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TEXTURAL AND COMPOSITIONAL VARIATIONS IN BEACH SANDS ALONG KARACHI COAST

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ABSTRACT: The texture of clastic sediments is a fairly reliable index of the erosional history and energy conditions of the depositional environment, while its mineralogy reflects the composition of the source rocks. The beach sands of Clifton, Sandspit, Hawkesbay and Paradise Point were studied to determine their erosional history, depositional environment and their source.

KEY WORDS: Sedimentology - beach sand - Karachi coast.

INTRODUCTION

Textural attributes of clastic sedimentary deposits are generally related to the mode of transportation and the energy conditions of the transporting media, while their mineralogical composition largely reflects the nature of the source rock and the physico-chemical environment of deposition. The latter is in turn controlled by the geomorphic configuration of the coast. The present configuration of the Karachi coast is the result of shallow marine processes of erosion and deposition, which are normal to any coastal environment, and also of eustatic changes in sealevel. However, from time to time these processes have been disturbed by changes in the river regimen that is responsible for the supply of terrigenous material to the coast.

An attempt is made here to investigate the nature of variations in the texture and composition of beach sands and to identify the factors which control such variations. In the present work the coastal area between Clifton and Paradise Point (Fig.1) has been sampled for sedimentological studies. Different textural parameters, heavy mineral contents and carbonate contents of the beach sands were determined and comparisons between sands of different sites, in terms of their texture and composition were also made.

The earliest references to the regional geology of the area are found in the works of Blandford (1879), Vredenburg (1909), Nuttal (1926), and Kidwai (1931). In the Reconnaissance Geology of Western Pakistan by the Hunting Survey Corporation under Colombo Plan Co-Operative Project 1960, a very general description of the geology of the Karachi coast was given. The SUPARCO (Pakistan Space and Upper Atmospheric Research Commission) engaged in an elaborate study of the area based on photographs taken by satellites. Available literature tends to be general and superficial in nature. However, no detailed study of beach configuration and its effects on the texture of beach sands of Clifton, Sandspit, Hawkesbay, Paradise Point areas has so far been published. Both Siddiqui (1959) and Snead (1969) studied the geology and physiography of the coastal area of Karachi coast and adjoining parts of Baluchistan.

MATERIALS AND METHODS

Samples were collected from the surf zone and the fore beach. At Clifton the samples were collected at intervals of 75 m. Samples at Sandspit were collected at intervals of 230 m, since a long stretch of beach had to be covered. From Hawkesbay to Paradise Point the sampling interval was 150 m (Fig.I).

The samples were split using a sample splitter and about 100 grams were used for grain size analysis. Based on the data, cumulative curves were drawn and different statistical parameters such as graphic mean (M_Z), inclusive standard deviation (δ_I), inclusive graphic skewness (Ski) and graphic kurtosis (Kg) were determined, samples were categorised according to the scheme proposed by Folk (1968). (Table I). The carbonate fraction in the sands was determined using a calcimeter which is a rapid device that records the carbonate percentages in a given sample on a graph paper (Fig.2). Heavy minerals were separated with Bromoform using a separating funnel. The heavy minerals thus obtained were washed and their nature and quantity determined using the Eclipse method. According to this four fractions were obtained: (1) strongly magnetic, (2) moderately magnetic, (3) weakly magnetic and (4) non magnetic. Graphs were plotted to demonstrate the lateral variation in carbonate content and heavy mineral content (Fig.3).

RESULTS AND DISCUSSION

In the present study, four stations were established at Clifton, Sandspit, Hawkesbay and Paradise Point and samples of sediment were collected for textural and compositional analyses. The graphic mean is the most sensitive measure denoting the average grain size in a sample, and its value is used to categorise the sample as to the degree of coarseness or fineness based on the Wenthworth grade scale (1922). The inclusive graphic standard deviation expresses the uniformity or scatter of grain size distribution. It effectively represents the degree of sorting of a sediment. The efficiency of a depositional medium as an agent of sorting is related to the properties of density and viscosity of the fluid. Skewness refers to the asymmetry of the grain size distribution. Inclusive graphic skewness has been selected as the representative measure of the skewness of the distribution. Intrisically it demonstrates the relative proportion of the coarse and fine fractions present in a sample. A positive value of skewness indicates tailing off the curve to the right of the mean, or particle size shows an excess of fine particles. By contrast, a negative value implies a tailing off the curve to the left of the mean and an excess of coarse particles. Graphic kurtosis is a measure of the ratio between the degree of sorting in the central parts to that of the tails of the distribution. If the central part is better sorted than the tails, it is categorised as leptokurtic while the opposite represents a platykurtic condition.

The average numerical value for the textural parameters already mentioned for the four different sites are given in table I. The Clifton sands, on an average, are the finest (2.93 ϕ) which fall within the range of fine sands (2-3 ϕ) as opposed to those of Sandspit and Paradise Point, which are coarse sand (0-1 ϕ). According to the values of inclusive standard deviation, only the sands from Paradise Point are poorly sorted (1-2) whereas the rest are moderately to moderately well sorted (0.35 - 1.0). Samples

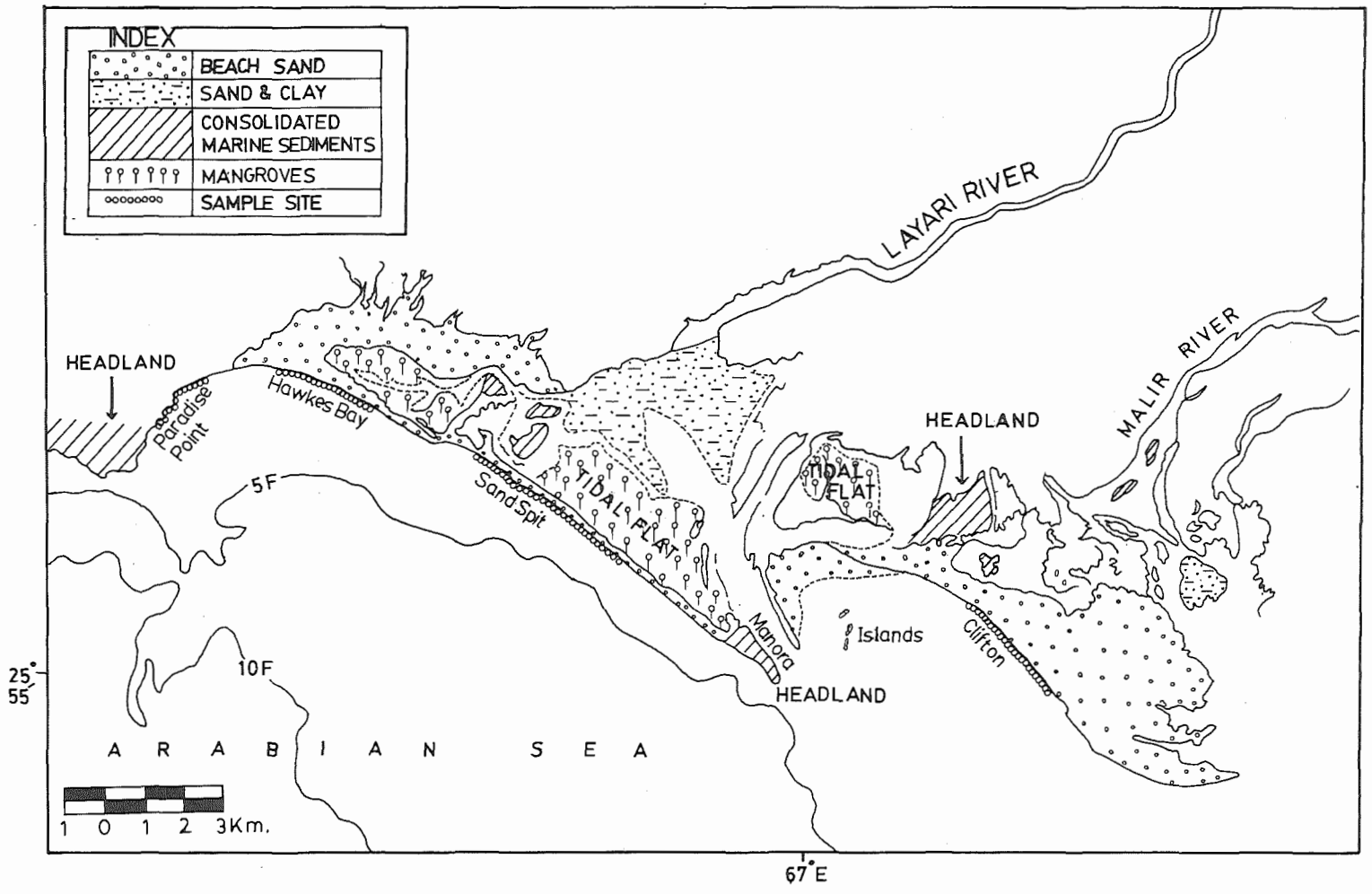

Fig. 1. Map showing location of sample sites (After Siddique)

from different stations exhibit a wide variation in the degree of skewness from very finely skewed sands of Clifton (+1.0 to +0.1) to coarse coarsely skewed sands (-0.1 to -0.3) of Sandspit and Hawkesbay. Except for the beach sands from the Sandspit area that are platykurtic (0.67-0.90), the rest of the beach sands are leptokurtic (1.11 - 2.0).

Table I: Average textural and compositional characteristics of samples from Karachi coast.

St./Total	M_Z	δ_I	SKi	K_G	Carbonate content (%)	Heavy mineral (%)
Clifton CF/20	2.93 ϕ Fine sand	0.563 Mod. well sorted	0.544 V. fine skewed	2.268 V.lepto-kurtic	7	8.25
Sand-spit S.SP/15	0.966 ϕ Coarse sand	0.932 Mod. sorted	-0.112 Coarse skewed	0.810 Platy-kurtic	80	2.7
Hawke-sbay H.B/12	2.265 ϕ Fine sand	0.864 Mod. sorted	0.210 Fine skewed	1.41 Lepto-kurtic	54	4.45
Paradise Point P.P/10	0.825 ϕ Coarse sand	1.41 Poorly sorted	-0.165 Coarse skewed	1.285 Lepto-kurtic	78	2.1

According to Friedmann (1961) the textural characters of the sediments are related to the nature of the depositional medium, particularly its viscosity, density as well as the energy conditions of the environment. In general the attributes of grain size distribution are interpreted in three different ways: (1) the characteristics of the size distribution curve are explained in terms of hydrodynamics of the depositional processes as advocated particularly by Friedmann (1967) and Visher (1969), (2) the grain size distribution is largely the product of the generative processes of sediments so that the characteristics of a clastic sediment are attributed to the source material (Smalley 1966) and (3) an empirical study of the grain size characteristics of a sediment, with reference to the various geomorphic environment, establishes the relationship, if any, between them (Friedmann 1961).

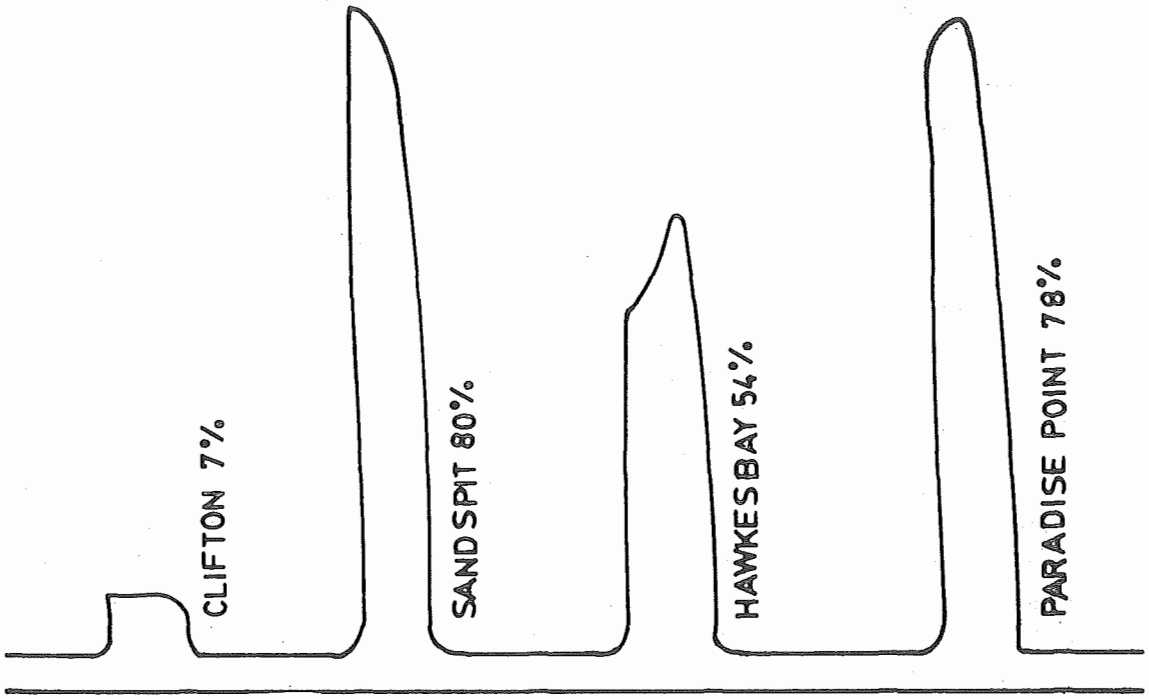

Fig.2. Graph showing calcimeter reading in percentages.

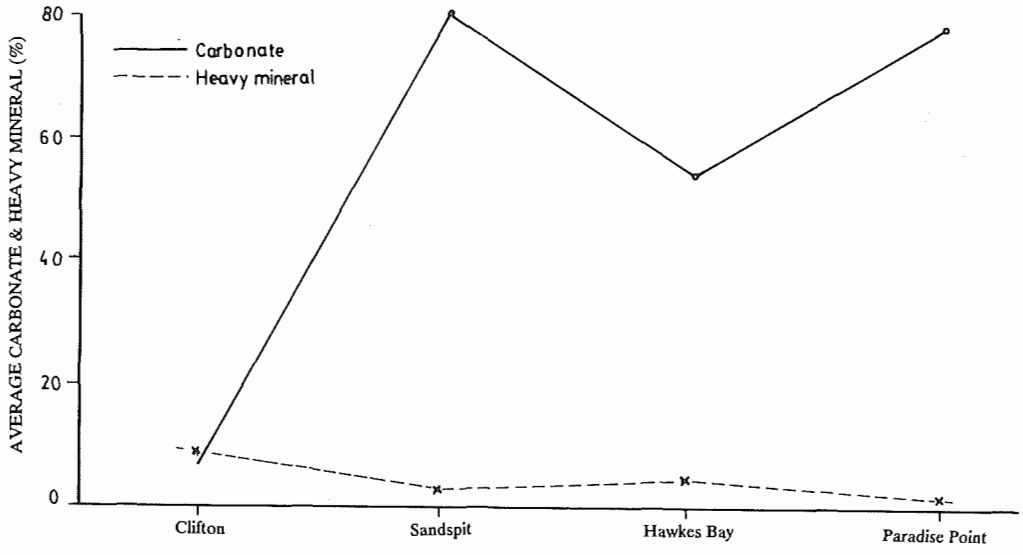

Fig.3. Variation in heavy minerals and carbonate content in beach sands along Clifton-Paradise Point stretch of Karachi coast.

The Karachi coast offers an excellent opportunity to examine variations in the texture of beach sands. In spite of the fact that these variations all were produced by wave erosion and deposition, so that there are no recognizable differences in the density and viscosity of the medium of deposition (wave) or the differences in textural characteristics. Therefore these variations may possibly be due to the differences in the energy conditions of the waves striking the coast at different angles depending upon their local configurations. Alternatively these textural differences may be attributed to the degree of dominance of fluvial processes in different sections of the coast (the unique values of textural parameters in Clifton sands as opposed to the rest of the beach sands may be cited as an example).

The average carbonate content and the heavy mineral content, as percentages, for the different sampling stations are also shown in (Table-I). It is to be noted that sands from Clifton are relatively very low in carbonate content as compared to other sample sites (Fig.2.). On the other hand, the heavy mineral content in Clifton sands is comparatively higher than those observed in the samples from the other three stations. Apparantly a reciprocal relationship between the heavy mineral content and carbonate content of the sands is evident (Fig.3).

These compositional differences in the sands are attributed to differences in the provenance of sands. The Clifton sands appear to be largely reworked sands of the Indus river, which forms a delta towards the east. The Indus river, during its long journey, drains areas surfaced by varied types of rocks, which include sizeable exposures of igneous and meltamorphic rocks. The comparatively high level of heavy mineral content, together with the richness in mica flakes and low carbonate content, supports this contention. In contrast, the beach sands of other three sites show high carbonate values and low heavy mineral percentages, which imply a different provenance altogether. This could possibly be due to the influx of sediments derived by rivers that flow across a terrain characterized by sedimentary rocks in which limestone is a dominant lithology. Some material on these beaches is undoubtly derived by the erosion of the carbonate rocks which fringe the coast such as Paradise Point.

The present study shows identifiable differences in textural characteristics and composition of the beach sands along Karachi coast. These differences are believed to have resulted from a variety of causes related to provenance, local differences in energy condition of waves, coastal configuration, degree of dominance of fluvial processes and the lithology of the rocks in the hinterland. Detailed work is needed to establish the nature of controls exercised by the factors mentioned above on the composition and texture of the beach sands.

REFERENCES

Blandford, W.I., 1879. The Geology of Western Sindh. *Memoirs of the Geological Survey of India* 17:1-196.

Colombo Plan Co-operative Project Report. 1960. *The reconnaissance Geology of part of West Pakistan*, Maracle Press, Ontario. Pp.1-550.

Folk, R.C., 1968. *Petrology of Sedimentary rock*. Hemphills, Austin, Texas. Pp.1-170.

Friedmann, G.M., 1961. Distinction between dune, beach and river sand from their textural characteristics. *Journal of Sedimentary Petrology* 31:514-529.

Friedmann, G.M., 1967. Dynamic processes and statistical parameters compared for size frequency distribution of beach and river sands. *Journal of Sedimentary Petrology* 37:327-354.

Kidwai, A.H., 1951. *Note on the Geology of Pab range. Lasbela State*, (unpublished report). Geological Survey of Pakistan, File No.536 (7). Pp.1-13.

Nuttal, W.L.P., 1926. The zonal distinction of larger Foraminifera of Eocene of Western India. *Geological Magazine*, London 3:495-504.

Siddiqui, M.J., 1959. *The geology and physiography of Karachi coast (West Pakistan)*. Department of Geography, University of Karachi.

Smalley, I.J., 1966. The formation of fine particles in sandy deserts and the nature of "Deserts" loess. *Journal of Sedimentary Petrology* 38: 766-774.

Snead, R.E., 1968. *Physical geography reconnaissance, West Pakistan coastal zone*. Department of Geography, University of New Mexico, Albuquerque, New Mexico. Pp.1-55.

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

Vredenburg, E.W., 1909. Report on the Geology of Saraha, Jhalawan, Makran and the State of Lasbela. *Records Geological Survey of India* 38: 189-215.

Wentworth, C.K., 1922. A scale of grade and class terms for clastic sediments. *Journal of Geology* 30:377-392.