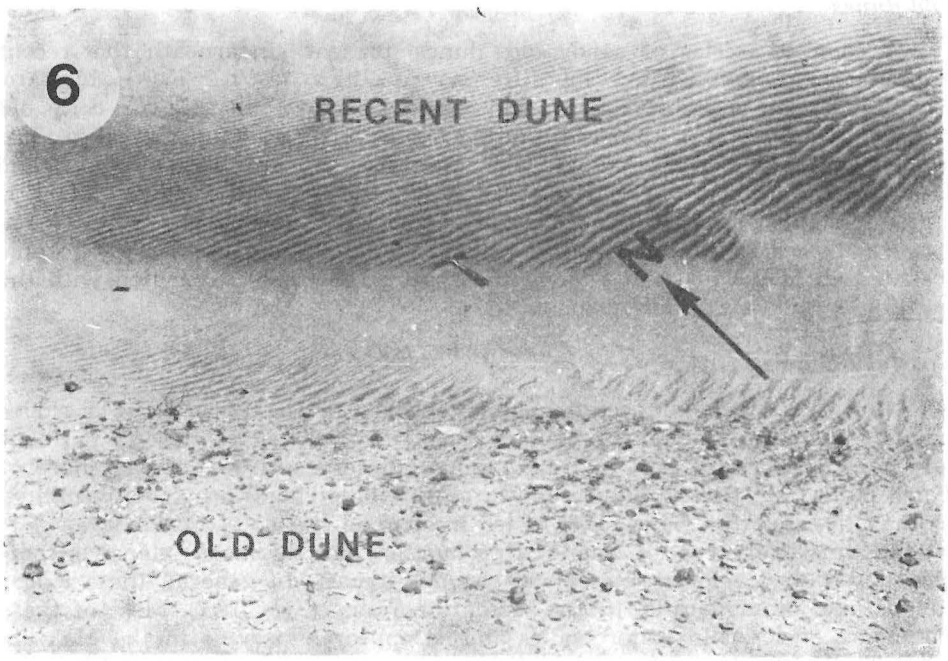


Fig. 6. Contact between recent and old dunes, the surface of the recent dunes is rippled while the old ones are covered with fire breaks, pottery pieces and primitive glass

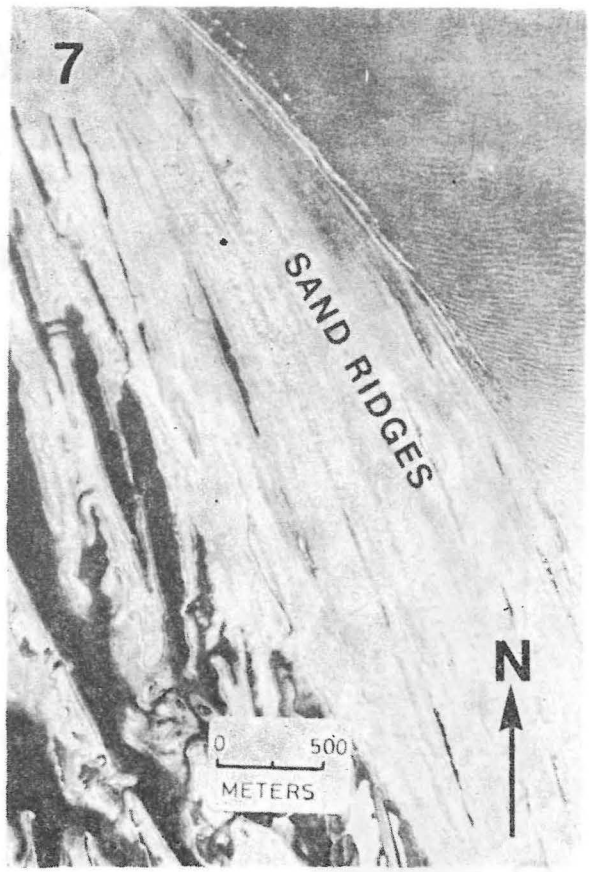


Fig. 7. Areal photograph showing sandy accretion ridges east of Damietta promontory

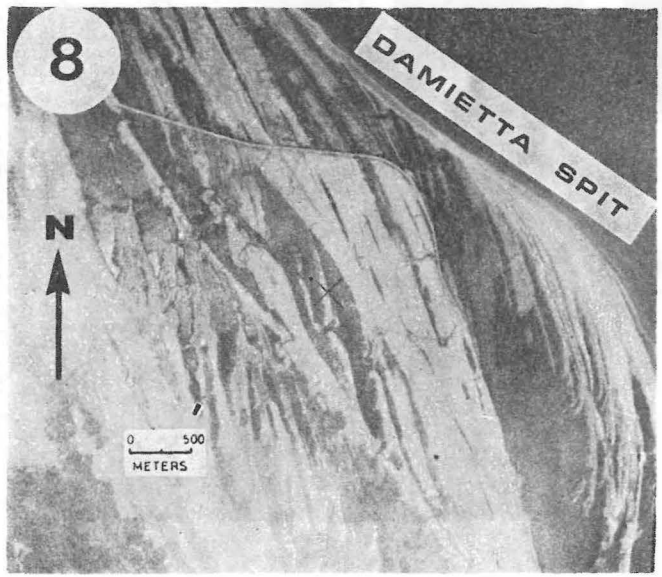


Fig. 8. Areal photos showing the development of the spit along the eastern part of the Damietta promontory in 1983.

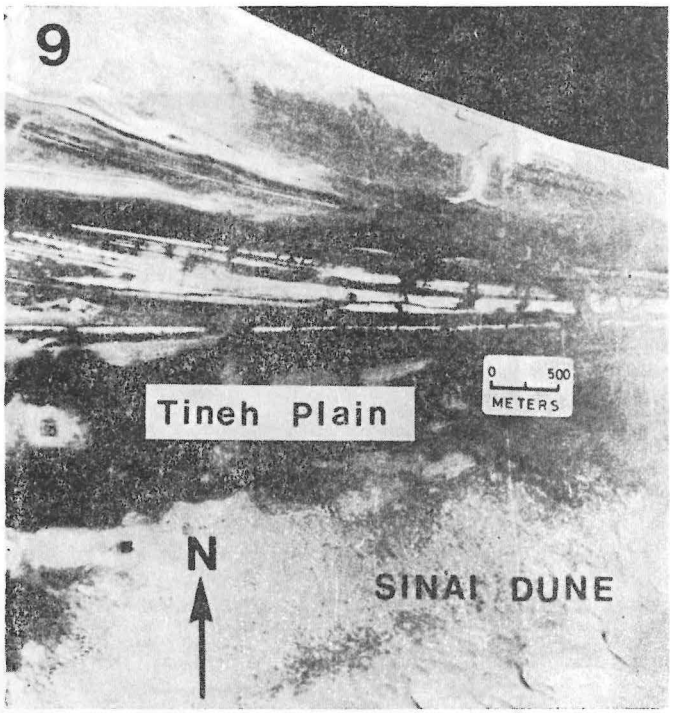


Fig. 9. Areal photograph showing the sandy coastal ridges and the deformed barchan dunes in Tineh Plain, nortwest Sinai

Fig. 10. Photograph showing tan linear sandy ridges (close up of Fig. 8).

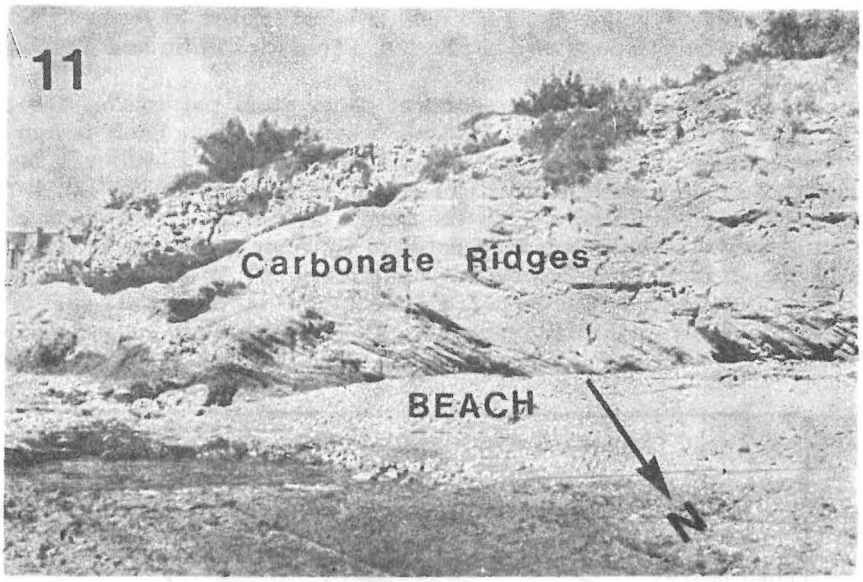


Fig. 11. Pleistocene carbonate sand ridges at El Montaza beach, east of Alexandria

distributaries. The sand accretion ridges of Tineh Plain run parallel to the present shoreline and are composed of fine sand and molluscan shells (Figs. 9&10).

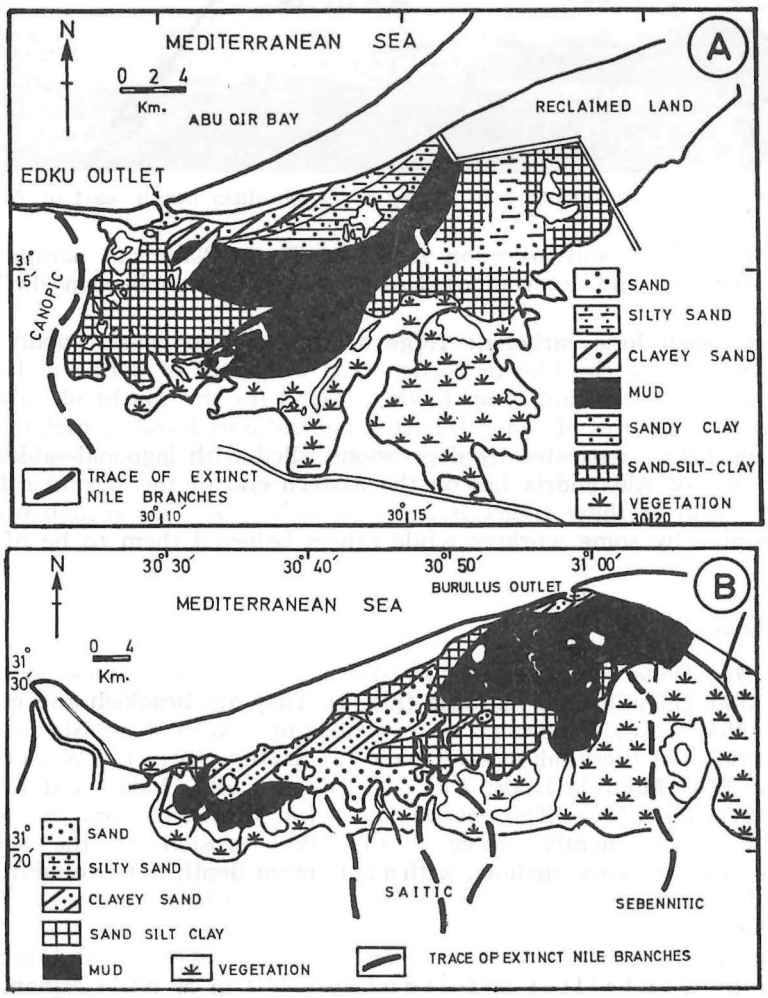
Older beach-dune carbonate ridge at the western coastal plain extends from Alexandria to the Libyan border. It is composed of oolitic and biogenic carbonate. Parallel to and lying further inland (to the south) of this coastal ridge there is a series of older (Pleistocene) indurated oolitic carbonate sand beach-dune ridges separated by depressions filled with lagoonal-sabkha deposits. The city of Alexandria lies on the eastern end of the second ridge (Fig 11). The origin of these ridges is a matter of dispute; an aeolian origin has been accepted by some workers while others believed them to be of marine origin.

Coastal Lakes

The Nile Delta comprises four coastal lakes, these from west to east are: Mariut, Idku, Burullus and Manzala (Fig. 1). They are brackish and connected with the Mediterranean through narrow openings except Lake Mariut. Earlier texture studies of these lakes were made by, among others El Wakeel and Wahby, 1970, Manzala Lake; Zazou, 1976, Burullus Lake; and El Ghobary, 1977, Idku Lake. The coastal lakes are separated from the sea by a sand barrier permanently subjected to severe erosion at the sea ward side. The lakes are very shallow, with a maximum depth not exceeding 150cm. Several drains open into the lakes mostly at the southern border of the lakes. Many islands scattered in the lakes seem to be remnants, but their origin is uncertain. Most of them encompass ruins of archeological sites. A recent study, made by Coutellier and Stanley (1987) in Manzala region, reveals

the location of four major Holocene deltaic lobes related to former distributary branches of the Nile river: Mendesian, Pelusiac, Tanitic and Pre-modern Damietta.

A comparative study of the sediment distribution patterns of the three coastal lakes, Idku, Burullus and Manzala is shown in Fig. 12. It is apparent that the sediment distribution patterns of Manzala and Burullus lakes are similar where there is a basinward coarsening of sediments (Fig. 12), i. e. the coarse sediments are distributed in the centre of the lake, comprising clayey sand and patches of sand encircled outward by finer sediments of muds. On the other hand, Idku Lake shows a reverse pattern. El Wakeel and Wahby (1970) attributed this order of sedimentation in Manzala Lake to the influence of drains and Nile connections. In this paper we suggest that the



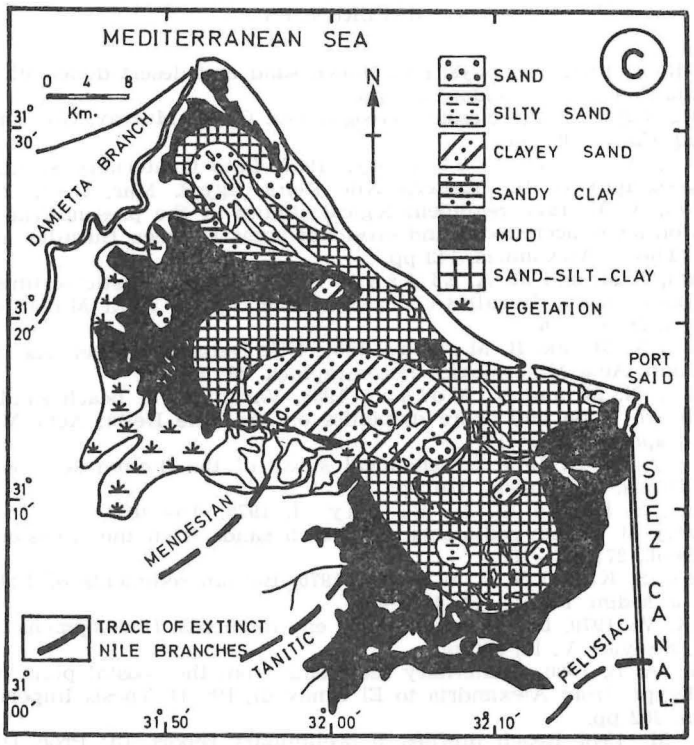


Fig. 12. Areal distribution of surface bottom sediments of the Nile Delta coastal Lakes. a-Idku, b-Burullus, c-Manzala

presence of the coarser sediments in the centre of Manzala and Burullus lakes is related to the the relict sediments which had been supplied to the sea by the former distributary branches of the Nile. Eventually, the redistribution of these sediments by currents is responsible for such sediment pattern inside the lake. This idea is supported by the conclusion of Coutellier and Stanley (1987). These relict sediments are unrelated to the recent sedimentation of the Nile. They must be relict Pleistocene sediments formed by the old Nile branches and reworked during rise of sea level.

CONCLUSIONS

The present study precisely defines the major geomorphological units in the Nile Delta coastal zone. It is based largely on the field trips, air and satellite photos. The defined major geomorphological units running landward from the northern coast to the South are: the nearshore zone, beach & coastal flat, coastal sand & carbonate ridges, coastal recent & old dunes and coastal lakes.

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KRATKI SADRŽAJ

Na obalnoj ravnini delte rijeke Nil, od Aleksandrije to Tineh Bay zaljeva, istočno od Port Saida, nalazi se nekoliko različitih geomorfoloških jedinica. Idući od obale Sredozemlja prema unutrašnjosti kopna razlikuju se slijedeće jedinice: 1 — priobalna zona do 6—7 m dubine proteže se preko abrazione zone, prelomljene zone i pješćane pruge; 2 — plaža i obalna ravnina, sastoji se od sitnog i vrlo sitnog pijeska sa malim područjima srednje velikog i velikog pijeska; 3 — obalni prirast pješćanih plaža obrubljenih obalnim ravninama delte. Starije karbonatne pruge (Pleistocen) protežu se prema zapadu, od Aleksandrije ka Libijskoj granici; 4 — obalne dine, poprečnih i uzdužnih pojaseva sitnog i vrlo sitnog pijeska, obično locirane na južnim rubovima glatke unutrašnje obalne linije.

Ostale neaktivne akumulacije pijeska i sitnog mulja starih dina protežu se više u kopno južno od recentnih dina i obalnih jezera; 5 — obalna jezera, rasprostranjenje sedimenata u jezeru Burullus slično je onome u jezeru Manzalla, gdje su reliktni sedimenti okruženi recentnom sedimentacijom. S druge strane, u jezeru Idku distribucija je uglavnom recentna.