Bull. Nat. Inst.Ocean. & Fish., A.R.E., (1992), 18: 25 - 35

DIFFERENTIATION BETWEEN ADVANCING AND RETREATING BEACH SANDS ALONG THE NOUAKCHOTT COAST, MAURITANIA.

M.F. LOTFY,

Coastal Research Institute, 15 Faraana Str., El-Shallalat, Alexandria, Egypt.

ABSTRACT

This study distinguishes between accreted and eroded beach sands along the Nouakchott coast of Mauritania on the basis of their grain size, shape of grain size distribution curves and statistical grain size parameter relationships. Such methods were found to be effective in differentiating between them. The accreted sands are coarser, less sorted, lightly negative skewed and have relatively higher kurtosis values than the eroded ones.

INTRODUCTION

Accretion and erosion are common to sandy shores exposed to waves and currents. The stability of any particular section of the shoreline depends upon the balance between the quantity of sediment supplied to that section and that carried away. If the sediment supplied is equal to that transported away, then the coastal section is said to be in dynamic equilibrium and the beaches are not subjected to erosion or accretion, but only to seasonal off-shore changes associated with seasonal fluctuation in wave climate.

The area under investigation represents a coastal sand plain created by wind and waves. It extends for about 20 Km in length, just to the north and to the south of the Nouakchott harbour, which is called the "Port of Friendship" (Fig. 1A). The shoreline is smooth, arch shaped and without great undulations. The most notable shoreline feature is the large asymmetric cusps with changing location.

The beach to the north has a gentle foreshore slope, containing considerable amounts of shells and shell fragments, and is also characterized by a low concentration of black sands. On the other hand, the beach to the south of the Port (Fig. 1B), has a steep foreshore slope, containing small amounts of shell fragments, and is also characterized by a high concentration of black sands that exist as a thin mantle along the shoreline. Underlying this black sand mantle, there are alternating black and light coloured thin laminae. Generally, the beach sands of both sides of the Port have approximatively the same major heavy mineral assemblage, mainly ilmenite, garnet, rutile, tourmaline and zircon. They also contain many of the same minor minerals.

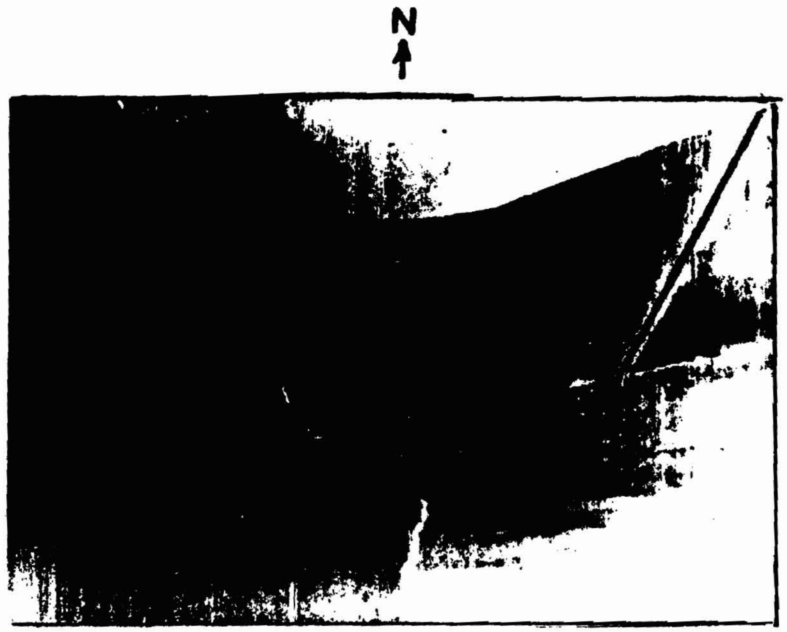

Fig. 1 A

The Nouakchott harbour, Known as the "Port of Friendship"

Fig. 1 B

Attack of waves on the base of coastal dunes
(south of the port).

The backshore zone is wide and flat to the north and to the south. It is bounded by a belt of sand dunes, mainly of longitudinal (sief) type, running parallel to the coast. The northern dunes do not differ from those to the south.

Along the coast, two types of sand beaches can be distinguished, namely (Fig. 2): (a) beach undergoing erosion, mainly located near the harbour to the south particularly in the area close to the man-made defence structures (Jetty), and (b) beach undergoing accretion, observed beyond the northern end of the harbour which has begun to grow since 1985 (Deconinck, 1987). Features of erosion and accretion along the beach are variable, a boundary may be observed at one time, while at another time, a description of such geatures in very important. for example, after a period of servere erosion or accretion, they are clearly present.

It is believed that among the important factors in coastal erosion and accretion along the Noukchott coast are the huge waves driven by the strong winter storms from NNW or WNW direction (Deconinck, 1987), strong predominant littoral current trends inducing a strong beach drift from north to south (Lotfy, 1990) and the man-made defence structures like jetty of the Nouakchott harbour. In addition, there are several other causes of coastal erosion and accretion, such as the character of the coast, off-shore relief and sea level changes, mentioned by El-Ashry et al., (1971); Zenkovich (1967); King (1972) and Lotfy (1984).

The purpose of the present study is to differentiate between accreted and eroded sands on the basis of the character of their grain sizes, shape of grain size distribution curves and statistical grain size parameter relationships.

SAMPLES AND PROCEDURE

The sand samples used in this investigation were collected from beaches of Nouakchott, where either erosion or accretion as evident, well marked to be visible in the field and hand taken place more or less continuously for periods longer than three years (Fig. 2). During several field observations, fifteen samples were collected from typical accreted parts along the beach at locations 1,6 and 10 Km north of the Port. In addition, fifteen samples were also collected from typical eroded parts along the beach at locations 0.5,2 and 10 Km south of the Port. This sampling programme was repeated five times between 1986 and 1988. The samples were taken from the swash zone by scraping the topmost 5 cm of the beach.

Since the sands under investigation are friable, no disaggregation was found necessary. All the samples collected were washed, dried and split. Mechanical analysis was carried out by the conventional sieving method, with

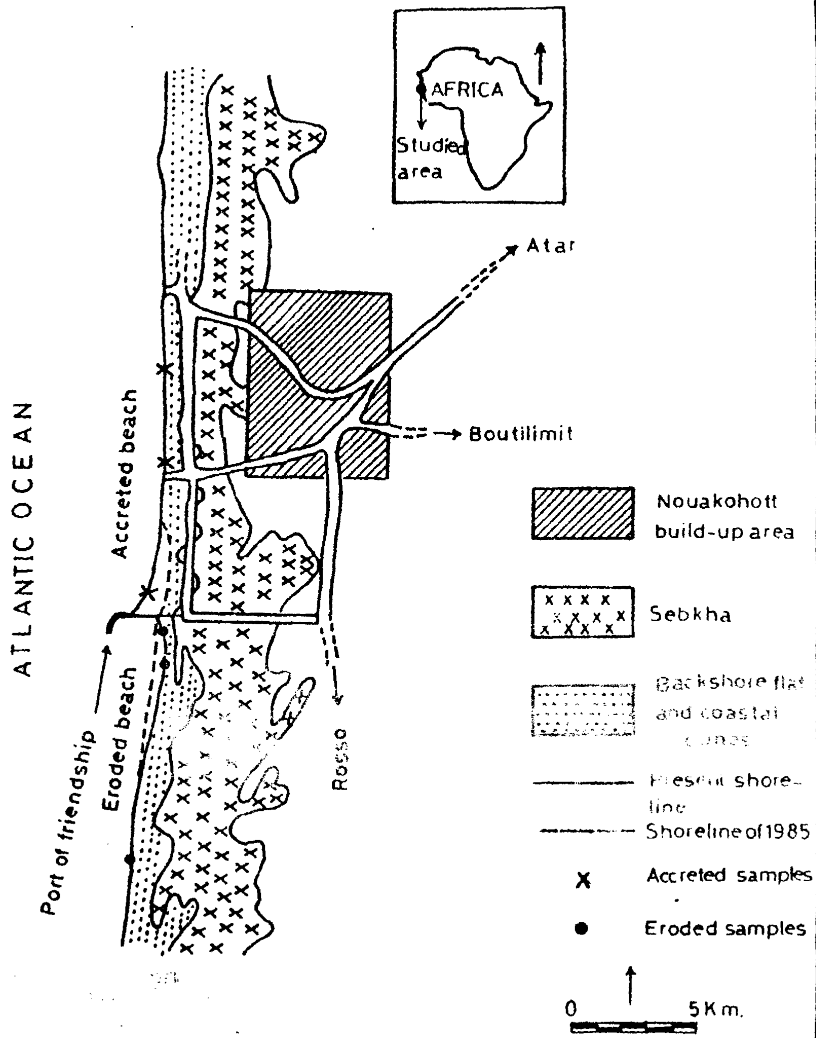

Fig. 2

Location map showing the studied area and beach sample location.

screens placed at one-phi (ϕ) intervals. It is planned to use the half-phi intervals in between 3-4 phi sets, because they give more accurate cumulative curves. About 100 g of material was taken for analysis, using a mechanical shaker with a sieving time of 15 minutes. The sieve meshes give the class intervals 2,1,0, 0.5, 0.25, 0.125, 0.088, 0.063 and 0.037 mm. These correspond to the phi classes of -1, 0, 1, 2, 3, 3.5, 4 and 5, respectively.

The data were plotted as cumulative curves on log-probability paper to ensure maximum accuracy in determining the grain size parameters by the graphical methods (Folk, 1968). Statistical measures proposed by Folk and Ward (1957) for mean size (M_Z), sorting (σ_I), skewness (SK_I) and Kurtosis (K_G) were then obtained from values intercepted at specific percentiles in these curves.

RESULTS AND DISCUSSION

Grain size fractions :

The beach sands on both sides of the Port (Fig. 3) are predominantly fine grained (2-3 ϕ) with a high percentage of very fine sand (3-4 ϕ); averages are 71.81 % and 20.5 %, respectively. Coarse (0-1 ϕ) and medium (1-2 ϕ) sands are present only in small amounts along the whole beach (averages 1.04 % and 4.89 %, respectively). Very coarse sand (-1 to 0 ϕ) rarely occur in the beach sands, the percentages being always less than 1 % of the distribution. Also, the percentages of silt (the size fractions higher than 4 ϕ) being about 1 % of the distribution.

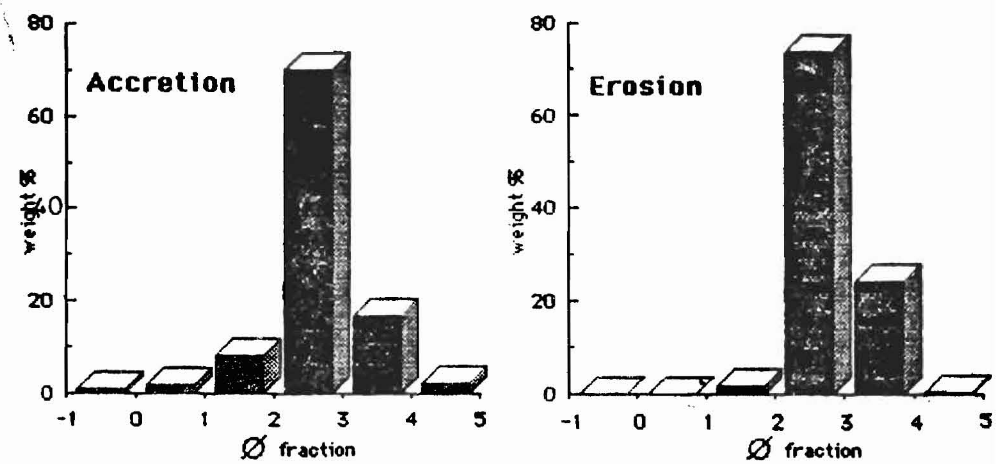

Fig. 3

Histograms of accretion and erosion beach sands.

Figure 3 shows that the normal size distribution (unimodal) appears to be characteristic for both accreted and eroded sands. The principal mode of the two types of beach sands lies in the fine sand class between 2 and 3 ϕ unit class indicating more or less similar sorting. They mainly differ in the amount of the coarser (the size fractions less than 2.0 ϕ) and the finer (the size fractions high than 3.0 ϕ) grained end, i.e. differ in the tails of the distribution. The amount of the coarser grained fraction is about 10.97 % of the distribution for the accreted beach sands and about 1.73 % for the eroded ones. On the other hand, the eroded sands contain a relatively larger percentage of the finer grained fraction than the accreted ones.

Generally, the grain size fractions indicate that the eroded beach sands are finer grained (average M_Z2.79 ϕ) than the accreted sands (average M_Z2.59 ϕ).

Log-probability curves technique:

One of the most significant paper relating sedimentation dynamic to texture was published by Inman (1949). He recognized that there are three fundamental modes of transport: surface creep (rolling), saltation, and suspension. Many authors, such as Fuller(1961); Moss (1962 & 1963); Spencer (1963); Visher (1969 & 1972); and Anwar et al., (1979 & 1984) used the grain size distribution curves, drawn on log-probability paper, for environmental analysis and to know the different processes of sedimentation. Visher (1969) has shown that most grain size distributions are comprised in one or more subpopulations (coarse, fine truncations and central part), which reflect three modes of sediment transportation. On the grain size distribution curves, drawn on log-probability paper, the angle of slope of the central part is a function to the degree of sediment sorting. The position of the coarse and the fine grained ends which are known as coarse and fine truncations (CT and FT) and the percentages of each of the three subpopulations appear to be a useful variable in the study of sediment dynamic.

The fields of grain size distribution curves of accreted and eroded sands (Fig. 4) are generally similar in having the three subpopulations, i.e. traction, suspension with two saltation populations. They are also more or less similar in having the same position of the coarse and the fine truncations points occuring at near 2.0 and 4.0 ϕ, respectively in most of the samples. In each case, the percentage of the saltation population represents nearly 93 % of the gain size distribution. The samples are also characterized by relatively low percentages of material in the traction and suspension populations, being about 6 % and 1 %, of the grain size distribution respectively. The sorting of the saltation population as indicated by the

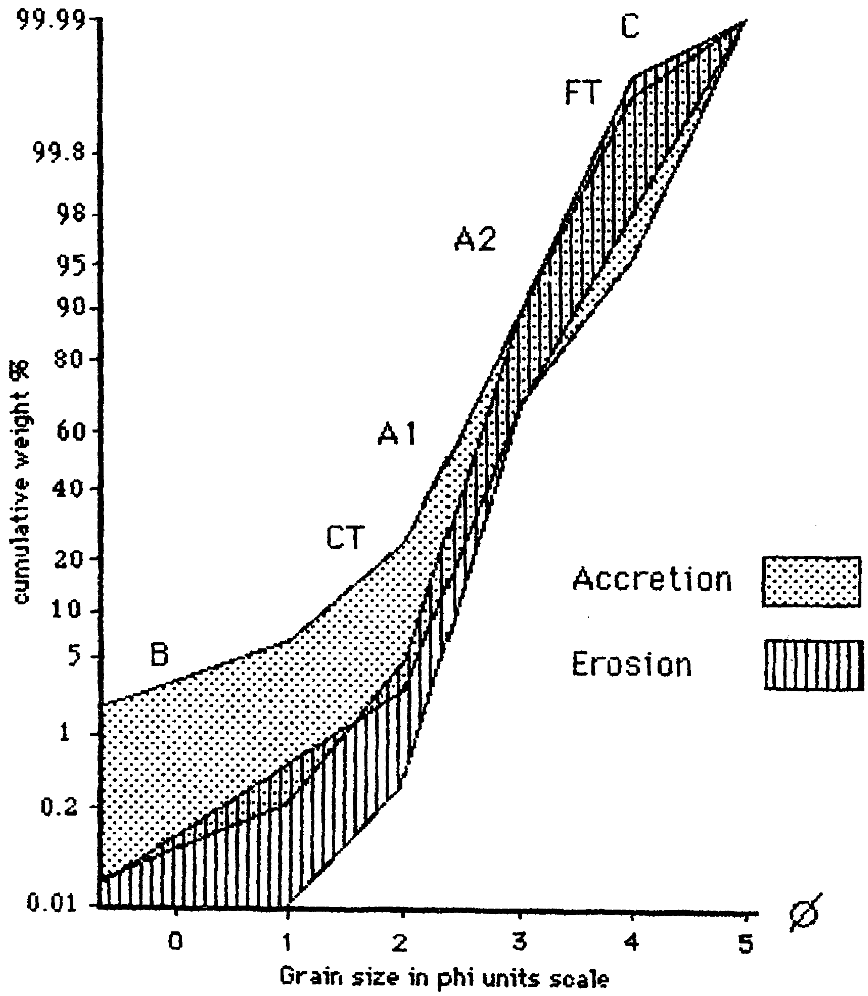

Fig. 4

Fields of grain size distribution curves of accreted and eroded beach sands
(B traction, A1 coarse saltation, A2 fine saltation, C suspension, CT coarse truncation point, FT fine truncation point).

slope of the central part of the curves, is excellent (74 to 77 degrees) as compared to the sorting of the traction (41 to 45 degrees) and suspension (55 to 60 degrees) populations.

The grain size distribution curves of the accreted and eroded sands (Fig. 4) show differences in these respects, mainly in the slope or sorting of the central part of the distribution and the amount of the traction - suspension populations. The average angle of the slope is relatively higher in the eroded sands (77 degrees) than in the accreted ones (74 degrees), reflecting the better sorting of the former. The eroded sands have a very small percentages of the suspension and traction populations (0.46 % and 1.73 %, respectively). Finally, the accreted sands have a relatively high amount of coarse traction populations comprising up to 11 % of the distribution, and the amount of suspension population is represented by about 2.3 % of the distribution.

Generally, the analysis of log-probability grain size distribution curves was found to be a good approach for differentiating between accreted and eroded beach sands. The coarse traction population is effective in this differentiation.

Textural parameter relationships :

Dal Cin (1976); Anwar et al., (1979) and El-Askary et al., (1980) noticed that the textural parameters are environmentally sensitive and combinations of these parameters permit differentiation between receding and advancing beaches.

Scatter diagrams of couples of grain size parameters for both accreted and eroded sands are shown in Figure 5. Boundary lines have been drawn, so that as many samples as possible, from the same type of sand, are on the same side of the line.

Bivariant plot of mean size versus skewness (Fig. 5A) gave a nearly complete separation of distinct fields. The eroded sands tend to be positive skewed and finer than those of the accreted ones. Mean size versus standard deviation (Fig. 5B) shows that the eroded sands tend to be better sorted than those of the accreted ones. Skewness versus standard deviation (Fig. 5C) shows again that the eroded sands are positively skewed and better sorted than those of the accreted ones. Skewness versus kurtosis (Fig. 5D) gave also a nearly complete separation of distinct fields. Eroded sands have lower kurtosis values (mesokurtic) than those of accreted ones. It is observed in Figure 5 that the eroded sands tend to be concentrated in a narrow field, while the accreted sands tend to be spread in a wider range.

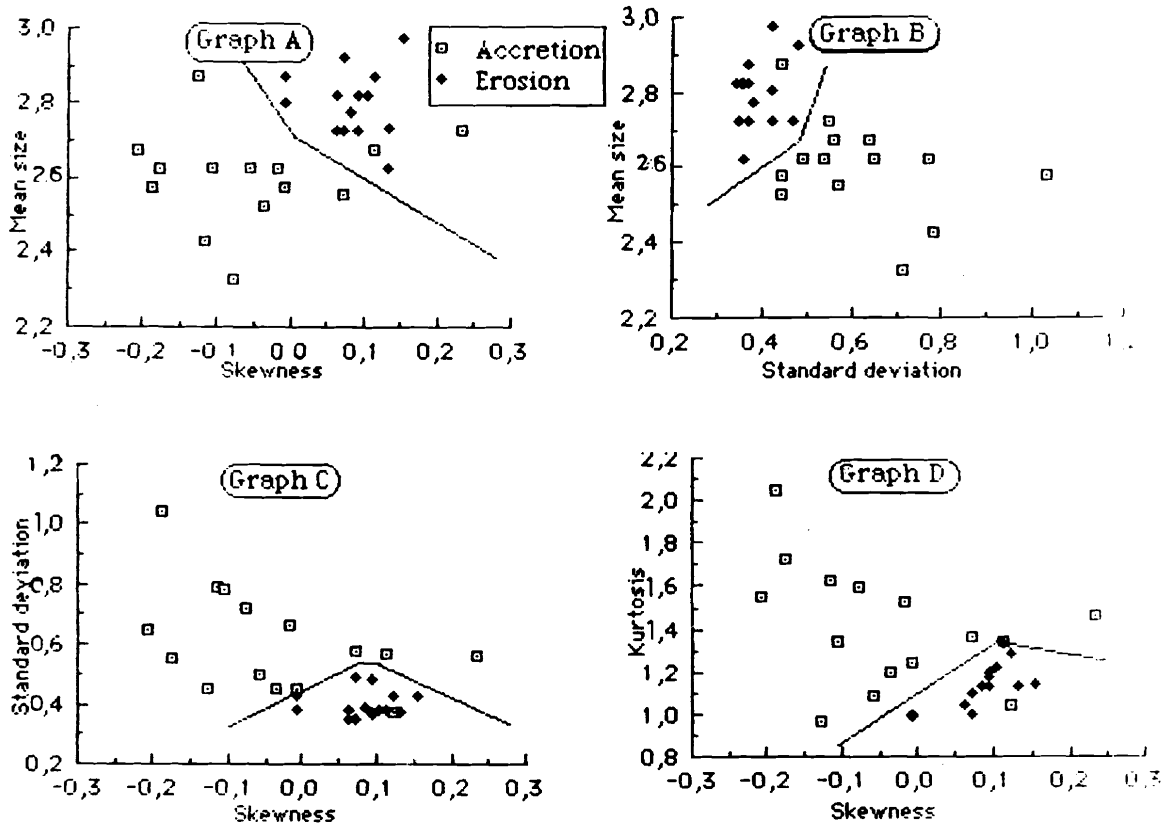

Fig. 5

Relations between statistical parameters of accreted and eroded beach sands.

Generally, the accreted sands are coarser, less sorted, somewhat negatively skewed and have a relatively higher kurtosis values than those of the eroded sands.

CONCLUSION

The present study serves to differentiate between accreted and eroded beach sands from the advancing and retreating coast of Nouakchott, Mauritania. The accreted beach sands contain more coarser grains than the eroded ones. This is probably due to the lower speed of beach wash in sheltered areas under the action of flat waves on a gently sloping beach. On the other hand, high stormy waves on a steeper beach face will move coarse sands downshore leaving the eroded beach sands more finer. The shape of grain size distribution curves and textural parameter relationships were found to be sensitive and effective in differentiating accreted sands from the eroded ones..

REFERENCES

Anwar, Y.M., A.R. Gindy, M.A. El-Askary and N.M. El-Fishawi, 1979. Beach accretion and erosion, Burullus-Gamasa coast, Egypt. Marine Geology Journal, 30, Mi-M7.

Anwar, Y.M., M.A. El-Askary and O.E. Frihy, 1984. Reconstruction of sedimentary environmrnts of Rosetta and Damietta promontories in Egypt, based on textural analysis. Journal of African Earth Sciences, 2, No. 1, p. 17-29.

Dal Cin, R., 1976. The use of factor analysis in determing beach erosion and accretion from grain size data. Marine Geology Journal, 20, p. 95-116.

Deconinck, J.N., 1987. Consequence de la construction due Port de l'Amitie sur la sedimentation cotiere au voisinage de Nouakchott. Ler colloque sur le Droit de la Mer. Univ. de Nouakchott, R.I. de Mauritanie, 31 p.

El-Ashry, M.T., 1971. Causes of recent increased erosion along U.S. shorelines. Geological Society of America Bulletin, 82, p. 2033-2038.

El-Askry, M.A. and M.F. Lotfy, 1980. Coastal erosion and accretion to the east of Damietta coast, Egypt. Bulletin of the Faculty of Science, K.A.U., Jeddah, 4, p. 257-264.

Folk, R.L., 1968. Petrology of sedimentary rocks. Hemphill's Texas, 170 p.

Folk, R.L. and W.C. Ward, 1957. Brazos River bar, a study in the significance of grain size parameters. Journal of sedimentary Petrology, 27, p. 3-27.

Fuller, A.O., 1961. Size characteristics of shallow marine sands from Cape of Good Hope, South Africa. Journal of Sedimentary Petrology, 31, p. 256-261.

Inman, D.L., 1949. Sorting of sediment in the light of fluid mechanics. Journal of sedimentary Petrology, 19, p. 51-70.

King, C.A.M., 1972. Beaches and coasts. 2nd ed. Edward Arnold Ltd., London, 570 p.

Lotfy, M.F., 1984. Lithology of the recent sediment and dynamics of the Nile delta coastal zone between Abu Quir and Port Said. Ph.D. Thesis, Moscow University, 251 p.

Lotfy, M.F., 1990. Textural characteristics of the coastal sands along the Atlantic coast of Mauritania. Bulletin of the Faculty of Science, Alexandria University, 30 B, p. 241-254.

Moss, A.J., 1962. The physical nature of common sandy and pebbly deposits. Part II, American Journal Sciences, 260, p. 337-373.

Moss, A.J., 1963. The physical nature of common sandy and pebbly deposits. Part II. American Journal Sciences, 261, p. 297-343.

Spencer, D.W., 1963. The interpretation of grain size distribution curves of clastic sediments. Journal of sedimentary Petrology, 33, p. 180-190.

Visher, G.S., 1969. Grain size distribution and depositional processes. Journal of Sedimentary Petrology, 39, p. 1074-1106.

Visher, G.S., 1972. Physical characteristics of fluvial deposits. In: Recognition of Ancient Sedimentary Environments (Edited by Rigby, J.H. and Hamblin, W.K.), 16. p. 84-97. SEPM.

Zenkovich, V.P., 1967. Processes of coastal Development. Oliver and Boyd, Edinburgh and London, 738 p.