Papers

Coastal processes of Central Tamil Nadu, India: clues from grain size studies

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Abstract

The sediments of the beaches along the central coast of Tamil Nadu from Pondicherry to Vedaranyam were studied for their textural variation. 108 sediment samples collected from the low-, mid-, and high-tidal zones, as well as the berms and dunes of different beach morpho-units were analysed. The study area was divided into three sectors (northern, central and southern) on the basis of prevailing energy conditions and oceanographic parameters. The poorly sorted, negatively skewed, coarser sediments of the northern sector are indicative of denudational processes taking place there. Medium-to-fine, moderately-to-well sorted, positive-symmetrically skewed sediments dominate the central sector, probably as a result of the influence of palaeo-sediments deposited by rivers from inland as well as by waves and currents from offshore. Fine, poorly sorted, positive-symmetrically skewed sediments dominate the southern sector, highlighting depositional processes.

Linear Discriminant Function Analysis (LDF) of the samples indicates a shallow marine environment origin for all the three sectors. These results show that reworked sediments, submerged during the Holocene marine transgression, are being deposited on present-day beaches by waves, currents and rivers in the study area.

1. Introduction

In view of its strategic and economic importance, and being a dynamic zone where air, land and water interact, the coastal zone is a focus of particular interest among the scientific community. The complex coastal processes operating in the past and operative today have left their imprints in the sediments. In this regard, the sedimentology of beach sediments plays a vital role in documenting the depositional history of a region. Pioneering studies were undertaken by Bascom (1951), Inman & Chamberlain (1955), Friedman (1961, 1965, 1967), Passega (1964), Moiola & Weiser (1968), Visher (1969), and others.

7800 km long, the Indian coastal region is subject to complex coastal processes and boasts multifarious landforms. Granulometric studies of the beach sediments on the east and west coasts of India have been carried out by Chakrabarti (1977), Chaudhri et al. (1981), Rajamanickam & Gujar (1984, 1988, 1997), Chauhan et al. (1988), Chauhan & Dubey (1989), Chauhan (1990), Mohan & Rajamanickam (1998), Mohan et al. (2000), Rao et al. (2005), and Angusamy & Rajamanickam (2006). In India, coastal regions are increasingly being used for placer sand mining, recreation, aquaculture, coral mining, and fishing. The introduction of the Coastal Regulation Act and the Offshore Mining Bill for the exploitation of mineral deposits off the Indian coast has highlighted the importance of documenting coastal processes and sediment characteristics. The increasing demand for exploring and exploiting non-living coastal resources like placer deposits emphasises the need to compile inventories of coastal processes that include aspects of sediment systematics such as grain size. Unfortunately, only scant data is available on the coastal processes and the depositional environment of the sediments of the Central Tamil Nadu coast, where some of the richest concentrations of placer deposits have been reported. The present investigation was thus undertaken to fill this information gap.

2. Study area

The present study area extends for about 220 km along the central coast of Tamil Nadu in southern India; it is bordered on the east by the Bay of Bengal. On the basis of drainage pattern, geomorphology and diverse energy conditions, it was divided into three sectors: North (stations I–VI – a distance of 50 km), Central (stations VII–XIX – 120 km) and South (stations XX–XXVI – 50 km) (Table 1).

Table 1. Classification of the study area into three sectors

	Sectors		
	North	Central	South
	Stations		
	I–VI	VII–XIX	XX–XXVI
Drainage	Uppanar, Gadilam	Vellar, Coleroon Cauvery	absent
Geomorphology			
beach ridges	2 to 3 series	selectively present	18 series
cheniers	2–3 series	absent	absent
beach cliff	75–90 cm high	absent	absent
beach width	30–50 m	68–98 m 850 m in the zones of enrichment of heavies	50–100 m
Beach composition	patches of heavy mineral enrichment	heavy mineral rich	clayey and siliceous
Coastal configuration	N–S	N–S, NNW–SSE	N–S
Shelf topography	steeply sloping	moderately sloping	very gently sloping
Submarine canyons	present	absent	absent
20 m contour from shoreline	4.5 km	8–10 km	20–34 km
100 m contour	10–12 km	18–21 km	40–54 km
Wave current velocity	1.8–3.6 m s^{-1} northerly	1.5–1.8 m s^{-1} northerly	0.01–0.08 m s^{-1} northerly
Wave height range	1–1.5 m	0.75–1.25 m	0.3 m
during cyclones	4–6 m	3–4 m	0.3–1.5 m
Geology	Mio-Pliocene, Cretaceous deposits, Quaternary sediments	Archaeans, Cretaceous deposits, Quaternary sediments	Quaternary deposits

The northern sector is characterised by 3–4 series of beach ridges and submarine canyons, the central one by numerous rivers like the Gadilam, Cauvery and Coleroon, and the southern sector by the presence of 18 series of beach ridges, especially in the vicinity of Vedaranyam (Table 1) and also by a wave shadow or wave inert condition, where the waves neither converge nor diverge, or hardly reach the coast. According to Varadachari et al. (1968), the submarine Cuddalore canyon has two major valleys with heads located between 36 m and 54 m, and steeply sloping, V-shaped walls. The head of the Pondicherry canyon lies at a depth of c. 54 m.

The beaches in the northern sector are backed by beach cliffs 75–90 cm in height, resulting from the erosion of the foreshore by waves under high-energy conditions. The width of the backshore is 30 m, that of the foreshore is 20-30 m. In the central sector, from Poompuhar to Karaikal, the entire foreshore and backshore is carpeted with rich concentrations of black sands and garnets. At Karaikal, the backshore is wider for about 850 m (Table 1); in the enriched zones, symmetrical and asymmetrical ripple marks in the backshore and the dune areas are rich in garnets and black sands. There are no beach ridges in the heavy-mineral-rich zones. In the southern sector, lying in the lee of the island of Sri Lanka, ridges 1.5–3 m in height abut the beaches. Though muddy and swampy, these abound in quartz and feldspars, and balls of clay are revealed at low tide. Deep cracks in the mud are characteristic of the backshore region.

3. Material and methods

3.1. Pre-treatment of samples

Samples were collected during April/May 2001, at 10 km intervals from Pondicherry to Vedaranyam (Fig. 1). No samples were taken, however, wherever marshy ground near river mouths or difficult terrain prevented access to the beach. In contrast, the intervals between sampling stations were less than 10 km wherever striking lithological differences in the sand were observed, whether due to grain size, black sand enrichment, or the presence of detrital materials. Using a hand auger, 108 sediment samples were collected down to a depth of 25 cm from 26 stations. Samples were also taken from the different morphological units of the beach (low-, mid-, and high- tidal zones, berms and dunes). The geographical co-ordinates of the sample locations were fixed with a hand-held Magellan GPS.

The sediment samples were dried in an oven at 60°C. 100 g of the dried sample were then removed from the sample by repeated coning and quartering to ensure uniformity and to prevent errors in the analysis. After being soaked in water overnight, the samples were agitated by a mechanical stirrer to disaggregate them and to remove the clay fractions. The stirred samples were decanted repeatedly using distilled water until a clear column of water, free of turbidity, was obtained. Conc. HNO_3 was added to samples

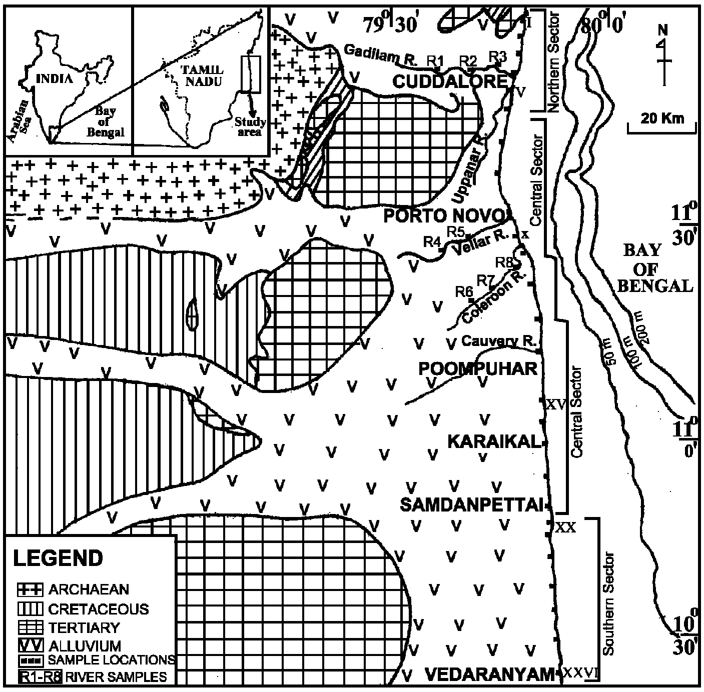

Fig. 1. Sample location and geology of the region from Pondicherry to Vedaranyam

with a ferruginous coating. For complete removal of the coating, a pinch of $SnCl_2$ was added to the conc. HNO_3 and the mixture warmed slightly.

Sieving was carried out in ASTM sieves at $1/4\ \phi$ intervals. The sieve sets, stacked in descending order of size, were shaken using a Ro-tap sieve shaker continuously for about 20 minutes. Using graphic (Folk & Ward 1957) and

Table 2. Formulae used for computing various size parameters

Parameters	Formulae of Friedman (1962)	Formulae of Folk & Ward (1957)
Mean	$\hat{\mu} = \frac{1}{100}\sum f(m_\phi)$	$M_z = (\phi_{16} + \phi_{50} + \phi_{84})/3$
Standard deviation	$\bar{\sigma} = (\sum f(m_\phi - \bar{x})^2/100)^{1/2}$	$\sigma_l = \frac{(\phi_{84} - \phi_{16})}{4} + \frac{(\phi_{95} - \delta_5)}{6.6}$
Skewness	$\bar{\alpha}_3 = \frac{1}{100}\hat{\sigma}^3 \sum f(m_\phi - \bar{x})^3$	$Sk_1 = (\phi_{16} + \phi_{84} - 2\phi_{50})/2(\phi_{84} - \phi_{16})$ $+(\phi_5 + \phi_{95} - 2\phi_{50})/2(\phi_{95} - \phi_5)$
Kurtosis	$\grave{\kappa} = \frac{1\hat{\sigma}^4}{100}\sum f(m_\phi - \bar{x})^4$	$K_G = \frac{(\phi_{95} - \phi_5)}{2.44(\phi_{75} - \phi_{25})}$

Explanation for the formulae of Friedman (1962): f – frequency as a percentage for each size class, m_ϕ – the mid-point of each ϕ size class, $\bar{x}$ – mean, σ – standard deviation, α_3 – skewness, $\grave{\kappa}$ – kurtosis.

moment methods (Friedman 1962) (Table 2), the weight percentage data of the samples were processed on a P–IV computer with the aid of a modified version of Schlee & Webster's (1967) procedure. Bivariant plots were drawn from the statistical parameters.

4. Results and discussion

4.1. Mean (Mz)

The moment mean values are identical to the graphic mean data of the analysed samples, so, after Folk & Ward (1957), who observed that 'the graphic mean values are twice as accurate an approximation as the moment mean data', we discuss only graphic mean values. In the northern sector, from Pondicherry (stn. I) to Talanguda (stn. IV), the graphic mean size ranges from 0.71 ϕ to 0.99 ϕ in the LT, MT and HT zones (Fig. 2). Because of the prevailing high-wave-energy environment, strong winnowing must have removed the fine sediments, leaving the coarser sediments behind on the foreshore. This is also evidenced by the presence of a wave-cut cliff to a height of 0.75 m, as measured in the field, formed by the erosive action of the waves. This high-energy condition is also attributable to the presence of submarine canyons in the Pondicherry and Cuddalore regions (Varadhachari et al. 1968). The sudden deepening and the steeply sloping nature of the narrow beach along this coastal stretch are very apparent. Factors like the steep slope of the shelf and open sea condition must have made the composition of beaches coarser in the foreshore region. Chauhan (1990) likewise considers the coarser sediments at Cuddalore to be the result of erosion. However, the presence of finer sediments in the backshore region (2.34 to 2.68 ϕ in the berms and 2.14 to 2.69 ϕ in the dunes) is attributable to the activity of the wind, which will have carried fine sediments in suspension

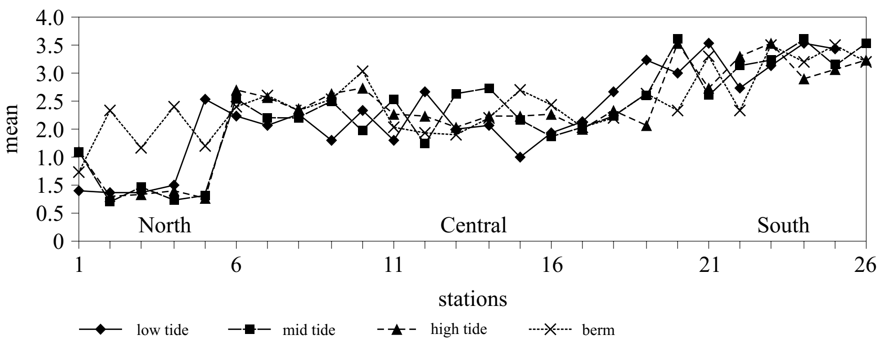

Fig. 2. Variogram of means – Pondicherry to Vedaranyam region

to the backshore from the beach ridges and cheniers, 2 to 3 series of which are adjacent to the coastal region of the northern sector.

In the central sector, the mean size of the sediments on the foreshore ranges from 1.51 to 2.95 ϕ (Fig. 2), indicating the predominance of fine sediments (80–85%) with an admixture of medium-grained sands. The preponderance of such fine sediments is probably due to the deposition by the fluvial system of reworked Mesozoic and Tertiary sediments (Fig. 2). Sedimentological studies of the rivers in the study region by Mohan (1990, unpublished) (Vellar region) and Muthukrishnan (1993, unpublished) (Gadilam region) corroborate these inferences. In the backshore region, the sediments are very fine, indicating the influence of aeolian activities in transporting fine sediments in suspension and of saltation from the adjoining coastal landforms.

In the southern sector, sediments are the finest in the whole study region, with mean values varying from 2.63 to 3.45 ϕ in both foreshore and backshore regions. Beaches are gently sloping with muddy clay balls strewn around on them. As this stretch of coastline is sheltered from wave-action by the adjoining Palk Bay and the island of Sri Lanka, the sediments there are predominantly very fine. According to Jena (1997, unpublished), the temporary rise in wave activity during cyclonic weather often increases the southerly drift in the southern sector. During this southerly drift, sediments from the central sector are carried by currents to the southern sector and deposited there, in addition to the northerly drift from Palk Bay located to the south.

4.2. Standard deviation (σI)

In the northern sector, standard deviations in the foreshore region vary between 1.67 and 1.95 ϕ (Fig. 3), indicating that the sediments are very

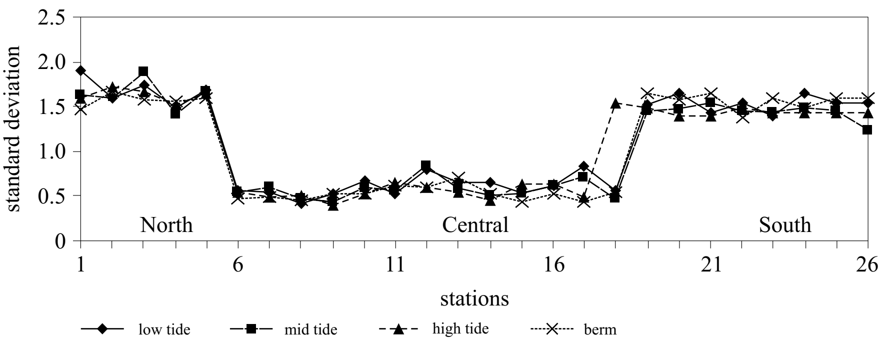

Fig. 3. Variogram of standard deviation – Pondicherry to Vedaranyam region

poorly sorted. Although this sector is characterised by high-energy wave conditions, the poorly sorted nature of the sediments could be due to the churning action of the waves, which facilitates the deposition of a mixed type of sediments. This is in line with the observations of Inman (1952) and Friedman (1967) that coarser sediments tend to show a deterioration in sorting whereas fine sediments are well sorted. The much poorer sorting in the berms indicates that sediments brought from the dunes and beach ridges have been wind-mixed. Nonetheless, the dune sediments are better sorted than the foreshore sediments.

In the central sector, where major rivers are present, the sorting values range from 0.42 to 0.82 ϕ (Fig. 3) on the foreshore; the sediments are thus well sorted (40%) to moderately well sorted. This well sorted nature can be put down to the mixing of sediments brought by waves and currents, in addition to the inputs of palaeo-sediments from the major river systems. This tallies with Friedman's (1961) observation that fine sediments exhibit an improvement in sorting. Chakrabarti (1977) and Chaudhri et al. (1981) have observed that moderately sorted sands are predominant on the beaches of the east and west coasts of India, respectively.

In the backshore region, the sorting value for the berms (0.60 ϕ to 0.68 ϕ) and dunes (0.50 to 0.63 ϕ) indicates that the sediments there are moderately well to moderately sorted. This is the result of the mixing of sediments brought there by aeolian processes from the adjacent beach ridges and cheniers, which were formed as a consequence of successive sea level oscillations during the Quaternary period.

In the southern sector, the sediments of both foreshore and backshore regions are poorly sorted (1.54 to 1.64 ϕ) (Fig. 3). The influence of size on sorting was acknowledged by Griffiths (1951), Inman & Chamberlain (1955) and Folk & Ward (1957); those studies established that medium to fine sand is better sorted than very fine sediments. However, our study presents contradictory observations, namely, that fine sediments are poorly sorted. As this stretch of coast is very swampy, with wave shadow conditions and no riverine discharge, the sediments carried by waves and longshore currents are continuously being mixed. The combination of various modes of transport (creep, saltation and suspension) may lead to poorly sorted sediments. Littoral drift prevails in a northerly direction from south of Palk Bay, which is one of the five major permanent sediment sinks in India; Chandramohan et al. (2001) calculated the annual sediment load for this sink at 58.8×10^6 m^3 yr^{-1}. During monsoons and cyclonic storms, enormous quantities of suspended sediments are pushed into the southern sector from Palk Bay, which must be responsible for the poor sorting of the sediments in this region. Similarly, Mohan et al. (2000) observed the

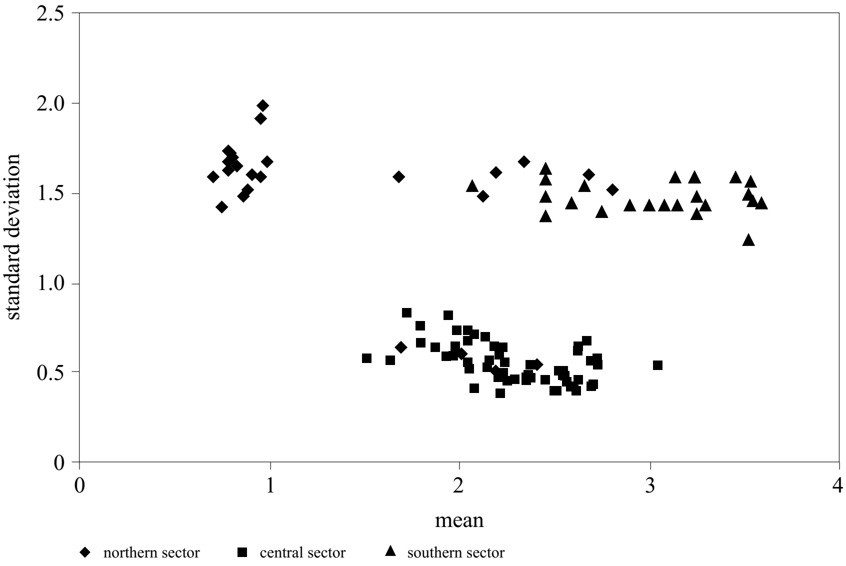

Fig. 4. Mean vs. standard deviation

poor sorting of sediments of Palk Bay, which is located just adjacent to the southern sector. The bivariant plot of mean vs. standard deviation (Fig. 4) shows that the sediments in both the northern and southern sectors are poorly sorted, irrespective of their coarseness or fineness; in the central sector, however, the sediments show an improvement in sorting with increase in grain size. This emphasises the fact that sorting is independent of grain size and that sorting deteriorates in both coarse and fine sediments.

4.3. Skewness (SKI)

In the northern sector, foreshore samples are negatively skewed, indicating the prevalence of high-energy conditions (Fig. 5). The excess of

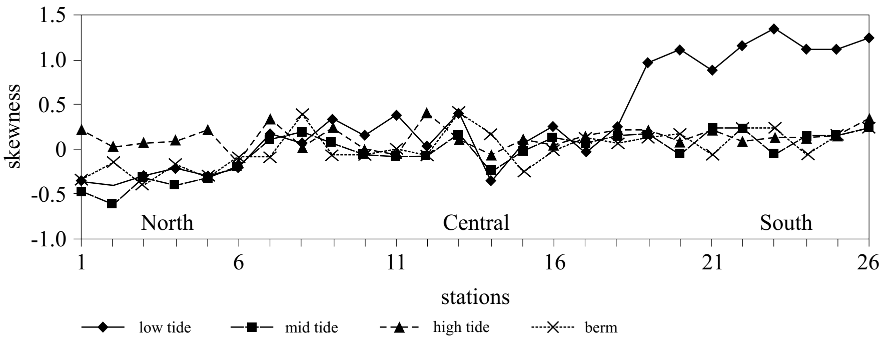

Fig. 5. Variogram of skewness – Pondicherry to Vedaranyam region

coarser sediment (negatively skewed distribution) illustrates the depletion of fine-grained sands and suggests the dominance of erosional processes. The positively skewed distribution (a greater quantity of fine sediments) indicates a depositional tendency (Duane 1964). A sandy platform with a height of 0.5 to 1.5 m, cymatogenic downwarping of the sedimentary basin (Anbarasu & Rajamanickam 2002) and the presence of submarine canyons between Cuddalore and Pondicherry are further evidence of the high energy conditions prevailing here. In similar vein, Duane (1964) and Chauhan (1990) reported the presence of negatively skewed sediments in beaches of high-energy conditions. The backshore samples deviate to positively skewed, probably due to the influence of aeolian activities that deposit the fine sediments derived from the reworking of beach ridges and cheniers.

In the central sector, sediments are nearly symmetrical to positively skewed (Fig. 5), suggesting the influence of fine sediments discharged by rivers like the Cauvery (stn. XIV) and the Coleroon (stn. XI). The river mouths are also marked by the growth of sand bars, visible at low tide. This accretionary nature indicates the prograding nature of the coast and, in turn, the prevailing low energy conditions. Even in places where there is no river input (stn. VI, VII, XI, XII to XVIII), sediments are positively skewed. These positive values indicate an excessive supply of very fine material brought in by littoral currents. Furthermore, the strong convergence of wave orthogonals (Angusamy et al. 2005) removes the coarser, lighter fractions, thereby enriching even more the finer, heavy-mineral-rich sediments. These stations also display a high concentration of heavy minerals (Angusamy et al. 2005), which supports the inferences that the coarser fractions are selectively winnowed.

In the southern sector, sediments are positively to symmetrically skewed (Fig. 5). Friedman (1967) observed that most present-day beach sands show a symmetrical or negatively skewed distribution. But the predominantly fine-skewed distribution indicates deposition of fine sediments transported by littoral currents under prevailing low energy conditions. According to Jena (1997, unpublished), the maximum wave height at Vedaranyam is 0.4 m during the southeast monsoon, and the littoral transportation rate is 16 -21×10^3 m^3 yr^{-1}. This low energy condition accounts for the positive skewness of the sediments. Similarly, Rajamanickam & Gujar (1997) observed that a near-symmetrical distribution of sediments is only possible where extreme conditions like wave breaking, tidal variations, and a seasonal supply of detritus are absent. In like manner, Rao et al. (2005) attributed the positive skewness of the beach sediments of False Devi in Andhra Pradesh to the excessive supply of fine material brought in by littoral

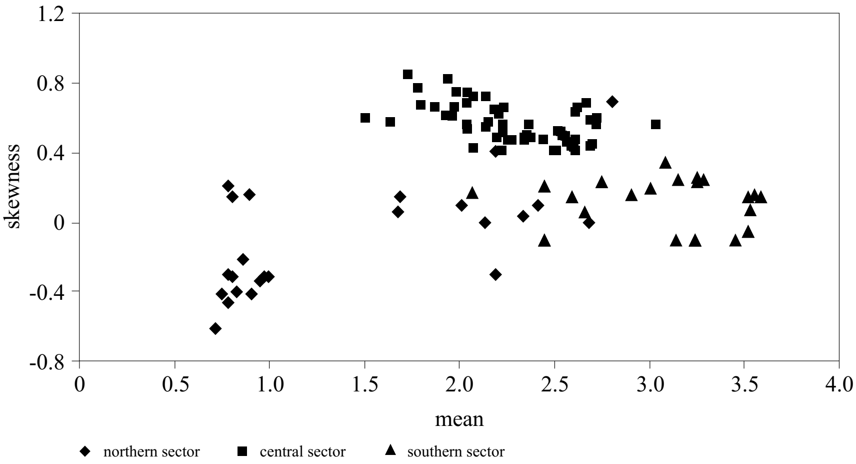

Fig. 6. Mean vs. skewness

currents. The plot of mean vs. skewness (Fig. 6) shows that the skewness values vary from positive to negative with increasing mean sediment size (Mz decreases).

4.4. Depositional environment

The bivariant plot of standard deviation vs. mean (Fig. 7) shows a distinct grouping of the three sectors as a separate cluster. This plot shows

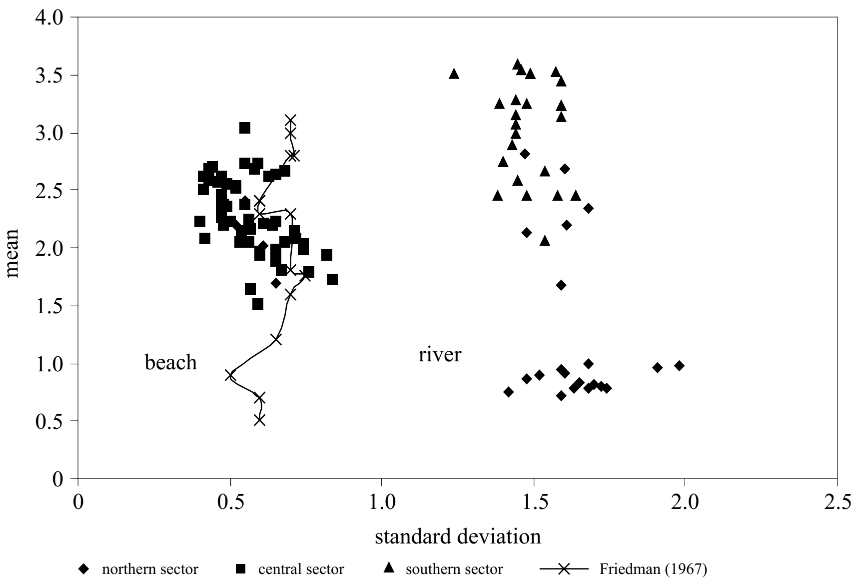

Fig. 7. Standard deviation vs. mean

that in the northern sector sediments become poorly sorted as the mean size decreases, but that in the central sector, the sorting characteristics of the samples deteriorate as the mean size increases. Conversely, in the southern sector, sorting becomes poorer as the sediment size increases. While the southern and northern sectors have no fluvial environment, the central sector shows separate clustering of samples in both the beach and fluvial environments (Fig. 7).

The scatter plot of standard deviation vs. skewness also helps to characterise these three sectors as a separate cluster. Whereas the southern sector and northern sectors have no fluvial environment, the central sector does show the influence of fluvial and beach environments (Fig. 8). The southern sector is devoid of any drainage network, and the lack of sediments in the fluvial environment suggests that the sediments have retained antecedent characters.

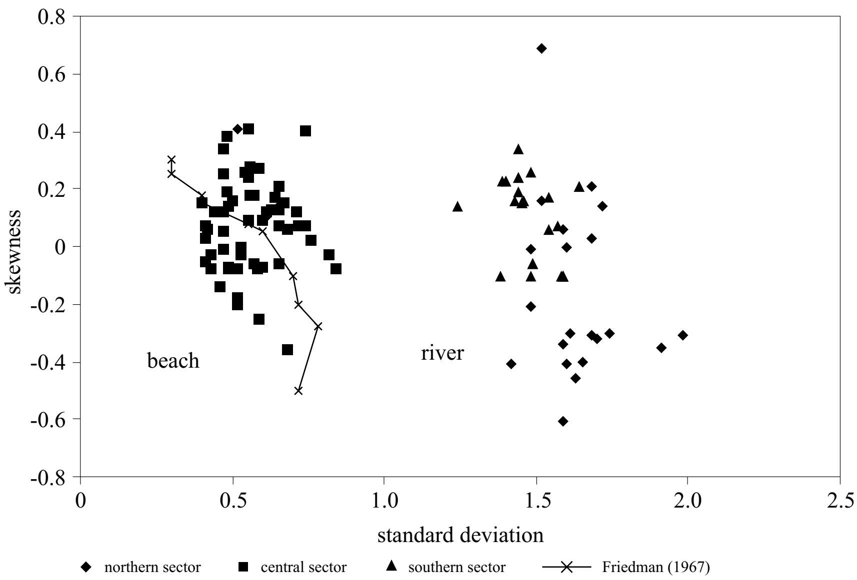

Fig. 8. Standard deviation vs. skewness

4.5. Linear discriminant analysis

The Linear Discriminant Function (LDF) of Sahu (1964) was used for the multivariate analysis of the beach sediments. The following formulae and their limitation to a particular environment were utilised to interpret the environment.

1. To distinguish between the aeolian and beach environments, the following equation was used:

$$\mathrm{Y1}_{\mathrm{aeol:beach}} = -3.5688\,\mathrm{M} + 3.7016\,\mathrm{r}^2 - 2.0766\,\mathrm{SK} + 3.1135\,\mathrm{KG}.$$

If 'Y' is > -2.7411, then the environment is 'beach', but if it is < -2.7411, the environment is aeolian.

1. To confirm the environment once again, the following formula was used to delineate the beach environment (Y=$\leq$ 63.3650) from the shallow marine environment (Y=$\leq$ 63.3650)

$$\mathrm{Y2}_{\mathrm{Beach\,:Sh.Mar}} = 15.6534\,\mathrm{M} + 65.7091\,\mathrm{r}^2 + 18.1071\,\mathrm{SK}$$
$$+18.5043\,\mathrm{KG}.$$

2. To distinguish a shallow marine environment from a fluvial environment, the following formula was used:

$$\mathrm{Y3}_{\mathrm{Sh.Mar}} = 0.2852\mathrm{M} - 8.7604\,\mathrm{r}^2 - 4.8932\,\mathrm{SK} + 0.0482\,\mathrm{KG}.$$

If 'Y' is > -7.4190, a shallow marine is indicated environment, but if 'Y' is < -7.5190, then a fluvial environment is indicated.

(M = mean, r = standard deviation, SK = skewness and KG = kurtosis).

The values obtained for the differentiation of aeolian and beach processes (Table 3) show that with the exception of the berm samples of stations I to IV, all the samples represent a littoral environment. The influence of the aeolian environment in the berm samples is clearly reflected in the poor sorting of the sediments, since aeolian processes mix up sediments.

Table 3. Linear discriminant function analysis of sediment samples in the study region: results

Sub environment	Aeolian and beach processes (Y1)	Beach and shallow environment (Y2)	Shallow marine and fluvial processes (Y3)
Sahu (1964)	< -2.7411 aeolian	$<$ 65.3650 beach	< -7.4190 fluvial
classification	> -2.7411 beach	$>$ 65.3650 shallow agitated environment	> -7.4190 shallow marine deposits
northern sector	-1.56 to 13.97	79.33 to 284.94	-3.12 to -29.93
central sector	-0.02 to -7.21	68.25 to 95.86	-6.12 to -0.93
southern sector	-0.01 to 7.37	180.32 to 239.04	-15.39 to -23.83

In the case of the central sector, aeolian processes influence 21% of the samples. At stations X, XI, XII, XVI and XVII, the foreshore and backshore samples are representative of aeolian processes; the remainder of the samples represent the littoral environment.

In the southern sector, 30% of the samples came about as a result of aeolian processes, whereas littoral processes influence the remainder.

For shallow marine and fluvial processes, LDF analysis of the northern sector shows that only 10% of the samples fall within a fluvial environment. The samples from station IV, located in the mouth of the River Gadilam, and station V (berm) reflect the influence of a fluvial environment. The sediments discharged by the River Gadilam must have been redeposited in the berm regions during the monsoon period, when larger-amplitude waves erode the berm regions, thereby depositing the river-borne sediments. In the central sector, entire samples are influenced by fluvial debris, whereas in the southern sector, the samples represent a shallow marine environment. This indicates that the central sector is influenced primarily by a network of rivers like the Cauvery and the Coleroon.

In the classification of the beach and shallow marine environments, LDF results (Table 3) indicate that all the samples from the northern, central and southern sectors are of shallow marine origin. The results of the present study indicate that the sediments in the northern sector are derived from a fluvio-marine environment, those in the central sector from a fluvial environment, and those in the southern sector from a marine environment. From these values, it can be inferred that the sediments in the present-day beaches must have been deposited in a shallow marine environment and in due course of time, marine regression must have led to the development of the present-day shorelines. In the northern sector, 4 to 5 series of beach ridges are aligned parallel to the coast with 2 to 3 sets of cheniers, indicating localised marine transgressions and differential sea level oscillations during the Quaternary period.

In the central sector, beach ridges are present in selective pockets in a discontinuous pattern. Especially at stations X and XIV, beach ridges are absent. Poompuhar (X) and Tarangampadi (XIV) were thriving ports during the 3rd century A.D. But today, no such ports are in existence. During the most recent transgression, around 900 A.D, these historical cities were submerged (Anbarasu & Rajamanickam 1999). Marine archaeological studies (Vora & Subbaraju 1987) have revealed the existence of the submerged city of Poompuhar in the present shelf between 7 and 15 m, 5 km offshore. From Tarangampadi, isolated artefacts of various sizes were found at depths of 9 and 11 m (Rao & Mohana Rao 1990). Hence, as a result of the transgression along the study area, beach ridges formed during the late Holocene regression must have become submerged under the sea. The continuous reworking of these submerged ridges must have provided an ongoing supply of heavy-mineral-rich fine sediments to the present-day beaches of this sector. On this basis it can be concluded that the present-day beach sediments in the study must be relic sediments deposited earlier in a shallow marine environment. This is again corroborated by the results of LDF analysis, indicating a shallow marine environment for the sediments of the present study area, which is modified by contemporary fluvial processes in the central sector, and aeolian processes in the northern and southern sectors.

5. Conclusion

In the northern sector, sediments are coarser as beaches are steeply sloping and high wave energy conditions predominate. In the central sector, the moderately sloping beach sediments are finer owing to fluvial discharge; in the absence of the latter, and in spite of the presence of high wave energy conditions, they reflect the possibility of having been derived from palaeo-sediments. In the southern sector, extremely fine sediments are the result of a prevailing wave shadow regime.

The mixing of sediments under high energy conditions, as in the case of the northern sector, and under low energy conditions as in the case of southern sector, has affected the sorting of sediments: in those sectors they are poorly sorted. Aeolian processes have affected the sorting characteristics of the sediments, and the addition of relict sediments has improved the sorting characteristics of the central sector samples.

The skewness values indicate the prevalence of denudational processes in the northern sector, but of depositional processes in the central and southern sectors. This is endorsed by the development of sand bars at the mouths of the Rivers Coleroon, Cauvery and Vellar in the central sector.

Owing to the possible relic nature of the sediments, the bivariant plots present an overlapping of the fluvial, marine and beach environments in the beach samples of the study area. LDF results show that shallow marine deposits dominate the three sectors; they had probably supplemented sediment deposition prior to the Holocene transgression and were submerged during it. They are being reworked by present-day coastal processes.

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