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CHARACTERISTIC FEATURES OF COASTAL SAND DUNES ALONG BURULLUS—GAMASA STRETCH, EGYPT

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ABSTRACT

Coastal sand dunes play an important protective role due to recent severe erosion along Nile Delta coast, especially in areas where the backshore is low-lying. The study performed in this research illustrates the results of the work carried out on the coastal sand dunes to put a body of basic data to be used in coast protection.

Between Burullus outlet and Gamasa drain, the main geomorphological features of coastal sand dunes are discussed on the basis of dune type, origin, modification, wind velocities, wind ripples, internal structure and dune vegetation.

Along Burullus outlet-Kitchener drain stretch, grain size relationship between coastal sand dunes and beach sands have been studied on light of sand transport by onshore wind action. It is found that there is a fining grain size cycle from the beach, throughout the bottom and up to the top of dune sands. There is a sympathetic relationship between grain size peaks of beach and dune sands. The field can be described as being under dominantly unidirectional wind control from WNW and NW.

An attempt was made to differentiate between the two populations of sorting occurred in coastal dune sands. The differentiation depends upon grain size distribution curves, statistical parameters and scatter diagrams. Top of dune sands are finer, more sorted, slightly positive skewed and has lower kurtosis values than the bottom sands.

Internal structure of barchan dune studied by making three cuts in the windward side, leeward side and in the barchan horn. The three types of stratification can be differentiated depending upon angle of dip and thickness of lamina.

INTRODUCTION

The majority of coastal sand dunes along Nile Delta coast lies between longitudes 30° 59′ — 31° 33′ E, and latitudes 31° 36′ — 31° 23′ S *(Fig. 1)*. The area extends for about 59 km between Burullus outlet and Gamasa drain. The southern extension of the area is from the shoreline landwards for about 10 km. Burullus outlet connects the Mediterranean sea with Burullus lake at Burg El Burullus village.

The study of the geomorphological features of the area was based on the examination of its air photographs of the scale 1:25 000 comparison with older topographic maps and on the field examination. The ERTS satellite photographs have served as a good basis for recognising the important aspects of the geomorphology of the coast.

The main changes that have occurred on the Nile Delta coast during historical times are the reduction of the Nile mouths from seven to two *(Fig. 2)* [TOUSSON O., 1934], and the deterioration of the coastal regions due to the formation of marshes and lakes, following subsidence or other causes.

Estimated volumes along Burullus-Gamasa coast are at least 50×103 tons of sand [SESTINI, G., 1976]. The area is characterized by two belts of different extension

(Fig. 1), type and age. The first dune belt is coastal, recent and runs parallel to the coast between Burullus and Gamasa drain for about 59 km. Most of these dunes are of barchan and longitudinal types with elevations up to 40 m above their base-level, their width ranges between 1—8 km. The other dune belt is older, smaller and extends parallel to the northern shore of Burullus lake for about 8 km east El Burg village. Such lower belts (5—10 m high) consist of dome-shaped dunes, made of yellowish brown sands.

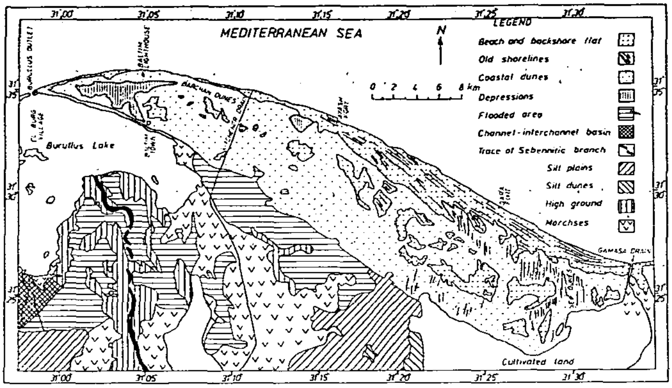

Fig. 1. Geomorphological map of the coastal area between Burullus outlet and Gamasa drain

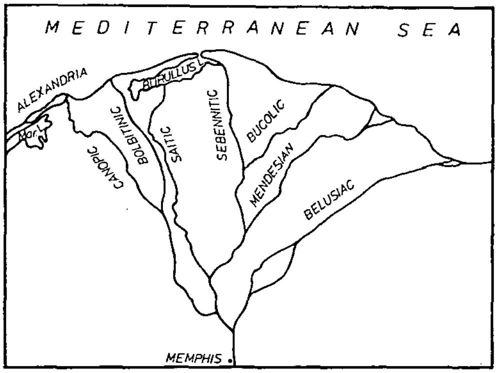

Fig. 2. Nile branches in classical times

The two dune belts represent two distinct periods of dune formations. Between the high coastal dunes, there are hollows with flat or rolling floors made of sand and fixed by grass and clay. This grassy surface is continuons from hollow to hollow under the high dunes. It is moreover marked by pottery fragments, bons and shells. This surface is at elevations of 1.5 to 5.0 m above sea level and was once occupied by settlements (Islamic and not very ancient). East of Burullus outlet, a very clear section is observed in contact with the older, lower surface and the younger, higher dunes *(Fig. 3)*. A similar situation of older, lower dunes fixed by vegetation and (or indurated, and overlain by younger higher dunes occurs south of Rosetta where the Nile cuts the dunes (Coastal Erosion Project, 1973), and at Gamasa [Barakat, M. G.

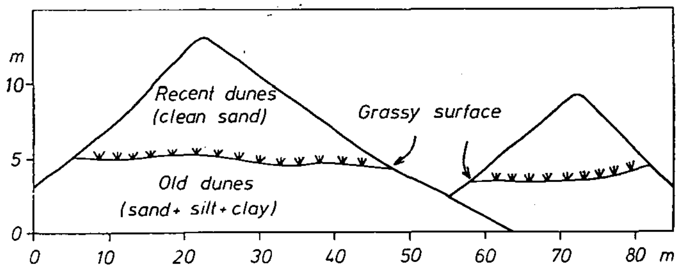

Fig. 3. Vertical section in coastal sand dunes — 1 km west of Burullus outlet

and IMAM, M. 1976]. So, the grassy surface separates two different facies of dune The lower dunes may be derived from the old deposits of Sebennitic branch, whereas the upper ones derived from the beach.

The area between the two dune belts is occupied by numerous depressions, some even below sea level. Between the depressions, there are some mounds and sheets of wind blown sand and low dunes, occupied by small lakes. Others are flooded during the winter and used as salt pans, but none are lagoons or old marshes. A series of elongated flat areas are also present in the depressions, they are oriented parallel to the present beach which may indicate the old shorelines.

The depressions between Burullus outlet and Baltim, and those flat areas west of Gamasa may indicate two periods of different times. The first period include the old shoreline which is followed by the formation of older and lower coastal dunes. The second period represent a past advancing of this part of the coast forming a wide coastal plain, along its newly shoreline the younger coastal dunes have been formed. Consequently, there was a gradual increase in their high due to sand transport from the near beach. On the other hand, due to lack of sedimentation, the older dunes still lower and modified to dome-shaped. Some of the flat areas between the two belts of dunes subjected to subsidence owing to the load of its sediments and the progressive flooding during winter seasons.

SAMPLES AND PROCEDURE

For studying the grain size relationship between beach and coastal dune sands, the stretch of Burullus outlet-Kitchener drain is chosen because the coastal dunes are somewhat near to the beach and it is easy to illustrate the effect of wind action on coastal sediments.

Three series of samples were collected along the coast; one from the beach (12 samples), and the other two series from the bottom and top of coastal dunes facing the sea (11 samples for each). These three series of samples were collected in the same date (18*th* November, 1974). It was intended to collect sample every 2 km.

Mechanical analysis was carried out by the conventional sieving method using a Ro-Tap shaker. About 100 gm split of each sample was sieved for 20 minutes. It is planned to use the half phi interval in between 3—4 phi set of sieves to give more accurate curves and statistical parameters [ISPHORDING, W. C., 1972].

The cumulative percentages were plotted on probability paper and graphical method was used. The grain size statistical parameters were calculated by computer using the formulae of FOLK, R. L. and WARD, W. C. [1957].

WIND DIRECTION AND VELOCITY

Daily measurements made over 4 years from 1972 to 1975, at Baltim city by the Egyptian Meteorological Authority, indicate that the prevailing wind comes from WNW, NW and N (*Fig.* 4), although winds from all directions are represented. Hence, the presence of a prevailing wind, effective in sand transport has been clearly established for the sand dune of Burullus area. The majority of daily readings (74%) range between 1—9 knots/hour, while 26% of these readings range between 9—23 knots/hour.

Through use of data from the original daily wind readings, a total wind rose diagram and monthly rose diagrams result *(Fig. 4)*. The total wind rose diagram *(Fig. 4A)* indicates that both 1—9 and 9—23 knots winds are mainly from the WNW. The strong winds occur most frequently during winter season, especially during December and January. It is observed from *(Fig. 4B)* that during winter season (from December to March) an additional minor trend (from E and NE) was observed which was absent during summer season (June, July and August). However, the dune field may be described as being under a dominantly unidirectional wind control from WNW an NW.

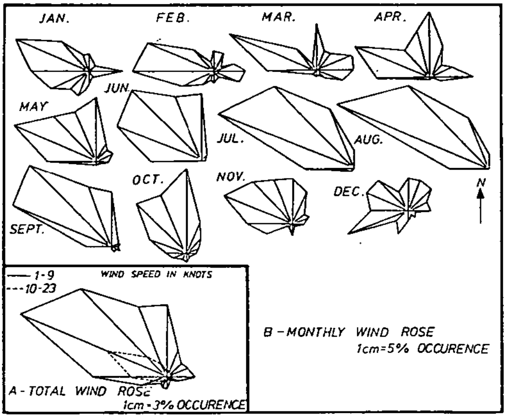

Fig. 4. Wind rose — Baltim 1972—1975

It is observed that the orientation of barchan and longitudinal dunes in relation with wind regime is to NW, but west of Gamasa drain, some of the dune orientations are slightly deviated to the north from that of the prevailing wind while others follow the proper directions.

TYPES OF BURULLUS-GAMASA COASTAL DUNES

Wind blown dunes are commonly found to surmount beach ridge plains on the coast. The beach is narrow and sandy, providing sand to blow onto the dune. The following coastal dune types, based on morphological features as established in the literature, are recognized:

Barchan dunes: They are crescent-shaped sand mounds. Between Burullus outlet and Kitchener drain most of the dunes are of the barchan type. They occur both as isolated and in complex forms tend to concentrate inland, while the isolated barchans are located near and parallel to the coast. On the other hand, between Kitchener and

Gamasa drains, most of barchan dunes occur as isolated bodies, but at 20 km WSW of Gamasa another area of complex barchan forms is present.

The orientation of barchan dunes in relation to wind regime is to WNW and NW, where the gently-shaped windward side of dunes is toward the sea, and the steep leeward side is to SE. The height of the dunes ranges between 10—30 m above their base-level, in length parallel to wind between 20—250 m, and the width across the horns between 15—200 m.

Longitudinal dunes: This type of dunes is common west of Gamasa and extends for 20 km parallel to the shoreline. These dunes are elongated in shape, more or less straight. Their long axis lie parallel to the prevailing wind direction with continuous crest without breaks but serrated. The height of the dunes ranges between 15—40 m and in length between 1200—1400 m.

There are various views regarding the origin of barchan and longitudinal dunes. Bagnold, R. A. [1971] believes that the barchan dune-type can only occur when the wind is nearly unidirectional, and the longitudinal dunes are produced when strong winds blow from a quarter other than that of the general drift of sand. McKee, E. D. and Tibbitts, Jr. G. C. [1964] and McKee, E. D. [1966] suggest that longitudinal dunes are produced in the vector of two converging wind directions blowing from two quarters, about 90° apart. Glennie, K. W. [1970] believes that a more important factor for generation of that dunes is the existence of a strong wind of uniform direction, and adds that barchan dunes develop at lower wind velocities and longitudinal dunes are formed when wind velocities are higher. He also believes that during Pleistocene glaciation, 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, R. A. [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 modify a series of isolated barchan dunes *(Fig. 5),* such modification occur with the direction of prevailing wind. Consequently, the barchan dunes occur together with longitudinal ones in the same series. Moreover, the interdune areas between

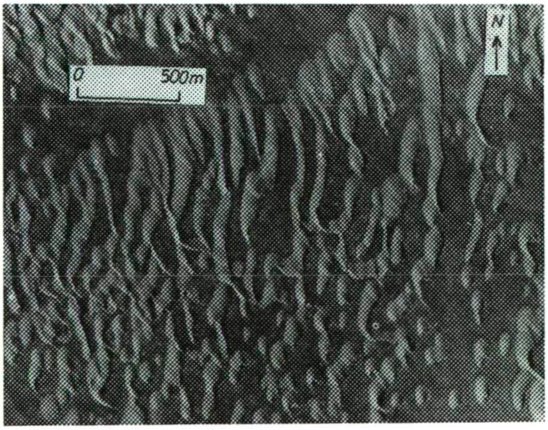

Fig. 5. Aerial photograph of longitudinal dunes — west of Gamasa.

longitudinal dunes contain some well-formed barchans in small scale. Such phenomena may support the last opinions of GLENNIE, K. W. [1970] and BAGNOLD, R. A. [1971] about the occurrence of barchans with longitudinal dunes.

GRAIN SIZE RELATIONSHIP BETWEEN COASTAL DUNE AND BEACH SANDS

Between Burullus outlet and Kitchener drain (22 km), three series of samples have been collected, one from the beach, and the other two from bottom and top of dunes. This system of sampling easily permits comparison and shows a sort of relationship between beach and dune sands on light of sand transport.

Fig. 6 shows the cumulative percentage of coarse plus medium sand and standard deviation against distance between Burullus outlet and Kitchener drain for the three types of sands.

The variation of percentage of coarse plus medium sands in the coastal dune (for both bottom and top), from west to east, follows quite closely those that are found on the beach *(Fig. 6)*. From the beach, passing through the bottom, and up to the top of the dunes, the percentage of coarse plus medium sands decreases, whereas the standard deviation improves. Thus, there is a fining cycle from the beach passing through the bottom and up to the top of dunes.

Generally, the lateral variation of the percentage of coarse plus medium sands for the dunes shows an eastward increase *(Fig. 6)*. But the most observed feature is the presence of a pattern of peaks ("highs" and "lows"). Four major highs could be recognized for the dune sands at 4, 10, 18 and 21 km, and three lows at 6, 12 and 20 km

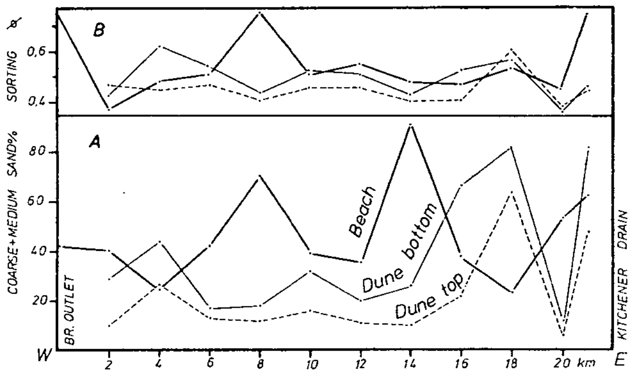

Fig. 6. Grain size relationship between beach and coastal dune sands

east of Burullus outlet. Similarly, the series of beach sands also shows 4 major highs at 0, 8, 14 and 21 km, and 3 lows at 4, 12 and 18 km east of Burulluss outlet.

To discuss the grain size relationship between beach and coastal dune sands, it is of importance to take into consideration the following factors:

1. The dune sands are finer grained than beach sands.
2. The field can be described as being under dominantly unidirectional wind control (WNW and NW).
3. The sand forming the dunes is derived from the beach.
4. The sympathetic relationship between peaks of beach and dune sands.

On light of last factors, it is found that the highs and lows of dune sands are related to those of beach with eastward shifting *(Fig. 6)*. This lateral eastward shifting of sand dune peaks from those of beach sand ones ranges between 2—4 km, due to the prevailing WNW and NW winds.

The following are four major examples for sand transport from beach to dune with their eastward shifting *(Fig. 6)*:

Shifting of highs:

a) Dune sand at 10 km is related to beach sands at 8 km due to decreasing in percentage of coarse plus medium sands from beach (70.34%), through the bottom (31.80%), and up to the top of dunes (16.40%).

b) Similarly, dune sands at 18 km is related to beach sands at 14 km (the percentage of coarse+medium sands for beach, bottom and top of dune being 91.07, 81.44 and 63.36%, respectively).

Shifting of lows:

a) Dune sand at 14 km is related to the beach sand at 12 km due to the decreasing of percentage of coarse+medium sands from the beach (35.61%), through the bottom (26.03 %), and up to the top of dune (9.90%).

b) Similarly, dune sand at 20 km is related to beach sand at 18 km (the percentage of coarse+medium sand for beach, bottom and top of dune being 23.69, 11.62 and 6.03% respectively).

It is now clear that there is a fining grain size cycle from the beach, through the bottom and up to the top of dune sands. The present work maintain that the beach sands are the source of wind blown sands and sand dunes along Burullus coast. Owing to prevailing WNW and NW winds, the sand transport is accompanied with an eastward shifting from the beach to the dune. So, it is reasonable that the dune sands are more sorted than that of the beach ones.

DIFFERENTIATION BETWEEN BOTTOM AND TOP OF COASTAL DUNE SANDS

The results of mechanical analysis and the calculated grain size statistical parameters of both bottom and top of dune sands are used in the differentiation between them. The averages of these data are given in Table 1 and shown in *Fig. 7*.

TABLE 1

Average grain size parameters of bottom and top of dune sands

Sand dune	Weight % of fractions					Statistical parameters			
	C. S	M. S.	F. S.	V. F. S.	C. silt				
	0—1∅	1—2∅	2—3∅	3—4∅	4—5∅	D_{50}	σ_I	SK_I	K_G
Bottom	2.88	34.87	55.32	6.83	0.07	2.20	0.59	—0.03	1,07
Top	0.52	21.19	68.25	9.91	0.11	2.40	0.52	0.01	1.02

Table 1 and *Fig. 7* show that the top of dune sands are finer, more sorted, slightly positive skewed, and has lower kurtosis value than that of the bottom ones. This is in agreement with ANAN, P. S. [1969] who found that the lower samples of dune sands

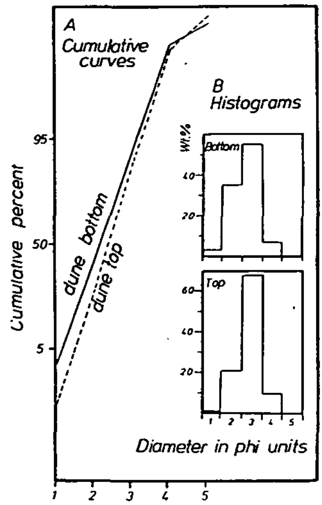

Fig. 7. Average cumulative curves and histograms of bottom and top of sand dunes

were slightly coarser and show some negative skewness values than the upper samples. In a single sand dune, GLENNIE, K. W. [1970] also found that there is a fining of sediment upward to the top of sand dune, at the same time standard deviation also improves.

To differentiate between bottom and top of dune sands, it is useful to plot the grain size parameters against each other in the form of scatter diagrams *(Fig. 8)*. In this way, their relationship can be determined. Such diagrams are very effective in differentiating and correlating the two types of sands. Boundary lines have been drawn so that many samples as possible from the same type of sand are on the same side of the line. A mixed area may be developed in some diagrams owing to overlap of such fields due to somewhat similarity of some sands of both type.

Median versus standard deviation *(Fig. 8A)* indicates that top of dune sands tend to be finer and more sorted than those of bottom ones. Kurtosis versus standard deviation shows that the bottom sands are less sorted and the samples have relatively higher kurtosis values than those of top ones *(Fig. 8B)*. Median versus skewness and skewness versus standard deviation indicate that some bottom sands tend to be negatively skewed *(Fig. 8C* and *D)*. Coarse percentile (D_5) versus fine percentile (D_{95}) shows that bottom sands are more scattered parallel to the D_5 axis *(Fig. 8F)* indicating their wider range of coarse fractions [PASSEGA, R., 1957]. The last combinations are effective and succeeded to differentiate between sands of bottom and top of dunes. On the other hand, kurtosis versus skewness seems to be ineffective in such differentatiation *(Fig. 8E)*.

It is observed from *Fig. 8* that the top sands tend to concentrate in a narrow field, while bottom ones, on the other hand, tend to spread in a wider range. Few samples of top are located in the field of bottom sands, this is due to the fact that these dunes which are located at 4, 18 and 21 km east of Burullus outlet *(Fig. 6)* are characterized by their higher median (for both top and bottom) than the neighbouring dunes.

The sand forming the dune is derived from the foreshore zone at low tide, from the beach sediments, and also from the backshore plain. So, the relatively coarser character of bottom sands than the finer top ones of dunes is probably due to processes associated with wind action. The onshore wind, when strong enough, is able to carry inland the coastal sediments lying on beach surface. The fine sediments can be easily transported by means of suspension, and are blown far up into the air, and deposited on the top of dunes due to presence of grassy surface or fences in exposed situations which act as a continuons deposition area. On the other hand, the coarse grains are difficult to be carried by wind action to the top of dunes. Thus, they are

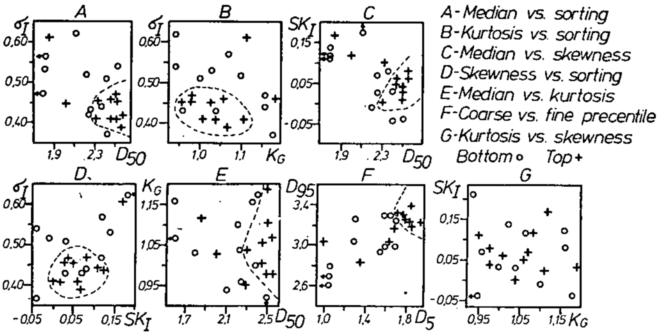

Fig. 8. Relationship between statistical parameters of bottom and top of sand dunes

transported close to the backshore surface by means of creeping and saltation. As a result, the coarse grains concentrate near the foot of dunes. According to ANAN, P. S. [1969], the lower samples were coaser than the upper ones because the larger particles can be easily rolling down and give negative skewness to the lower samples, while their loss gives the high positive values to the upper samples.

INTERNAL STRUCTURE OF BARCHAN DUNE

BAGNOLD, R. A. [1971] recognized that sand dunes are composed of accretion and avalanche deposits. These two types of deposits can easily be observed and have been described by various authors [McKEE, E. D. and TIBBITTS JR., G. C., 1964; and McKEE, E. D., 1966].

Internal structure of dunes may be known from the natural exposures of the interiors of the dune or by excavating it. Three cuts were made in a barchan dune *(Fig. 9)*, one in the windward side near the foot, the second in the leeward side near the crest, and the later in the barchan horn. The height of the barchan was about 10 m, and in length parallel to wind was 22 m, and the width across the horns was 8 m.

The stratification of wind blown sand is clearly observed and involves three types of laminae and bounding surfaces between sets of laminae. It was found that most of bounding surfaces are straight and showed apparent dips almost entirly towards leeward side.

Windward side lamina and those near the foot of dune are composed of low-angled lamina of sand. The angle of dip ranges between 5°—20°, although dips as high as 20° are not common. The individual laminae is rather thin and ranges between 0.7—1.2 cm thick. It is observed that heavy mineral-rich laminae alternate with heavy mineral-poor ones. The planer-tabular type of laminae is the most common. The sand of the horizontal bedding is rather firmly packed grains, deposited directly from the creep and saltation loads of the wind [ALLEN, J. R. L., 1970].

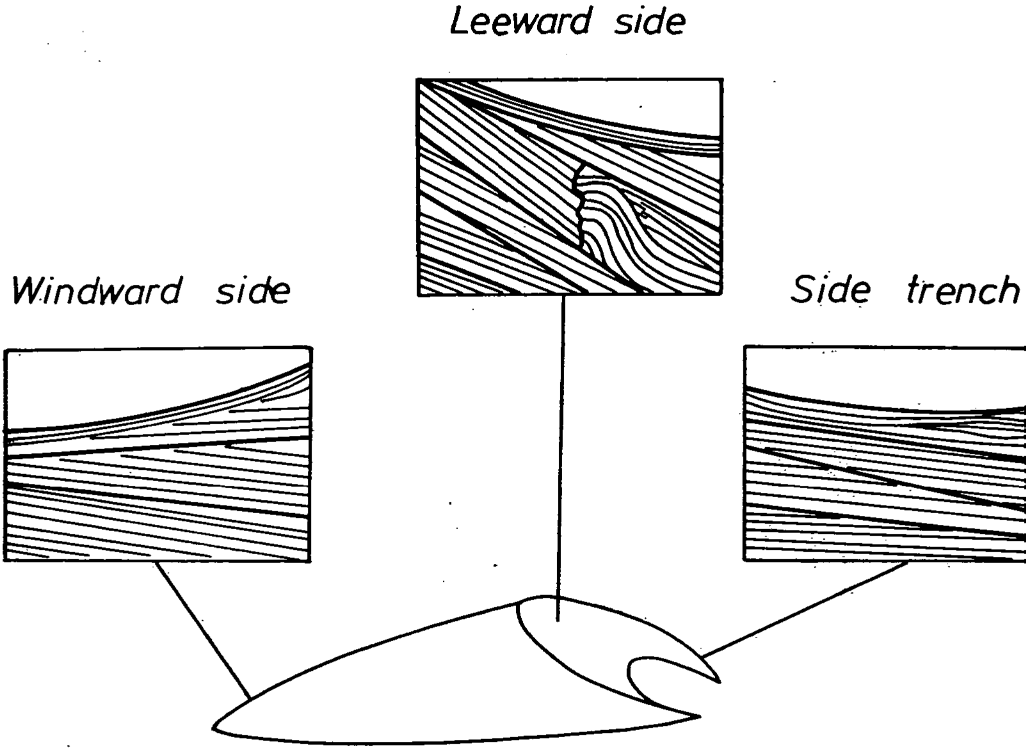

Fig. 9. Internal structure of barchan dune

Leeward side lamina near crest consists of cross-bedded units which are formed chiefly on the leeward slopes and are more steeper than those of the windward side due to avalanche deposits. Most surfaces bounding sets of cross-strata dipped from 18°—33° to leeside, and most lamina within them are dipping somewhat more and varies between 22°—35° (dips as low as 22° are not common). The individual laminae are rather thick, about 2—6 cm. A series of deformational structures such as irregularity of bedding, slump folds and fractures are observed and are probably formed as a result of local slumps on the avalanche side.

A cut in the curving barchan horn (side trench) shows a stratification pattern which consists of nearly flat surfaces bounding cross-strata sets with dip varying between 5°—13°. Laminae within each set dipped outward from the dune center and ranging between 3°—15°.

WIND SAND RIPPLES

On the dunes under investigation, wind ripples abound on surfaces of blown sand. These ripples are laterally extensive, straight, and parallel crested to slightly sinous crested. Their gentler slope side lying at the windward direction (WNW and NW). The wavelength is seldom less than 10 cm and rarely greater than 14 cm, the amplitude ranges between 0.4—0.5 cm. Accordingly, the ripple index ranges between 25—28. It is well known that wind ripples have greater ripple index (20—90) than the asymmetric water ripples (4—10).

The coarsest grains are commonly seen to collect on and near the crest of sand ripples where the average median size is 1.90 phi. On the other hand, the finest ones tend to concentrate in the trough of the ripples where the average median size is 2.15 phi. This fact is in agreement with TWENHOFEL, W. H., [1932] and BAGNOLD, R. A., [1971].

DUNE VEGETATION

Vegetation is very important in establishing the character of many coastal sand dunes. It plays an important role in the stabilization of the dune and also promotes its growth by porividng a trap for wind-blown sand.

The most important dune plants are the grasses which flourish in loose sand, beside grasses, it is observed that *Euphorbia terracina, Alhagi maurorum* and *Salicornia sp.** covered the coastal dunes between Burullus outlet and Kitchener drain. BARAKAT, M. G. and IMAM, M. [1976] observed that the characteristic plants which cover the longitudinal dunes west of Gamasa are: *Zygophyllum albam, Halocnemon strobiloceum* and *Salicornia fruticosa.*

Such plants play an important role in binding together the sand by their complex root system and thus help to protect the dunes from the erosive action of wind. If the vegetation is weakened for any reason, for example by trampling of people walking over the dunes, as a result, sands are exposed to wind action and the loose grains will blown away. Thus, the form of dunes will altered and appears as dome-shaped. Such phenomenon has been observed in the old dune belts which extend parallel to the northern coast of Burullus lake where that area is largely inhabited.

IMPORTANCE OF COASTAL DUNES FOR COAST PROTECTION

EL-FISHAWI, N. M., [1977] discussed the causes of beach erosion along Burullus coast and differentiated between accretional and erosional areas depending upon grain size parameters. He also studies the relationship between beach, coastal dune and nearshore zone sands. Eroded areas of the sandy coast are abundant where the beach and former coastal dunes are subjected to severe erosion. The ridges are cut in the coastal dunes due to the attack of waves on their foot *(Fig. 10)*. A single powerful storm may cut away a beach strip about 20 m wide and the sea washed away the coastal dunes up to 8 m high. More powerful erosion has been recorded near Burg El-Burullus village where numerous palm trees are observed today to be submerged by the sea. Nowadays also, many summer houses of Baltim resort located on the beach have been destroyed *(Fig. 11)* due to great advancing of sea water.

For the last reasons, coastal dunes are important forms of protective nature for the coast, especially in some locations where the backshore is low-lying. Coastal dunes along Burullus coast act as barriers against severe action of onshore winds. Other dune ridges slightly further inland are also protective but to a lesser degree than the front ones and help as second line of defence.

To prevent destruction, blow-outs of sand and instability in coastal dunes, suitable stabilization methods should be undertaken. American scientists have carried out successful methods [KING, C. A. M., 1972] for stabilization the coastal dunes. These methods are: *1* — providing of suitable plants which make much contribution

* Identification based on personal communication with PROF. DR. SHUKRI IBRAHIM, Botany Dept., Fac. Sci., Alex. Univ.

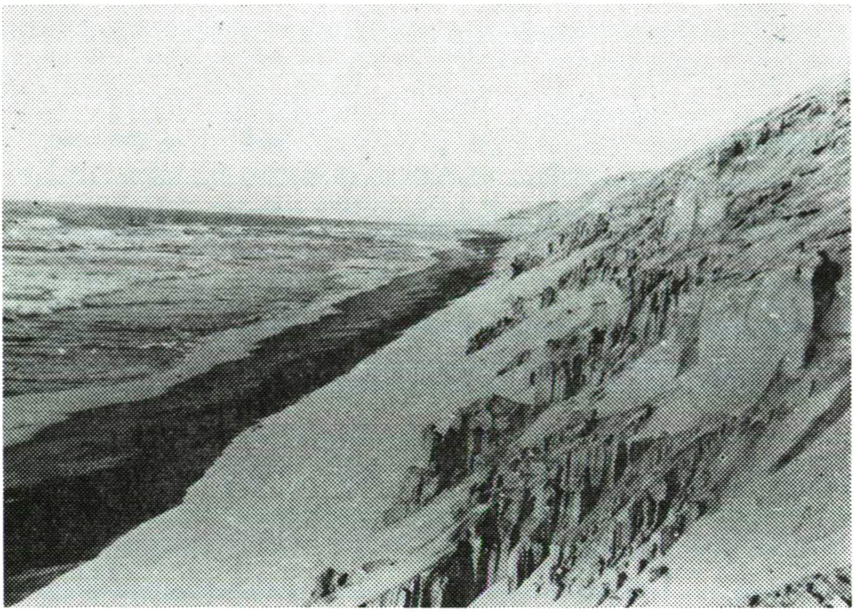

Fig. 10. Waves attack on the coastal dunes — 2 km west of Burullus outlet

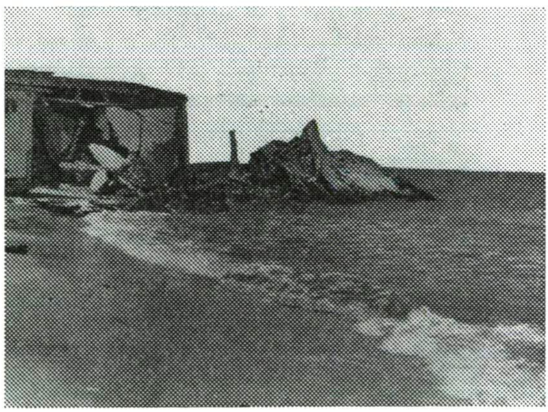

Fig. 11. Sea advancing and destruction of summer houses-Baltim resort.

to the trapping of sand. *2* — sand accumulation can be encouraged by placing brushwood fences in exposed situations. *3* — stabilization of the bare sand by spraying it with a suitable solution that holds the sand in place.

In fact, the vegetation and fences, which are successful methods for dune protection, have been carried out by inhabitants themselves on some restricted areas east of Burullus outlet and west of Gamasa to prevent the covering of their cultivated land by sands.

SUMMARY AND CONCLUSION

Along Burullus-Gamasa coastal dunes, two belts of different extension, type and age can be observed. The first dune belt is coastal, recent, high and run parallel to the coast. The other dune belt is older, smaller, lower and extends parallel to the northern shore of Burullus lake. The two dune belts represent two distinct periods of dune formation due to past advancing of the coast, forming a wide coastal plain and along its newly formed shoreline the younger coastal dunes have been formed. In some locations, a grassy rolling or flat floor separates the two types of dunes.

West of Gamasa, southern parts of longitudinal dunes tend to modify to series of isolated barchan dunes. Such modification occurs with the direction of prevailing wind. This may be an indication to the unstability of longitudinal dunes because recently wind velocities are not strong enough to maintain them.

On light of sand transport from beach to coastal dunes, by wind action, it is found that the variation of percentage of coarse plus medium sands in coastal dunes, follows quite closely those ones that are found on the beach. There is a fining grain size cycle from the beach, throughout the bottom of sand dune, and up to the top whereas the sorting also improves. It is observed that the grain size peaks of coastal dunes are related to those of beach sands with an eastward shifting due to WNW and NW winds. Such sympathetic relationship maintains that beach sands are the source of wind-blown sands.

Grain size parameters are sensitive and used to differentiate between bottom and top of coastal dune sands. The combinations of median and kurtosis *vs.* standard deviation, median *vs.* skewness, skewness *vs.* standard deviation, and coarse percentile *vs.* fine percentile are effective in such differentiation. On the other hand, combination of kurtosis *vs.* skewness is ineffective and failed to differentiate between the two types of sand. The present work indicates that top of dune sands are finer, more sorted, slightly positive skewed and has lower kurtosis values than the bottom sands. Owing to onshore wind affecting the coast, fine sediments can be easily transported from the beach by means of suspension and deposited on the top of dunes due to presence of grassy surface or fences placed in exposed situations. On the other hand, coarse grains are transported close to the backshore surface by means of creeping and saltation. At last, the coarse sediments concentrate on and near the foot of dunes.

Internal structure of barchan dune is clearly observed by excavating it. The stratification of wind blown sand involves three types of laminae of different thickness and dips, and bounding surfaces between sets of laminae. Most of bounding surfaces are straight and show apparent dips almost entirely towards leeward side. Leeward side laminae are more steeper and thicker than both windward and side trench laminae. A series of deformational structures are observed and probably formed as a result of local slumps on the avalanche side.

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