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Grain Size Parameters and Depositional Environments of River, Beach and Coastal Dune Sediments near Karwar, West Coast of India

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The problem of discrimination of different environment of deposition from grain size distribution of sediments has been investigated. For this study, for describing the size distribution of sediments, the graphic measures which are functions of the percentiles obtained from the cumulative size frequency curve are used. The paper highlights the environment sensitive textural parameters of the recent sediments from river, beach and coastal dunes.

Environment	Value	Mz (Ø)	σ_I	SKI	KG
River	Min.	0.730	0.361	0.038	0.669
	Max.	1.980	0.958	0.452	1.883
	Av.	1.465	0.520	0.170	1.060
Beach	Min.	2.030	0.290	-0.474	0.645
	Max.	2.550	0.686	+0.031	1.254
	Av.	2.220	0.443	-0.170	0.944
Coastal dune	Min.	2.420	0.191	-0.024	0.848
	Max.	2.730	0.389	+0.302	1.835
	Av.	2.558	0.259	+0.159	1.382

Beach and coastal dune sediments have more or less identical mean and median size characteristics whereas the river sediments bear considerably higher values. Coastal dune sediments are distinguished from river and beach sediments by their better sorted nature. Most of the analysed beach sediment samples are negatively skewed whereas coastal dune and river sediments are generally positively skewed. Kurtosis is not a very sensitive parameter for environment of deposition. The bivariant plots between different graphic measures clearly distinguish the river, beach and coastal dune sediments.

The study reveals that the grain size parameters of the recent sediments can safely be used to decipher the

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environment of deposition. The variation in grain size characteristics of the sediments between the environments, reflects the mechanism involved during sediment deposition.

Introdution

The literature available reveals that a distinction of depositional environment has been attempted in the recent past by Passega (1962), Shepard (1964), Visher (1969), Kloven (1966), Sevon (1966), Friedman (1961, 1967, 1979), Friedman and Sanders (1978), Chaudhri (1983) Sahu (1983) Nayak and Chavadi (1988) and others.

Passega (1962) observed that the study of recent sediments is a mediocre mean of understanding ancient sedimentation. Friedman (1961, 1967, 1979) mentioned that knowledge revealed by the textural study of recent sediments from known environment, can safely be applied to identify ancient environments of sedimentation, provided caution is exercised and limitations are kept in view. Visher (1969) recorded that log probability plots of the modern and ancient sands are comparable. Klovan (1966) and Sevon (1966) observed that the textural study of recent sediments is of limited value in interpretation of depositional environments.

Because of lack of correlation between the earlier studies, it is planned to check the use of grain size parameters on the available recent environments. Considering this, in the present study an attempt is made to utilise various grain size parameters along with bivariant plots and discriminant functions to distinguish various environments of deposition of recent sediments.

Method

The present study is based on 55 samples, collected from Kali river estuary and also from beaches and dunes on either side of the Kali river mouth near Karwar (Fig.1).

In all, 24 samples were collected from the 20 km long estuarine environment. A total of 21 samples were collected from low, mid and high water levels of Karwar and Sadashivgad beaches. For the study of coastal dune sediments 10 samples were collected from undulation subenvironments of the Karwar and Sadashivgad dune portion. In case of beach and dune samples, collection was made from surface, maximum upto 5 cm using plastic core-linear of 5 cm diameter. River bed samples were collected using grab sampler.

In the laboratory the samples were treated to remove the shell fragments, iron coating and organic matter following the method of Ingram (1970). The size analysis was carried out by sieving at quarter Phi interval using ASTM sieves on Ro-Tap sieve shaker. Weight and cumulative percentages were computed and frequency and probability curves were plotted for each samples of the three environments separately.

Graphic measures were calculated for all the samples using the formulae of Folk and Ward (1957). The program was written and calculations were made with the help of the DCM 3000 computer. The various graphic measures of the three environments are tabulated in Table 1. Scatter plots between the more significant environment sensitive size parameters were attempted.

TABLE 1 - Grain size parameters

S.No.	Md	Mz	σ_I	SKI	KG	Sos	α_s	PI
1.	1.10	1.17	0.563	0.289	0.961	0.985	0.77	0.35
2.	1.05	1.04	0.575	0.081	0.669	0.890	0.32	0.22
3.	0.65	0.73	0.410	0.384	0.935	0.685	0.63	0.18
4.	1.60	1.61	0.636	0.038	0.749	0.960	0.12	0.47
5.	1.72	1.77	0.570	0.089	1.039	0.875	0.11	0.60
6.	1.07	1.11	0.472	0.190	0.804	0.775	0.41	0.33
7.	1.08	1.27	0.958	0.452	1.883	1.700	1.98	0.23
8.	0.97	0.99	0.465	0.084	1.064	0.675	0.15	0.23
9.	1.02	1.07	0.438	0.182	1.098	0.670	0.26	0.32
10.	1.07	1.13	0.485	0.270	0.984	0.840	0.58	0.35
11.	1.67	1.69	0.489	0.065	1.125	0.755	0.11	0.63
12.	1.77	1.85	0.377	0.201	1.131	0.690	0.08	0.82
13.	1.58	1.62	0.520	0.131	0.966	0.825	0.25	0.58
14.	1.07	1.14	0.482	0.326	1.031	0.855	0.71	0.38
15.	1.67	1.68	0.469	0.081	1.213	0.740	0.18	0.67
16.	1.65	1.68	0.442	0.140	1.129	0.675	0.25	0.93
17.	1.75	1.83	0.600	0.134	0.922	0.900	0.14	0.62
18.	1.67	1.69	0.508	0.058	1.328	0.810	0.08	0.60
19.	1.68	1.73	0.621	0.085	0.716	0.935	0.11	0.55
20.	1.72	1.76	0.533	0.079	1.157	0.875	0.11	0.60
21.	1.68	1.74	0.574	0.109	1.061	0.880	0.14	0.57
22.	1.67	1.74	0.529	0.144	1.252	0.840	0.18	0.62
23.	1.90	1.98	0.361	0.182	1.461	0.695	-0.05	0.78
24.	1.05	1.14	0.390	0.285	0.769	0.610	0.28	0.40
25.	1.41	1.46	0.520	0.170	1.060	0.839	0.33	0.50
26.	2.27	2.17	0.603	-0.267	0.884	1.025	-0.55	0.63
27.	2.57	2.50	0.437	-0.310	1.188	0.725	-0.55	0.97
28.	2.47	2.45	0.299	-0.066	1.252	0.550	0.00	1.68
29.	2.47	2.43	0.406	-0.152	1.028	0.665	-0.21	1.60
30.	2.15	2.03	0.686	-0.212	0.878	1.050	-0.36	0.62
31.	2.08	2.12	0.547	0.031	0.833	0.915	-0.09	0.73
32.	2.07	2.10	0.575	-0.004	0.860	0.965	-0.17	0.68
33.	2.17	2.09	0.457	-0.287	0.883	0.765	-0.47	0.77
34.	2.35	2.33	0.339	-0.094	1.120	0.615	-0.13	1.53
35.	2.20	2.15	0.387	-0.136	0.799	0.575	-0.11	0.95
36.	2.18	2.13	0.372	-0.113	0.764	0.550	-0.06	1.52
37.	2.55	2.55	0.290	-0.034	1.254	0.505	-0.05	1.60
38.	2.12	2.09	0.345	-0.079	0.775	0.520	-0.04	1.02
39.	2.40	2.28	0.446	-0.262	1.180	0.720	-0.20	1.00
40.	2.08	2.06	0.377	-0.063	0.673	0.550	-0.06	1.12
41.	2.02	2.03	0.568	-0.007	0.988	1.025	-0.09	0.65
42.	2.25	2.13	0.517	-0.369	0.820	0.840	-0.68	0.72
43.	2.38	2.25	0.463	-0.474	1.237	0.785	-0.79	0.83
44.	2.50	2.38	0.389	-0.472	1.008	0.615	-0.63	1.07
45.	2.12	2.10	0.399	-0.043	0.645	0.590	-0.02	1.17

46.	2.25	2.19	0.394	-0.167	0.748	0.575	-0.15	1.33
47.	2.27	2.22	0.443	-0.170	0.944	0.720	-0.26	1.06
48.	2.47	2.46	0.239	0.000	1.442	0.475	0.050	1.68
49.	2.42	2.42	0.191	0.017	0.848	0.300	0.020	2.03
50.	2.38	2.46	0.389	0.186	1.138	0.625	0.090	1.23
51.	2.52	2.50	0.255	-0.024	1.284	0.470	0.060	1.70
52.	2.62	2.69	0.304	0.302	1.108	0.500	0.260	2.00
53.	2.60	2.62	0.207	0.166	1.619	0.395	0.150	2.05
54.	2.67	2.73	0.294	0.247	1.242	0.500	0.160	1.60
55.	2.65	2.69	0.231	0.281	1.546	0.415	0.230	2.12
56.	2.62	2.65	0.191	0.255	1.760	0.365	0.190	2.05
57.	2.62	2.66	0.289	0.166	1.835	0.515	0.090	1.30
58.	2.56	2.59	0.259	0.159	1.382	0.456	0.130	1.77

Note: S.No. 1-24 river samples, 25 - Av. of river samples
S.No. 26-46 beach samples, 47 - Av. of beach samples
S.No. 48-57 coastal dune samples, 58 Av. of coastal dune samples

Grain size parameters and bivariant plots

Passega (1957), Folk and Ward (1957), Mason and Folk (1958), Friedman (1961, 1965, 1966, 1979), Duane (1964), Chaudhri (1983) and others worked out that the beach, dune and river sediments can be distinguished by grain size parameters, especially standard deviation, skewness and kurtosis. On the other hand, Shepard and Young (1961) observed that grain size analysis has no value in discriminating the various environments. Subsequently, Shepard (1964) changed his views and noted that sorting and skewness are useful parameters in comparing modern and ancient sediments. Friedman (1967) stressed upon the importance of scatter plots which according to him are more effective than individual curves or values for showing the extent of differentiation and the degree of overlap.

The mean and median size parameters of the beach and the coastal dune sediments bear nearly identical values while the river sediments are coarser in size. An analysis of the data (Table 1) reveals that the mean size of the beach and dune sediments characteristically fall into the fine sand class. The river sands in contrast fall in medium to coarse sand class. The coastal dune sediments are better sorted than the river and beach sediments. The river and coastal dune sediments bear positive skewness values in contrast to those of the beach sediments. Table 1 also reveals that the kurtosis values varies with wider range and overlap to the other environments which adversely effect the utility of this parameter for the differentiation of sedimentary environments.

The weight frequency plot (Fig. 2) satisfactorily distinguishes the three environments. The mode and bandwidth of river, beach and dune varies characteristically. Modal values of river, beach and dune lie at 2.0, 2.5 and 3.0 ∅ respectively indicating their variation in size and bandwidth variation indicate their distribution pattern.

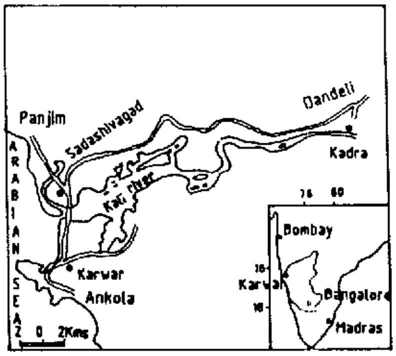

Fig. 1 Map showing the locations of the study area

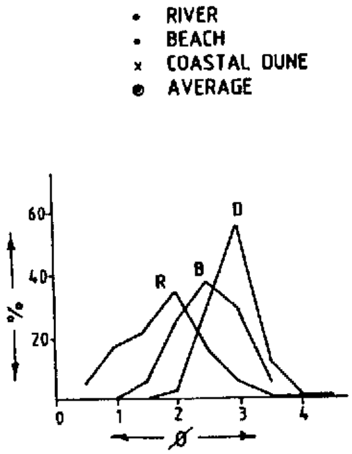

Fig. 2 Frequency plots of the River (R) Beach (B) and Coastal dune (D) sediments

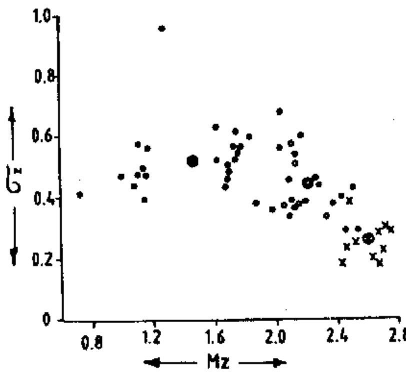

Fig. 3 Plot between inclusive graphic standard deviation and graphic mean

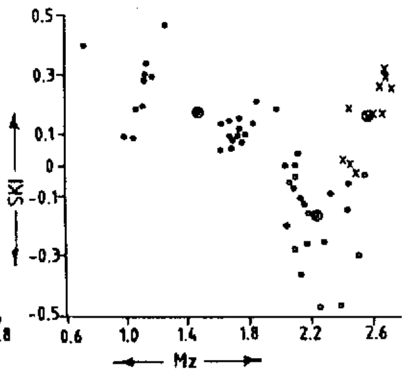

Fig. 4 Plot between inclusive graphic skewness and graphic mean

Scatter plots allow a quantitative comparison of the various parameters and therefore are more effective than individual parameters or curves. Therefore in order to distinguish between the various environs, textural parameters are used in the construction of bivariant plots. Bivariant plots between different parameters (Fig. 3 to 8) distinguished the fields occupied by the river, beach and coastal dune sediments satisfactorily. Scatter plot between kurtosis and other parameters are also tried and found that they are not helpful to distinguish the environments and therefore the related figures are not included.

In the recent past multigroup discriminant functions are also utilized to distinguish depositional environments (Sahu, 1983). According to him, first two discriminant functions practically exhaust all the discrimination (98%) and hence a diagram of V1 and V2 with V1 $\wedge$ V2 = 74.4° will be most useful for assignment and classification. Figure 9 distinguished beach and aeolian with the mean values at their respective field. However the river sediments fall within the beach field. This may be because, the river samples were collected from the estuarine environments.

In this paper another diagram has been introduced, where in, three parameters viz. graphic mean, inclusive graphic standard deviation and inclusive graphic skewness are considered (Fig. 10). The plot distinguished different environments satisfactorily.

Interpretation of depositional environments

The problem of interpretation of environments essentially involves the study of the sedimentation processes in operation vis-a-vis the textural parameters of the sediments accumulated (Chaudhri, 1983). Bagnold (1966) observed that mean velocity of 146 individual rivers varied from 1.4 to 9.0 ft/sec. and that most of the rivers have an average velocity of 2.5 to 6.5 ft/sec. Ingle (1966) worked out that the velocity of waves in the swash zone is 1.5 to 6.0 ft/sec and that of the transition zone varies from 1.5 to 8.0 ft/sec. while in the surf zone the velocity range is 1.5 to 4.5 ft/sec. The figures clearly indicate an overlap in the velocities of water in the two environments. It is because of these factors that the scatter plots between the various textural parameters of the river and the beach sediments as suggested by Friedman (1967, 1979) some time show overlapping and such plots are not presented herein.

Standard deviation has been widely used to distinguish the accumulation of the river, beach and dune environments mainly because sorting characteristics reflect the processes operating at the site of sedimentation. Inman (1949), Griffith (1951) Inman and Chamberlain (1955) recorded that medium to fine sands show better sorting and it becomes worse as the sediment gets either finer or coarser. Friedman (1967), Sonu (1972) and Kumar (1977) also made identical observation. Better sorting might as

- RIVER
- BEACH
- × COASTAL DUNE
- ● AVERAGE

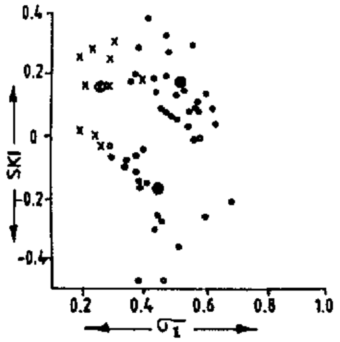

Fig. 5 Plot between inclusive graphic skewness and inclusive graphic standard deviation

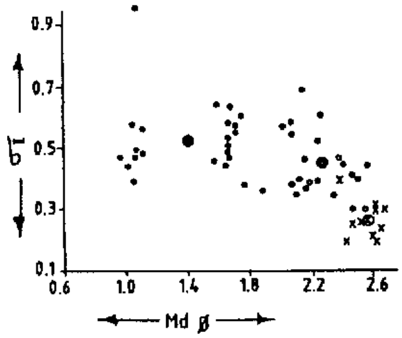

Fig. 7 Plot between inclusive graphic standard deviation and median

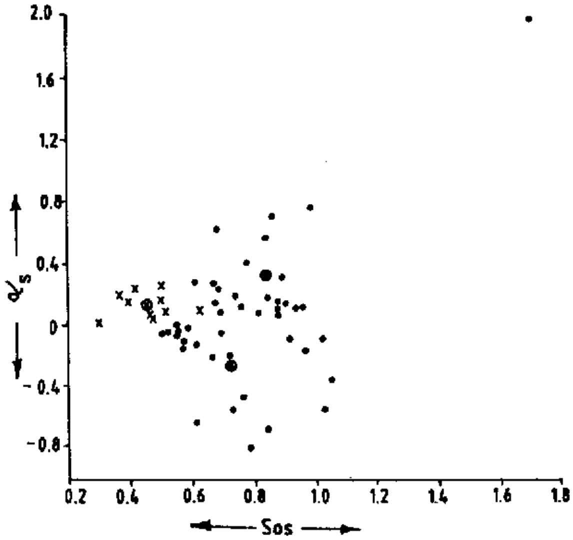

Fig. 6 Plot between simple skewness and simple sorting

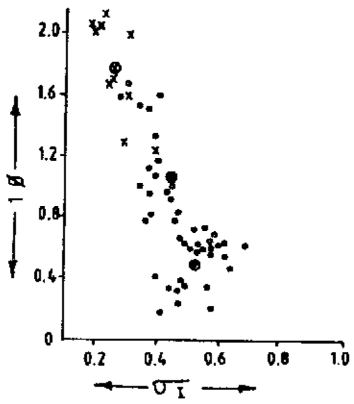

Fig. 8 Plot between first percentile and inclusive graphic standard deviation

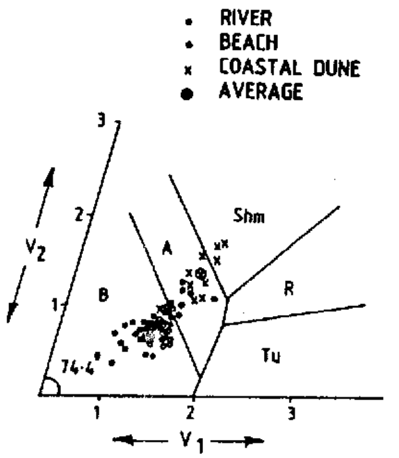

Fig. 9 Plot between sahu (1983)'s first two discriminant functions V1 and V2

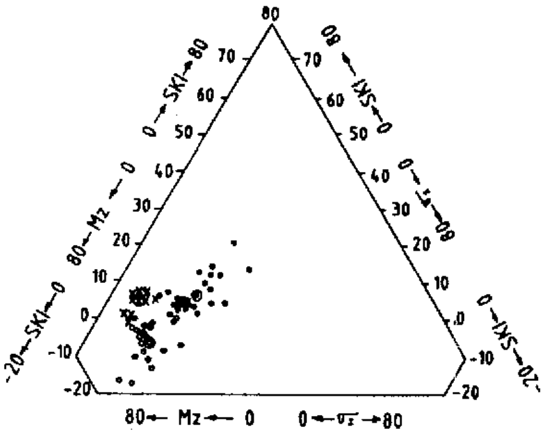

Fig. 10 Graphic mean, inclusive graphic standard deviation and inclusive graphic skewness diagram for recent river, beach and coastal dune environments of Karwar area

well have been achieved by the dune sediments on account of size sorting by wind.

Skewness is yet an another environment sensitive grain size parameter. The fact has also been emphasized by Mason and Folk (1958), Friedman (1961, 1979) Duane (1964), Folk (1974), Chaudhri and Khan (1981) and others. The positive skewness of the coastal dune and river sediments is attributed to the undirectional transport of the detrital grains. Duane (1964) has mentioned that positive skewness is a common character of estuarine sediments. Most of the beach sediments have negatively skewed population which is attributed to the winnowing action of waves on the sediments. In this process the finer particles are removed to the deeper parts of the sea and the negatively skewed sediments are left behind on the beach.

Scatter plots between graphic mean and inclusive graphic standard deviation, graphic mean and inclusive graphic skewness, inclusive graphic standard deviation and inclusive graphic skewness, simple sorting measure and simple skewness measure, inclusive graphic standard deviation and median and inclusive graphic standard deviation and first percentile (Fig. 3 to 8), satisfactorily distinguish the river, beach and coastal dune sediments. The weight frequency plot (Fig. 2), multigroup discriminant function diagram (Fig. 9) of Sahu (1983) and trivariant diagram of graphic mean, inclusive graphic standard deviation and inclusive graphic skewness (Fig. 10) also helped in distinguishing the river, beach and coastal dune sediments. The variation in kurtosis values and scatter plot between kurtosis and other parameters (not included) are not helpful to distinguish the environments.

The above results and discussions clearly indicate that the grain size parameters and their bivariant and trivariant plots can safely be used to decipher the recent depositional sedimentary environments. It is also clear that the grain size parameters especially standard deviation and skewness are helpful to interpret the mechanism involved during sediment deposition.

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