J. Nat. Aq. Res. Ag. Sri Lan. 32 (1985) 82 - 93

TEXTURE AND HEAVY MINERAL DISTRIBUTION OF SURFACE SEDIMENTS FROM THE NEGOMBO COASTAL AREA

by

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ABSTRACT

Provenance and sediment dispersal were investigated in the Western coast of Sri Lanka in the Negombo area. The siliclastic fraction of beach, nearshore, lagoon and river surface sediments were examined. Grain-size frequency and statistical analysis showed that the sands of these environments can be distinguished by their textural parameters.

Nearshore sediments adjacent to the Mouth of the Maha Oya river and the Negombo Lagoon entering the Negombo area have heavy mineral suites similar to those in the river and lagoon. The heavy minerals are composed of mainly ilmenite, rutile, zircon, limonite and garnet. The heavy mineral data from the river, lagoon and in the adjacent nearshore and beach areas indicate that the sediments were derived largely from metamorphic suites exposed in the hinterland.

The distribution of the light mineral components, although not diagnostic in differentiating between source areas, is helpful in understanding environments of deposition.

The beach, lagoon and river sediments are interpreted as recent in origin, whereas the nearshore sediments are presumably relict in origin.

INTRODUCTION

The Negombo coastal stretch situated 40km North of Colombo is a shallow area enclosed by the seaward extention of the submerged beach rock foundation of the Negombo Lagoon spit. As part of the National Aquatic Resources Agency's long term study of the continental margin of the west coast of Sri Lanka, the general mineral composition, texture and other characteristics of bottom sediments from the west coast have been determined. This paper discusses the results of detailed mineralogical and sedimentalogical analyses made on the gravel and sand-sized fraction (4.0-0.63mm) of 30 of these samples collected from the Negombo aera.

SAMPLING AND LABORATORY ANALYSIS

Beach and lagoon sediments were collected from the areas shown in Fig. 1. To examine the mineralogy of the contemporary sediment supply, samples were taken from the mouth of the Maha Oya river which flows into the Negombo area. The beach sediment samples were obtained by pressing a cylindrical glass jar into the surface sand. The lagoon and river samples were collected using a small Eckman grab sampler.

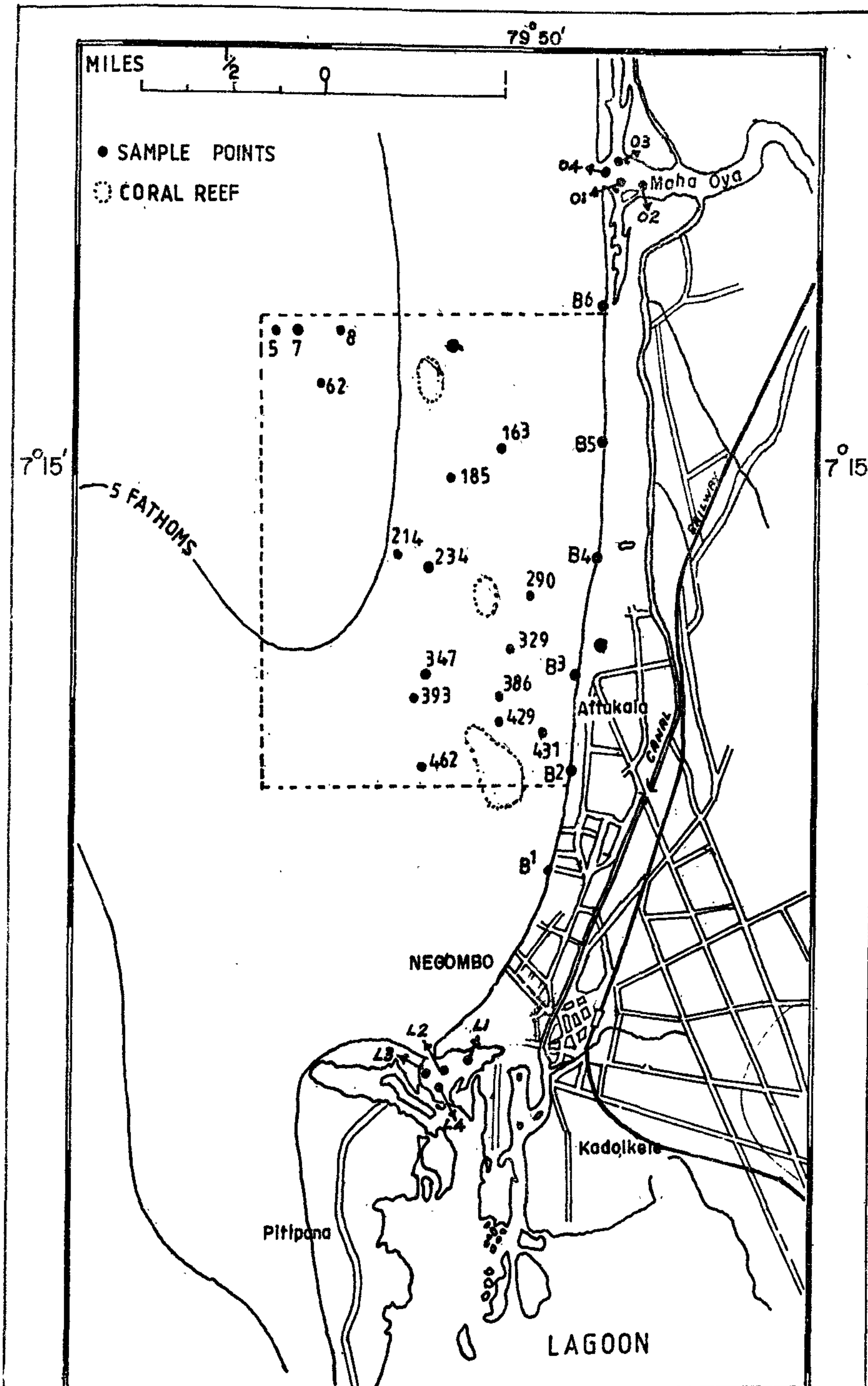

Fig. 1 Map Showing study area with sample locations

The sediments of the nearshore area were sampled during the hydrographie survey of the Negombo area in 1984. Grab samples of the surface sediments were taken by a Van-veen grab.

Sample preparation

The samples were washed, dried and sieved into 0.5 phi intervals plotted on probability paper and statistical parameters calculated (Folks 1961).

The heavy minerals of the sand-size material in the surface samples were seperated from the light minerals, using bromoform (r=2.8g/cm^3). The heavy and light minerals were identified using binocular and petrographic microscopes. Means and standard deviations of individual minerals in all samples from each association were calculated. The amount of Iron staining on quartz grains was determined by 100-grains counts of the sand sized fraction. Carbonate percentages were determined by the Co_2 evolved methods.

RESULTS AND DISCUSSION

Grain-size and statistical analysis

Results showed that the beach, lagoon, river and nearshore sands can be distinguished from each other by their grain-size parameters (Fig. 2, Table 1).

TABLE 1.

SEDIMENT PROPERTIES OF BEACH, NEARSHORE, LAGOON AND MAHA OYA RIVER SANDS

	Beach Sand	*Nearshore Sand*	*Lagoon Sand*	*River Sand*
Grain Size	Medium	Coarse to very coarse	Fine to medium	Medium
Colour	Yellowish brown to brownish yellow	Yellowish brown	Fawn grey to light brown	Yellowish brown
% Carbonate	0 — 3%	0 — 20%	0 — 5%	0 — 3%
Sorting	Moderately well to moderately	Very well to well to poorly	Well to poorly	Moderately well to moderately
Angularity	Very angular to subrounded	Angular to subrounded	Very angular to subangular	Angular to rounded
% Ironstained Quartz and Feldspar grains	25%	40%	15%	12%
% Rock Fragments	0 — 1%	0 — 3%	0 — 1%	0 — 1%
% Mud	0	Traces	Traces	Traces
Depth range	0 — 1M	0 — 10M	0 — 4M	0 — 5M

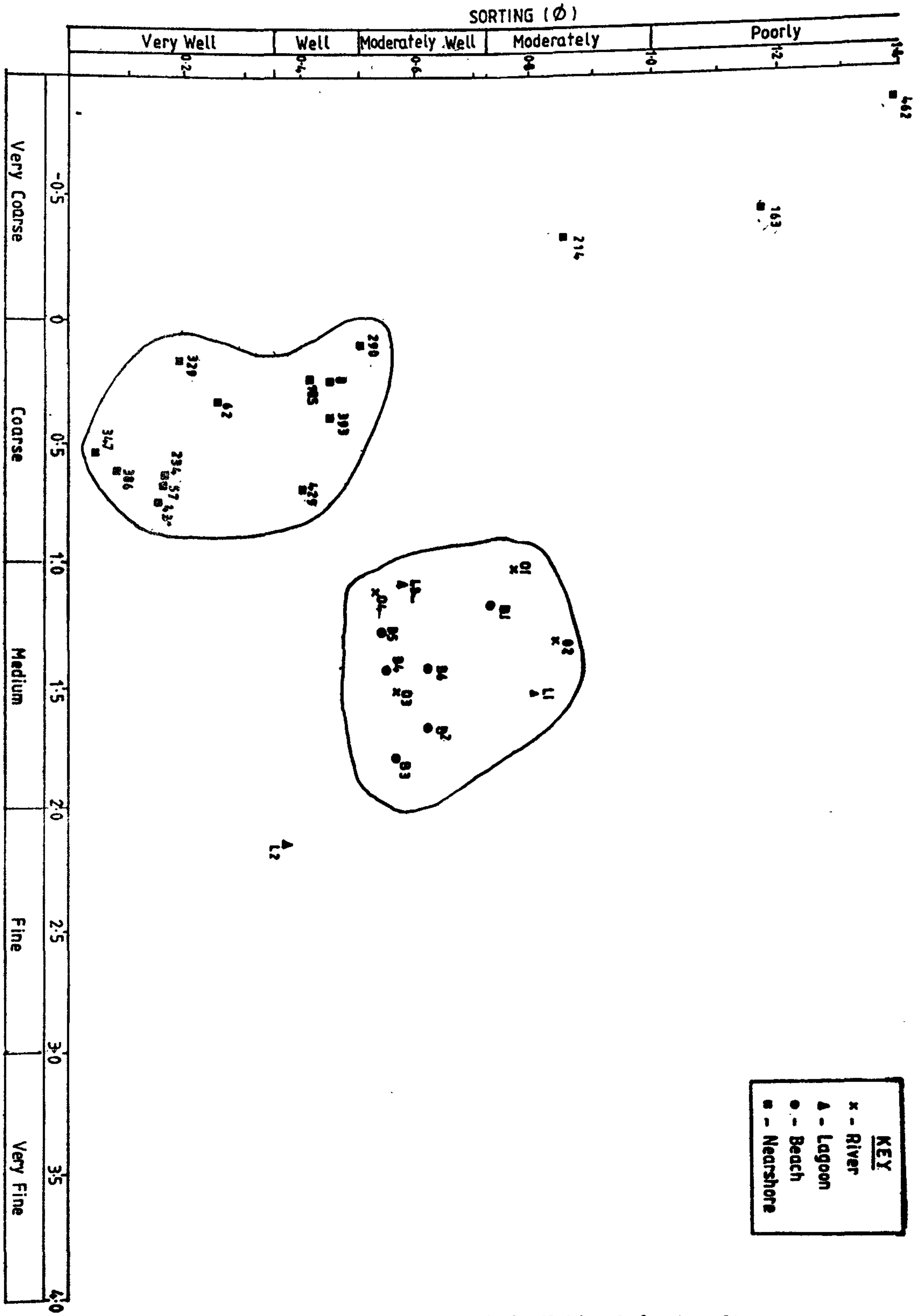

Fig. 2. Plot of sorting and mean grain size for the sand gravel (0.063-4.0mm) fraction of beach, nearshore and lagoon samples from the Negombo area andMaha Oya river samples.

The mean grain-size of the beach and lagoon sands varies between 1.17-1.82ϕ. and 0.99-2.18ϕ, whereas those of the river sands 1.03-1.53ϕ. The nearshore sands show two distinct grain-size ranges, very coarse sand with (-0.18)-(-0.70ϕ) and coarse sand with 0.10-0.7ϕ.

The standard deviation indicates (Fig. 2, Table 1) that the beach and river sands are moderately well to moderately sorted, with values of 0.54-0.73 and 0.53-0.84 respectively, while the lagoon and nearshore sand show a wide range of sorting. The lagoon sands are well to poorly sorted with 0.38-1.44. The nearshore sands show two modes of sorting with the majority being very well to well with 0.04-0.5 and the rest being moderately to poorly sorted with 0.86-1.40.

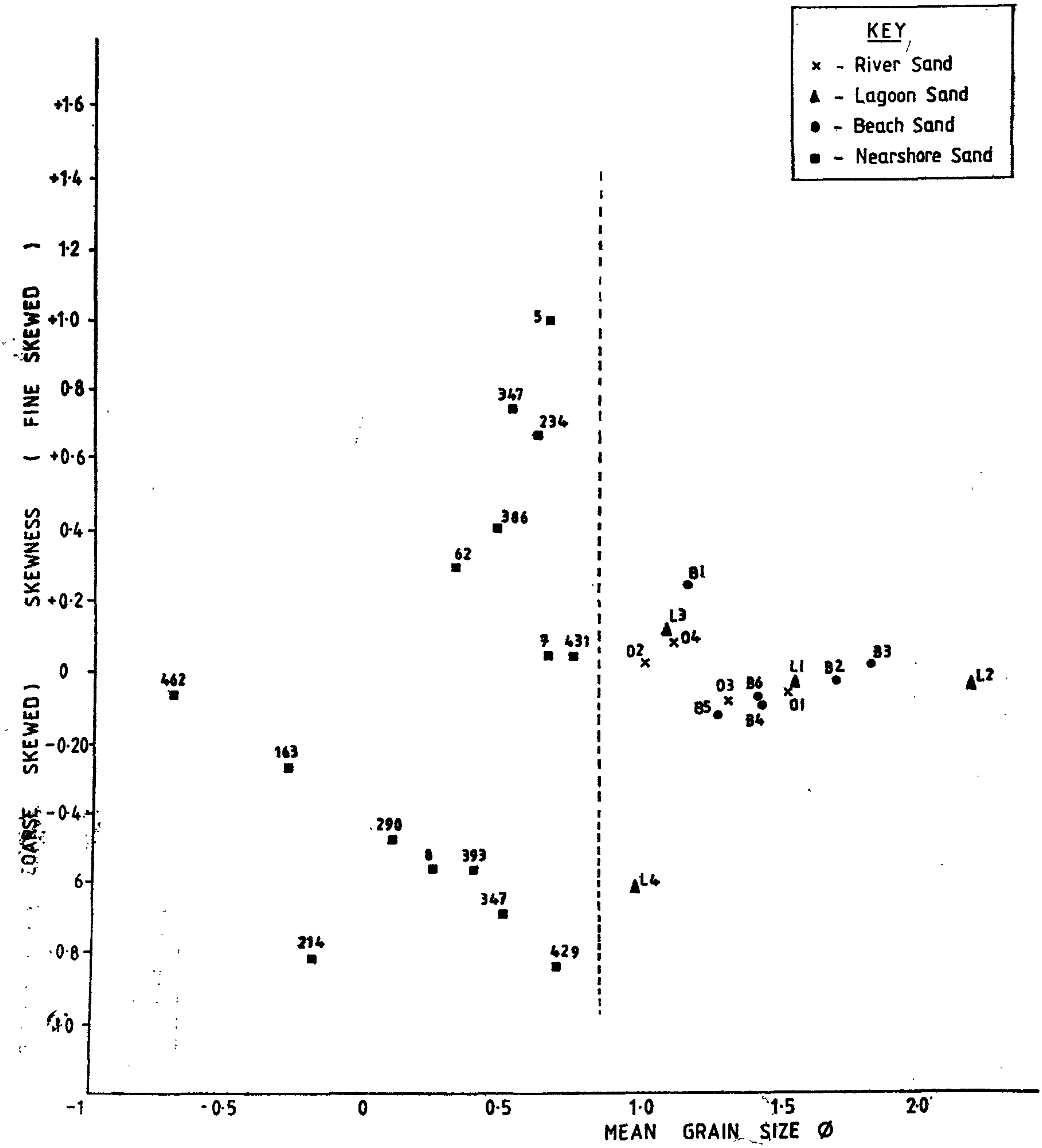

Fig 3 - Plots of skewness and mean grain size for the sand, gravel (0.063-4 mm) fraction of beach, nearshore, and lagoon samples from the Negombo area and Maha Oya river samples.

Data were plotted on scatter diagrams. Fig. 2 is the plot of mean grain-size versus standard deviation and shows that sands from various envrionments can be distinguised according to their position on the plot.

The plot of mean grain-size versus skewness is displayed in Fig. 3 and gives information regarding the measure of asymmetry or the mixing of basic population of sand and gravel. It shows that the majority of the beach, river and lagoon sands are near symmetrical indicating little or no unusual admixture of fine or coarse material. The majority of the very well sorted nearshore sands show a tendency towards having a fine admixture, which may reflect a small addition of fine material from the river or lagoon. The well to moderately well sorted nearshore sands occupy the area of coarse skewness, indicating the admixture of coarse material from local outrcops such as the reefs found in the area. The modreately to poorly sorted sediments are coarse skewed indicating the admixture of gravel.

Sorting of the sediments can be helpful in pointing out the agents that deposited it. The strong bottom currents and waves have winnowed and sorted much of the nearshore sands, judging from the ripples and shell debris observed by divers in the area. Elsewhere, admixtures of gravel lead to moderate or poor sorting. Analysis of histograms show that nearly all samples from the beach, lagoon and river are unimodal only one sample from the lagoon being bimodal, indicating, that this may be in part due to debris of organic origin mixed with the normal sediments (Revelle, 1944). Most of the nearshore samples are unimodal with a few bimodal. These bimodal sands overly the submerged reef and are indicative of the admixture of the basic populations of sand and gravel.

MINERALOGY

Heavy Minerals

Table 2 and Fig 4 illustrate that average heavy mineral contents of the samples analysed from the different environments of deposition. The heavy minerals of the sand fraction of these sediments are composed mainly of ilmenite, garnet, zircon, rutile and pyroxene. Magnetite, monazite, spinel and others are present in subordinate amounts in most samples studied. The variability of heavy minerals within individual associations can be considerable, as indicated by relatively large values of standard deviations around the mean (Table 2). Variations in the composition of sediments supplied to the area is a cause of variability both between and within associations. The small numbers of samples, added to the errors inherent in the laboratory and sampling techniques, can also contribute to the variability. However, mineral compositions do not vary significantly from one association to the other.

The Maha Oya river drains large areas of precambrian metamorphic rocks. The mineral composition of sediments from the Maha Oya river and the Negombo Lagoon, which itself is supplied by many small streamlets, generally reflects the composition of their drainage areas, as is seen by comparing the beach and nearshore samples with the river and lagoon samples (Fig. 4).

The drainage area of the Maha Oya river includes garnet-biotite gneisses, biotite gnesisses in the lower reaches of the river (Fig. 5) and garnet biotite gneisses, charnockites, granitic gneisses, quartizite and minor bands of marble in the upper reaches. In addition the

Maha Oya river drains areas overlain by red earth and basal fermuginous gravel. The rocks and soil in the catchment area of the river influences sediment type. This is clearly observed in the heavy mineral samples of the Maha Oya river sediment which are composed of the minerals ilmenite, rutile, zircon, garnet, pryoxene, spinel and limonite.

Several small streamlets that enter the Negombo Lagoon also drain the same Preoambrian metamorphic rocks and is clearly indicated in the similarity of mineral assemblayes from the river and lagoon samples (Table 2).

TABLE 2.

AVERAGE COMPOSITION OF HEAVY MINERALS FROM THE NEGOMBO BEACH, NEARSHORE, LAGOON AND MAHA OYA RIVER

($\bar{X}$ — mean σ — Standard deviation)

Sample Type		*HEAVY MINERAL PERCENT*										
		Ilmenite	*Rutile*	*Zircon*	*Garnet*	*Limonite*	*Magnetite*	*Pyroxcene*	*Monazite*	*Spinel*	*Others*	*Number of Samples*
Beach	$\bar{X}$	49.5	1.2	2.2	13.2	27.4	0.7	3.7	1.6	—	0.4	
	σ	21.7	0.6	—	10.4	25.1	—	3.3	2.4	—	—	06
Nearshore	$\bar{X}$	44.2	2.0	11.7	2.7	18.1	6.2	3.6	1.3	3.0	7.2	
	σ	28.3	1.2	8.4	1.5	14.6	4.1	2.4	2.7	1.7	5.3	16
River	$\bar{X}$	51.6	3.8	6.1	19.0	7.0	1.2	10.3	—	0.4	1.5	04
	σ	11.2	2.6	2.1	10.2	4.0	—	6.5	—	—	0.1	
Lagoon	$\bar{X}$	16.6	—	8.0	5.5	11.1	1.5	10.9	—	1.3	0.8	04
	σ	7.1	—	5.2	3.6	3.0	—	6.9	—	—	0.9	

Ilmenite which is a major accessory mineral in the metamorphic rocks of the area is found in high concentration in both river and lagoon samples (40.4-51.6% & 54.4-61.6%). Beach and nearshore samples show a similar high concentration of the mineral. Other accessory minerals present in the rocks of the catchment area of the river are found in all associations in varying proportions.

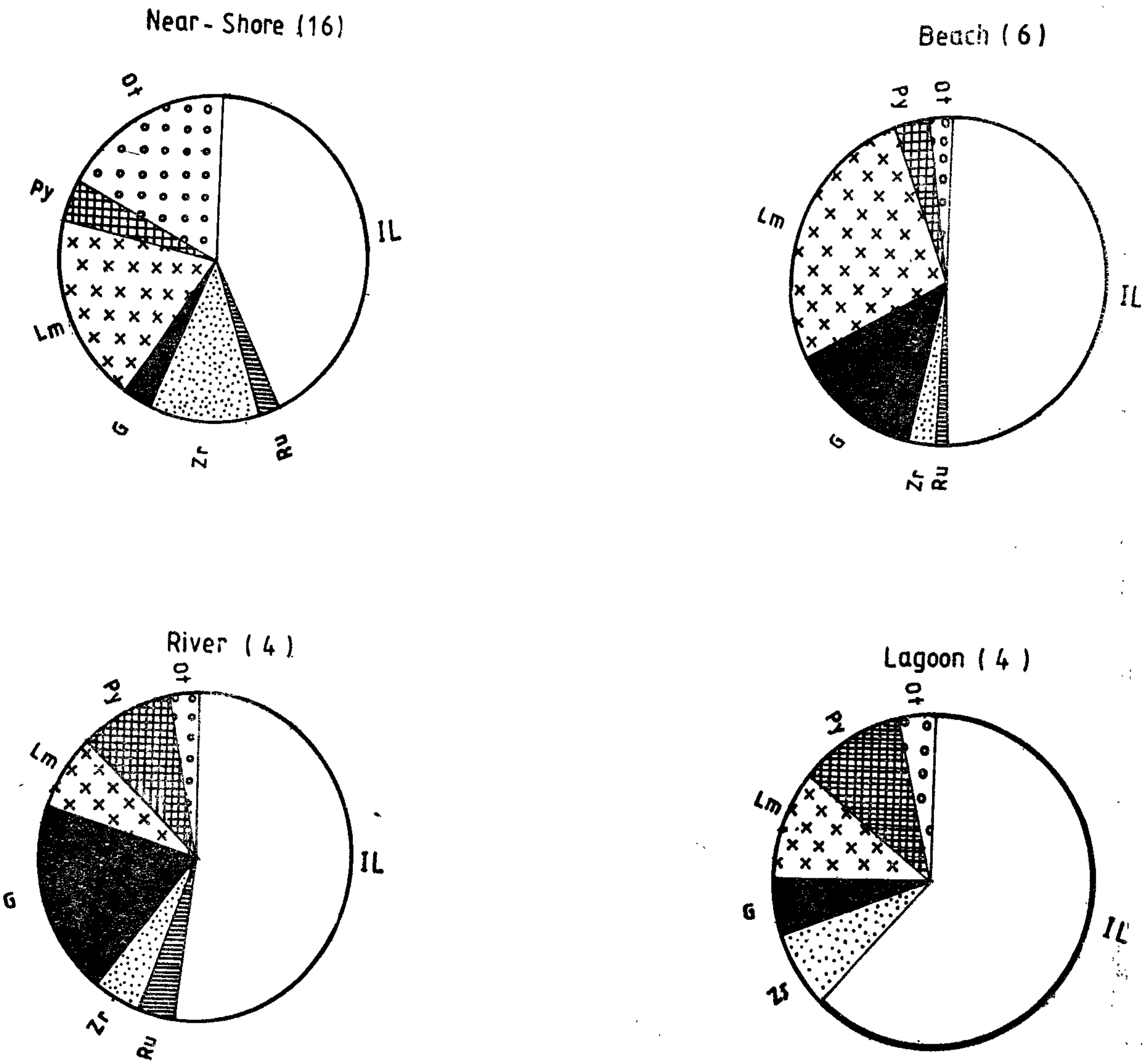

Fig. 4 - Heavy mineral composition of samples collected from the Negombo beach, nearshore and lagoon and the Maha Oya river IL - ilmenite, RU - rutile; Zr - zircon; G - garnet; LM - limonite; Py - pyroxcene; Ot others (monazite, mangnetite, Spinel etc). The number in parentheses refer to the number of samples.

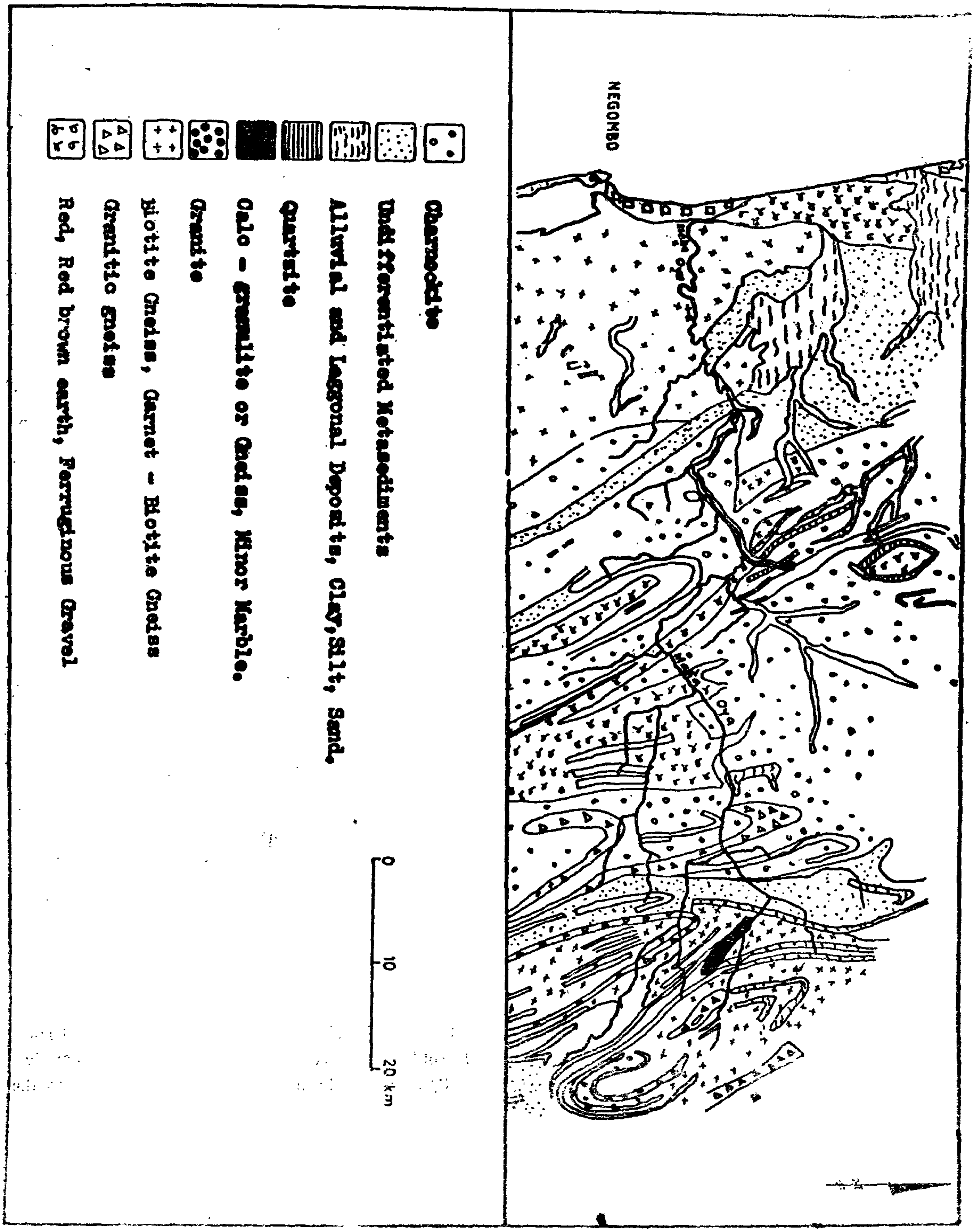

Fig. 5. The geology of the Maha Oya drainage basin (Geology Map of Sri Lanka 1985).

Three exeeptions to the general similarity of mineral composition in the associations are significant. One is in the Maha Oya river samples, where garnet is more abundant than in the nearshore sediments, and the other is the somewhat high concentration of limonite in the nearshore and beach samples. The third is the absence of rutile in the lagoon samples. The Maba Oya river drains some garnet metapmorphic zones in the coastal regions of its drainage basin and high concentration of very angular to anular garnets are therefore common in the Maha Oya river samples. The somewhat higher concentration of limonite in the nearshore and beach samples are attributed to the progressive erosion of the submerged beach rock which is encrusted in iron and found off Negombo (Wickremeratne 1984). Errors introduced by the limited sampling may account for the absence of rutile in the lagoon samples.

Light Minerals

Light minerals (density less than 2.89 gm per cm^3) compose the bulk of the sand fraction; however, they generally consist of only a few mineral species and therefore have limited application in determination of source area. The light material is mainly quartz and feldspar with minor amounts of rock fragments, mica and biogenous material (Table 3). Samples from the Maha Oya river and Negombo Lagoon contain small quantities of wood fibers.

The light mineral assemblages in all samples are rather similar (Table 2). Iron stained quartz and feldspar are more common in the nearshore (40%) and beach (25%) sediments (Table.) Mica which is common in sheltered shore environments is found in the river, lagoon and nearshore sediments but is lacking in the beach sediments.

TABLE 3.

LIGHT MINERAL COMPOSITION OF SAMPLES COLLECTED FROM THE NEGOMBO BEACH, NEARSHORE, LAGOON AND MAHA OYA RIVER

($\bar{X}$, mean; σ Standard deviation)

Sample Type		*Quartz*	*Feldspar*	*Stained Quartz and feldspar (percent of total quartz and feldspar)*	*Rock fragment (percent)*	*Biogenous Material (percent)*	*(percent)*	*Number of Samples*
Beach	X	95.0	2.3	24.7	0.1	2.3	0.3	06
	σ	1.6	1.0	10.0	—	0.7	—	
Nearshore	$\bar{X}$	86.7	4.0	44.1	2.5	5.4	1.4	16
	σ	5.6	2.4	15.1	2.2	4.0	0.7	
River	$\bar{X}$	95.0	2.1	11.7	0.2	1.1	0.4	04
	σ	1.6	0.7	10.9	0.2	0.7	0.4	
Lagoon	$\bar{X}$	92.3	3.5	15.0	0.7	2.8	1.5	04
	σ	2.7	1.6	5.6	0.2	1.5	0.5	

DISCUSSION

Heavy mineral data suggest a similar source for the beach and nearshore sediment in the Negombo area. The nearshore and beach samples have heavy mineral compositions similar to those of Maha Oya river. The mineral composition of the river sediment generally reflects the composition of their drainage areas. A metamorphic source is indicated by the minerals in the Maha Oya river. The presence of wood fibres in the river and lagoon samples sugests that the river and lagoon material is of recent origin. Thus the similarity of grain sizes of the beach samples with that of the river and lagoon samples suggest that most of the beach sediments may also be recent.

The significant size difference between the nearshore sediments with that of the rest of the sediments in the Negombo area together with the predominance of very well to well sorted sands suggests that these sands are relict (pre-modern) reworked sediments from which the finer sand components have been winnowed.

Iron staining in terrigenous sediment generally reflect deposition in an oxygen-rich subarial environment but staining also may reflect sediment source. The iron stained quar and feldspar sands of the study area could be attributed to laterization during a previous low sea stand, but iron stained grains could also reflect derivation from the low lying red earth and ferruginous gravel of the coastal region.

Thus the nearshore sands may represent Holocene reworkings of former environments but also sedimentary processes associated with the sea level advance.

The small number of samples does not allow adequate definition of dispersal patterns. The surface currents in the nearshore are generally from North to South and of low velocity (usually less than 15 cm/sec) during the NE monsoon (Gerristseen, 1974) during which the samples were taken. Distribution of heavy minerals in the nearshore samples in the Negombo area (Wickremeratne, 1984) however, suggests dispersion from south to north. Selective sorting or more local river current effects of the Maha Oya discharge may possibly be important.

The distribution of the light mineral components, apart from the wood fibres in the river and lagoon sediments, does not diffierentiate between source areas but helps in understanding the nature of environments of deposition. Mica, usually an indicator of a low energy environments is not present in most beach samples, indicating that the beach in Negombo is an area where a high energy environment prevails. This is exemplified by the coastal erosion hazard encountered in that area. The high mean grain size of the nearshore sediments, where the fine material has been winnowed, is also an indication of the high energy environment in the area.

ACKNOWLEDGEMENTS

This work was conducted with the assistance and cooperation of the Oceanography Unit of the National Aquatic Resources Agency. Special thanks are due to Messrs. A. Ameratunge, D. Silva for their assistance in sampling and laboratory work; Mr. P. B. Ratnapala for draughting the illustrations and Mrs. S. Paul for typing the final manuscript. This paper is published with the kind permission of the Chairman and Director General of the National Aquatic Resources Agency.

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