Chapter - IV

Beach Placer Characteristics
(Newara)

CHAPTER IV :

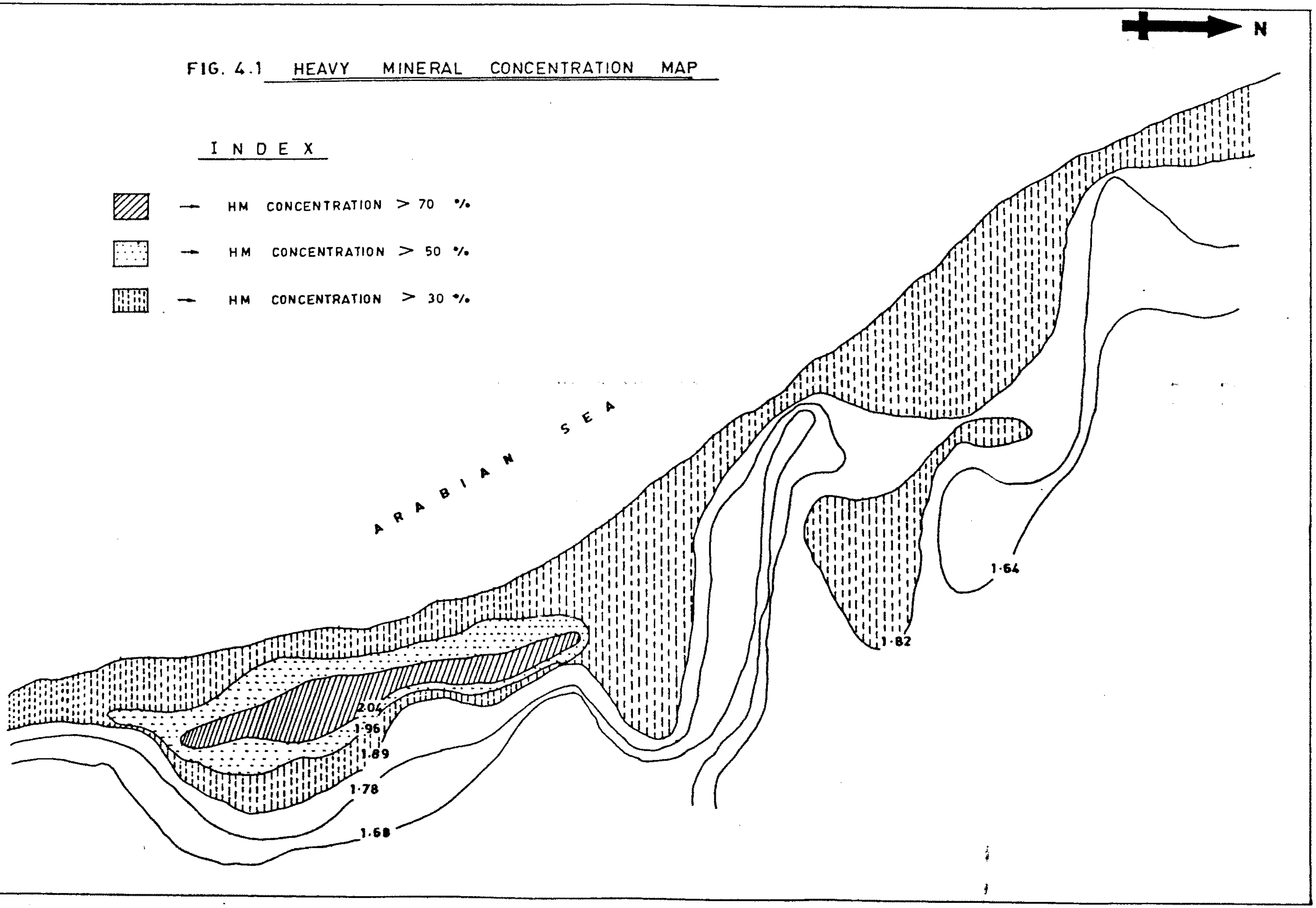
INTRODUCTION : The sediment characteristics reflect the types of the processes in the formation of placer deposits. In understanding the processes involved in the formation of placer deposits certain physical measurements such as bulk density and the grain size studies were carried out for the Newara beach sand samples. Modal analysis of the raw sand as well as those of the heavy minerals were also investigated in evaluating the qualitative and quantitative aspects of different heavy minerals in general and in specific the mineral - ilmenite. Apart from these studies an attempt is also made in deciphering the source and factors responsible for heavy mineral enrichment. The present chapter deals with the above mentioned studies.

BULK DENSITY MEASUREMENTS : Bulk densities of 140 samples collected from the Newara beach have been estimated and the method of estimating the bulk density is enumerated in the chapter II. The data obtained from the bulk density measurements is given in table no. 4.1. This data was used in preparing the bulk density distribution pattern map (Fig. 4.1). On examination of this map, it can be noticed that the southern part of the investigated area has highest bulk density values (> 2), signifying the heavy mineral concentration in that region. The average strike length of about 1300 meters and an average width of about 80 meters in this region forms a productive zone for the heavy mineral

TABLE NO. 4.1 : BULK DENSITY VALUES OF NEWARA BEACH SAND SAMPLES.

Sample No.	B.D. Values	Sample No.	B.D. Values	Sample No.	B.D. Values	Sample No.	B.D. Values	Sample No.	B.D. Values	Sample No.	B.D. Values
NW1	1.96	NW2	1.95	NW3	1.35	NW4	1.99	NW5	1.91	NW6	1.88
NW1A	1.74	NW2A	1.96	NW3A	1.95	NW4A	2.10	NW5A	2.22	NW6A	1.99
-	-	NW2B	1.84	NW3B	2.30	NW4B	2.04	NW5B	2.10	NW6B	2.00
-	-	NW2C	1.37	NW3C	1.80	NW4C	2.07	NW5C	2.00	NW6C	1.35
-	-	NW2D	1.30	NW3D	1.73	NW4D	1.60	NW5D	1.84	NW6D	1.79
-	-	-	-	NW3E	1.82	NW4E	1.77	NW5E	1.80	NW6E	1.75
-	-	-	-	-	-	NW4F	1.87	NW5F	1.70	-	-
-	-	-	-	-	-	NW4G	1.67	NW5G	1.62	-	-
NW7	1.95	NW8	2.04	NW9	1.47	NW10	1.80	NW11	1.62	NW12	1.20
NW7A	2.08	NW8A	1.82	NW9A	1.49	NW10A	1.75	NW11A	1.64	NW12A	1.79
NW7B	2.08	NW8B	1.61	NW9B	1.14	NW10B	1.54	NW11B	1.73	NW12B	1.87
NW7C	1.93	-	-	NW9C	1,79	NW10C	1.65	NW11C	1.82	NW12C	1.89
-	-	-	-	NW9D	1.86	NW10D	1.71	-	-	NW12D	1.78
-	-	-	-	NW9E	1.39	-	-	-	-	NW12E	1.85
-	-	-	-	-	-	-	-	-	-	NW12F	1.90
-	-	-	-	-	-	-	-	-	-	NW12G	1.80
NW13	1.69	NW14	1.42	NW15	1.60	NW16	1.55	NW17	1.55		
NW13A	1.74	NW14A	1.83	NW15A	1.49	NW16A	1.92	NW17A	2.00		
NW13B	1.80	NW14B	1.70	NW15B	1.39	NW16B	1.85	NW17B	1.98		
NW13C	1.60	NW14C	1.71	NW15C	1.74	NW16C	1.83	-	-		
NW13D	1.66	NW14D	1.82	NW15D	1.64	NW16D	1.60	-	-		
NW13E	1.72	NW14E	1.64	NW15E	1.58	NW16E	1.67	-	-		
NW13F	1.75	NW14F	1.62	-	-	NW16F	1.82	-	-		
NW13G	1.78	-	-	-	-	NW16G	1.67	-	-		
NW13H	1.34	-	-	-	-	NW16H	1.93	-	-		

FIG. 4.1 HEAVY MINERAL CONCENTRATION MAP



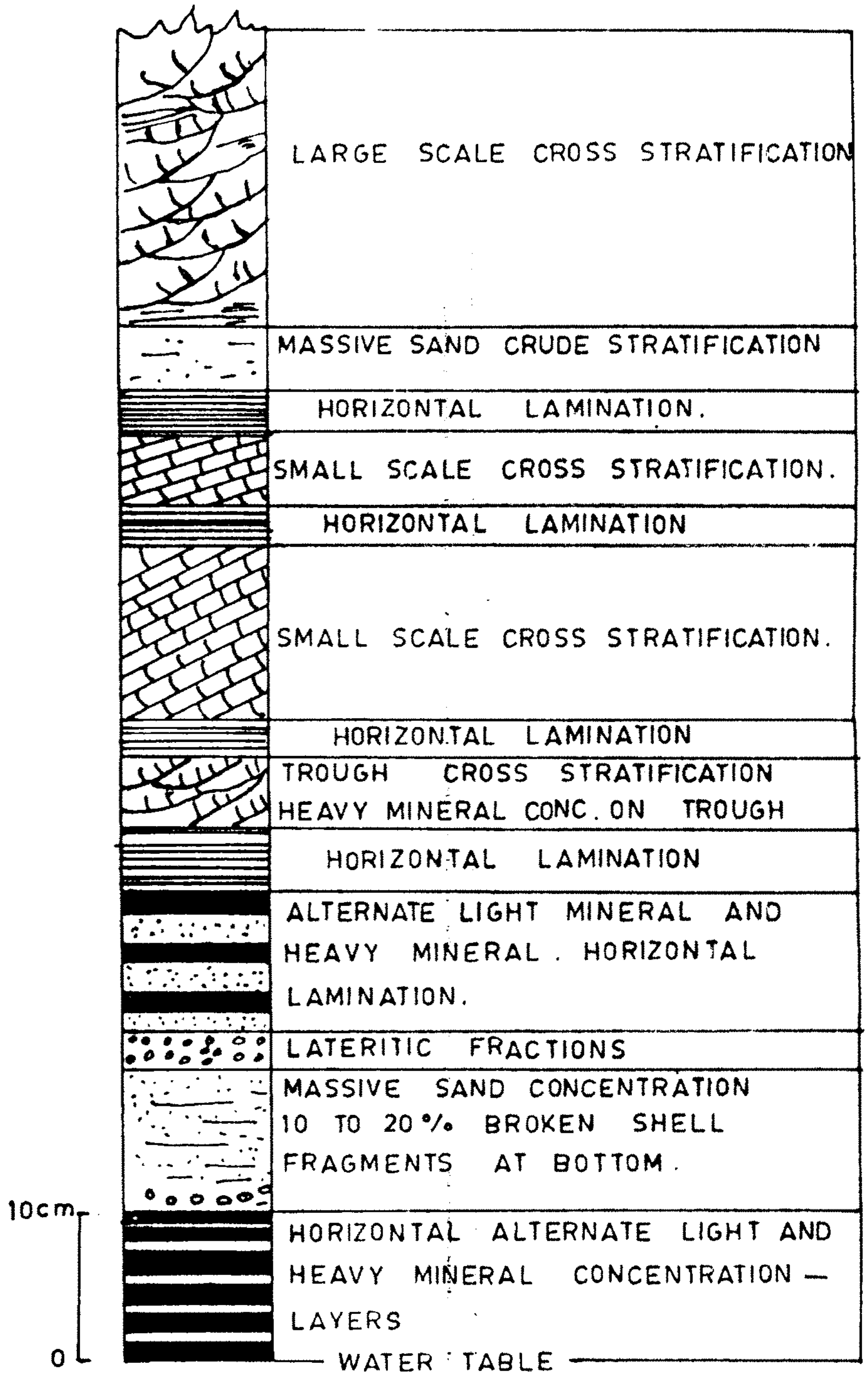
concentration.

In the northern part of the Newara beach, it is observed that the lower values of the bulk density measurements signify the lesser concentration of heavy minerals. From this observations, it is inferred that there is a selective deposition of the heavies towards the southern side and lighter minerals towards the northern side of the investigated area.

OCCURANCE OF PLACER DEPOSITS : As mentioned earlier in the chapter II, the consolidated and unconsolidated Quaternary sediments are found to occur in the Newara beach to an extent of 4.5 km between the two hillocks, one towards the southern side and the other towards the north. The arcuate shape of the beach is due to the relatively greater encroachment of the northern promontory into the sea. The black sands consisting of different heavy minerals are found in thin / thick laminated layerings within the white sands. It has been noticed that the concentration of black sands is more at the mouth of the Newara creek in the central part of the beach (plate 2.1). The area south of the Newara creek is characterised distinctly by the low and high-tide sediments. The region north of the Newara creek is predominently characterised by the barchans and longitudinal dune sediments.

In order to obtain the information about the vertical distribution of heavy minerals in the beach sands,

FIG. 4.2 GENERALISED CROSS SECTION OF SAND AT NEWARA



some dug wells in the vicinity of the beach were examined and the detailed cross section upto the water table level is obtained and is depicted in fig. 4.2. On observation of the litho-log, it is found that the heavy minerals are concentrated along with the light minerals in the form of horizontal layers of 10 cm thickness at the bottom of the cross section above the water table. The horizontal laminations and the dark / light coloured minerals are suggestive of their formation in the aqueous environment having cyclic energy variations.

This formation is overlained by massive sand with broken shell fragments at the bottom of the horizon. The thickness of this formation is also about 10 cm. The presence of shell fragments in this horizon is inferred to have formed in the marine environment. The lateritic fragment bed of 2.5 cm thickness follows the underlained massive sand formation. The laterite fragments might have been derived from the adjoining lateritic terrain and these fragments which are subangular to subrounded could be because of rigorous fluvial cycle with a rapid rate of erosion, transportation and deposition without these detritals being subjected to any degree of sorting. This feature is indicative of rapid tectonic disturbances in the fluvial environment.

The lateritic fragment bed is overlained by the alternate layers of equal thickness of dark heavy minerals followed by light coloured minerals. As stated earlier, such alternate layerings of different minerals may be attributed to cyclic energy changes of the depositing medium.

Thin horizontal laminations consisting of light minerals and to a subordinate amount of heavy minerals are found over the earlier bed consisting of purely heavy minerals. This is followed by trough cross stratifications of heavy and light sands of about 5 to 10 cm thickness, indicating the exposure of the depositional environment to the eolian conditions. As mentioned earlier, the horizontal laminations followed by trough cross stratifications of different magnitude are observed to overlay the earlier sequences. Such horizontal and cross trough stratifications of sand is inferred as the area might have experienced oscillatory changes of the depositional environments from aqueous to sub-arial conditions. (After Roep et.al 1975, Barwis 1976).

SEDIMENT CHARACTERISTICS : The beach sand samples collected from the Newara beach were analysed in terms of grain-size studies. This was carried in understanding the sedimentary environments and its influence on heavy mineral deposition.

Several methods such as those proposed by Udden (1914), Wentworth (1922), Krumbein (1934), Pettijohn (1957), Kane and Hubbert (1963) and Folk (1966) have been used in understanding the sedimentary environments. Amongst these, the methods proposed by Pettijohn (1957), Kane and Hubbert

(1963) and Folk (1966) are popular and have attained widespread use in understanding the grain-size and its relationship in terms of the processes involved in the sediment transport and their deposition. The grain-size can be studied in the two following methods, i) Graphic method as proposed by Folk (1966) and ii) Moment measure method as suggested by Kane and Hubbert (1963). The graphic method is a method in which graphs are plotted from the data and quantitative readings are taken for the statistical analysis. The moment measures is a method in which grain-size parameters are obtained directly from the size data. Of these two, the graphic method has been adapted in the present investigation for understanding the grain-size distributing pattern of the Newara beach sand.

After sieving the sand samples for 15 minutes, weights obtained against each size fraction were tabulated and converted to weight percentage (Table No. 4.2). Cumulative weight percentages have been further computed for each size fraction and is presented in table no.4.3 Histograms showing the weight percentages in different sieves for all sand samples from Newara beach have been plotted (Fig. 4.3 a to 4.3 d). Cumulative weight percentage by frequency grain-size has been plotted on arithmatic scale and cumulative frequency curves have been drawn. From these curves, different percentile values were readout for the computation of grain-size parameters.

TABLE NO. 4.2 : WEIGHT PERCENT IN GRAMS FOR THE SEDIMENTS FROM DIFFERENT LEVELS OF NEWARA BEACH.

Size inter. (Phi)	NW2 LT	NW3B HT	NW4D BOD	NW5 LT	NW6B HT	NW7C BOD	NW8B D	NW9 D	NW10B LT	NW11B D	NW12 LT	NW13B HT	NW14B D	NW15D D	NW16G D	NW17B BOD
+1.75	00.56	00.69	00.16	03.38	00.79	00.06	00.04	01.80	01.24	00.01	15.72	00.73	01.00	00.04	00.01	00.02
+2.75	14.80	12.20	07.19	07.83	12.06	09.83	14.62	08.29	02.17	04.00	40.15	05.54	20.31	04.50	02.02	01.82
+3.25	70.38	58.80	40.10	60.43	66.00	55.78	70.87	30.56	09.95	40.78	35.89	36.18	60.25	48.56	35.10	50.32
+3.75	12.94	15.72	28.55	20.80	17.74	17.50	10.07	31.39	31.33	23.77	06.06	26.03	13.65	25.50	23.00	22.60
+4.10	00.78	09.57	19.56	04.46	02.52	14.54	03.32	23.36	48.57	25.27	01.54	26.38	03.55	16.68	31.60	19.29
+4.25	00.44	02.69	03.87	02.55	00.87	02.20	00.96	04.53	06.58	06.10	00.69	05.07	01.14	04.51	08.22	05.77
+4.50	00.09	00.33	00.57	00.55	00.02	01.10	00.12	00.07	00.16	00.07	-	00.07	00.10	00.21	00.05	00.18

TABLE NO. 4.3 : CUMULATIVE WEIGHT PERCENT FREQUENCY FOR THE SEDIMENTS OF

DIFFERENT ZONES FROM NEWARA BEACH

Size inter. (Phi)	NW2 LT	NW3B HT	NW4D BOD	NW5 LT	NW6B HT	NW7C BOD	NW8B D	NW9 D	NW10B LT	NW11B D	NW12 LT	NW13B HT	NW14B D	NW15D D	NW16G D	NW17B BOD
+1.75	00.56	00.69	00.16	03.68	00.79	00.06	00.04	01.80	01.24	00.01	15.72	00.73	01.00	00.04	00.01	00.02
+2.75	15.36	12.89	07.35	11.21	12.85	09.89	14.66	10.09	03.41	04.01	55.88	06.27	21.31	21.54	02.03	01.84
+3.25	85.74	71.69	47.45	71.64	78.85	65.67	85.53	40.65	13.39	44.79	91.71	42.45	81.56	53.10	37.13	52.16
+3.75	98.68	87.41	76.00	92.44	96.59	83.17	95.60	72.04	44.69	68.56	97.77	68.48	95.21	78.60	60.13	74.76
+4.10	99.46	96.98	95.56	96.90	99.11	97.71	98.92	95.40	98.26	93.83	99.31	94.86	98.76	95.28	91.73	94.05
+4.25	99.90	99.67	99.43	99.45	99.98	99.91	99.88	99.93	99.83	99.93	100	99.93	99.90	99.79	99.95	99.82
+4.50	99.90	100	100	100	100	100	100	100	100	100	-	100	100	100	100	100

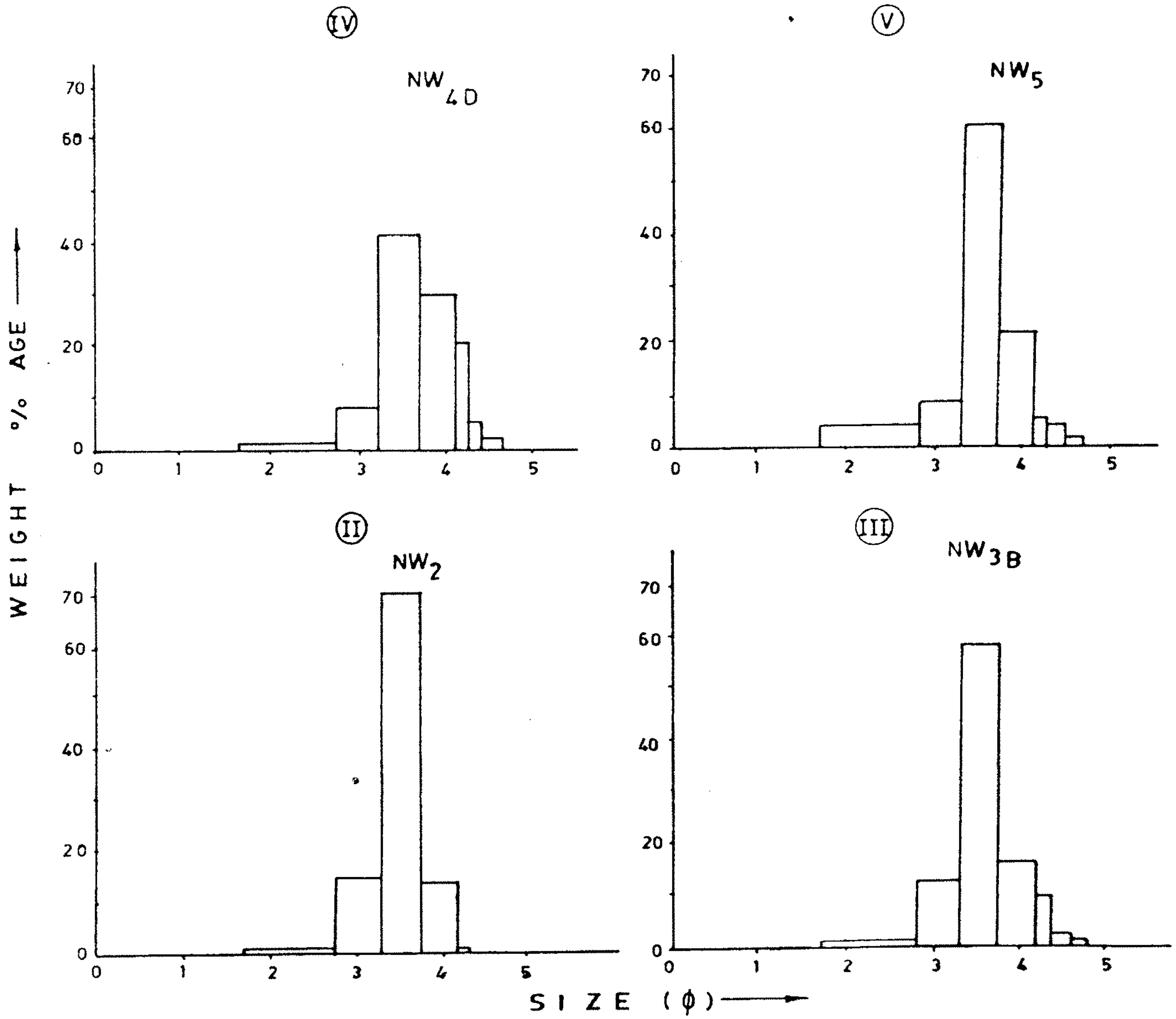


FIG.4.3(a) HISTOGRAMS SHOWING THE SPATIAL DISTRIBUION OF GRAIN SIZE OF SAND

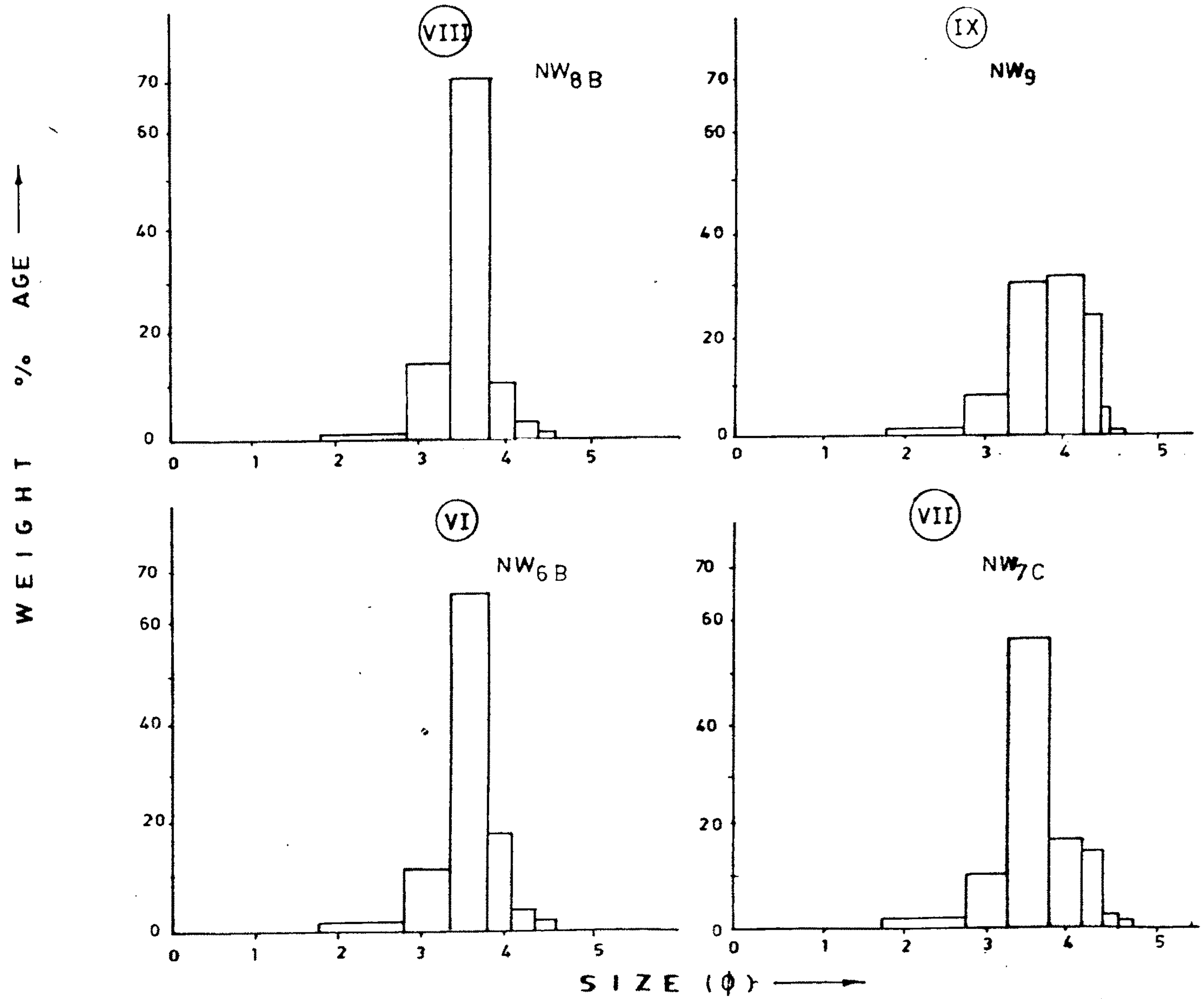


FIG.4·3 (b) HISTOGRAMS SHOWING THE SPATIAL DISTRIBUTION OF GRAIN SIZE OF SAND

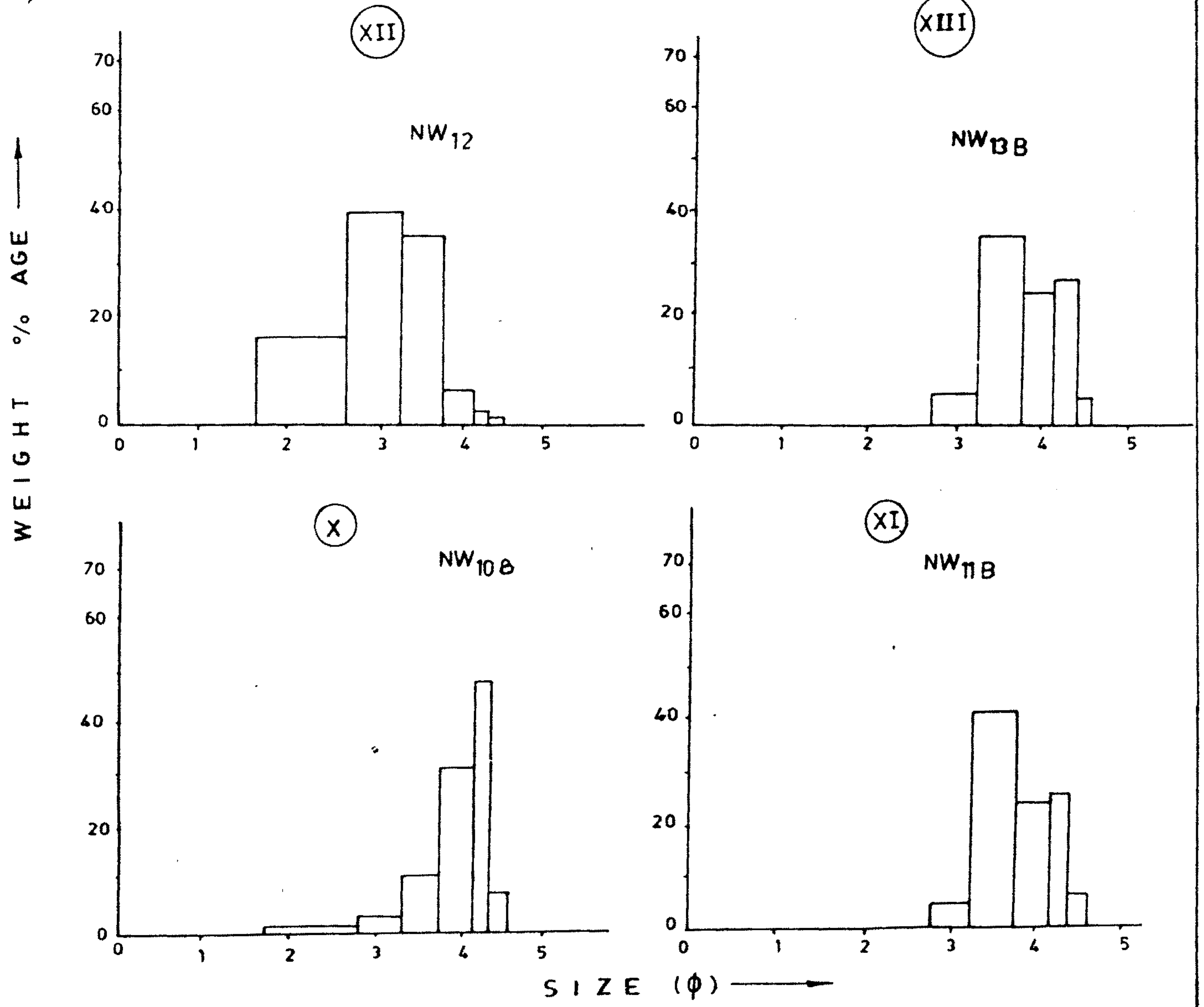


FIG. 43(c) HISTOGRAMS SHOWING THE SPATIAL DISTRIBUTION OF GRAIN SIZE OF SAND

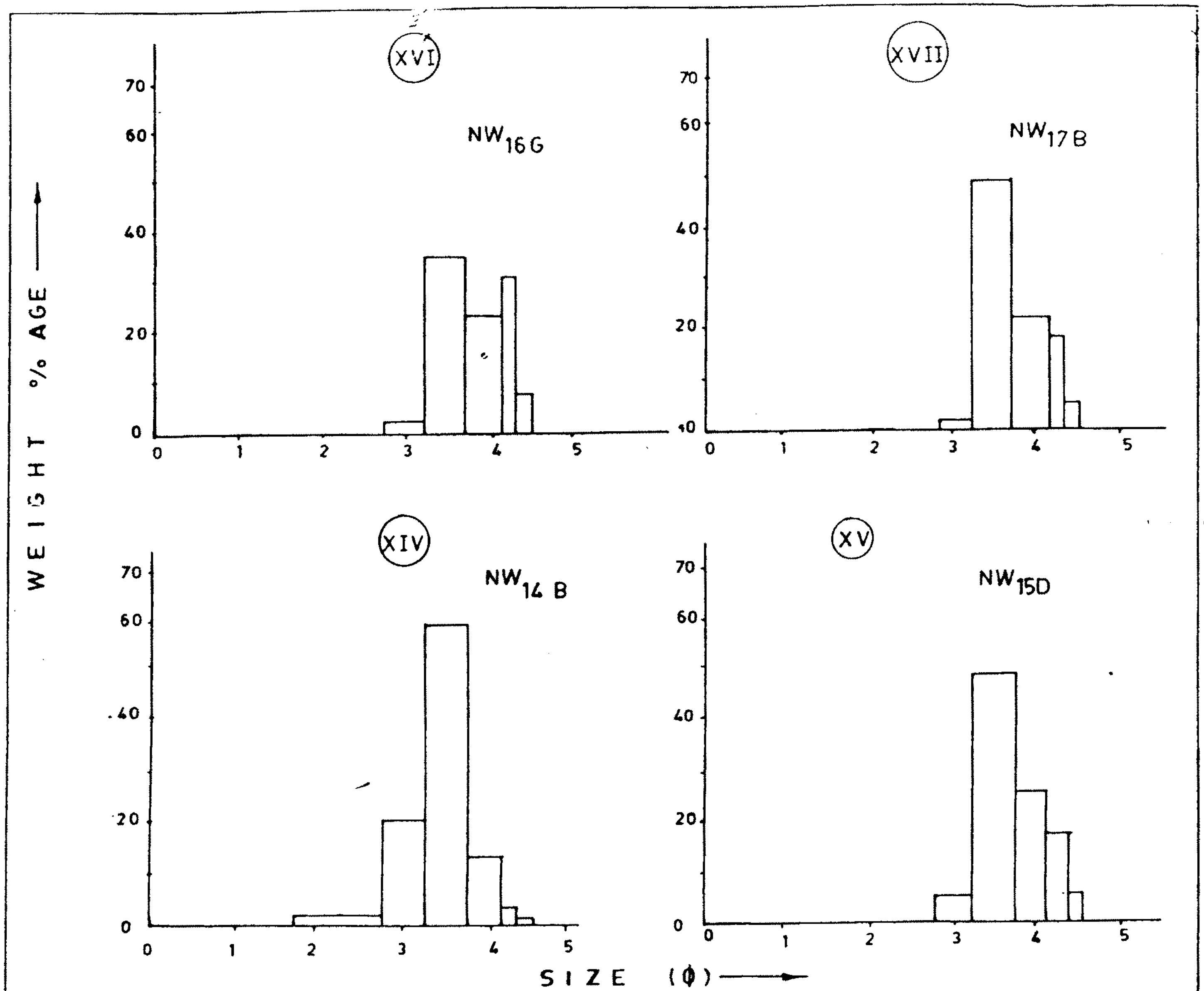


FIG. 4·3 (d) HISTOGRAMS SHOWING THE SPATIAL DISTRIBUTION OF GRAIN SIZE OF SAND

Four grain-size parameters viz, graphic mean, standard deviation, skewness and kurtosis are used to describe the grain-size distribution.

i. Mean Grain-Size (Mz) : The mean is simply the statistical average expressed in phi (ϕ) units. Different workers have used different formulae for mean size calculation. Folk and Ward (1957), have given the formula as,

$$Mz\ (\phi) = (\phi 16 + \phi 50 + \phi 84) / 3$$

ii. Standard Deviation : It is a measure of sorting and defined by the grain-size on either side of the average. It measures the uniformity of grain-size within a sediment sample. It is one of the most useful parameter, since it gives an indication of the depositional medium in separating grains. In the present study, this parameter is calculated by using formula as suggested by Folk and Ward (1957), which is as,

$$\text{std.devi.} = \frac{\phi 84 - \phi 16}{4} - \frac{\phi 95 - \phi 5}{6.6}$$

iii. Skewness (Ski) : The skewness gives an idea about the symmetry of the curves and expresses the tendency of distribution, which depart from symmetrical form. Folk and Ward (1957) proposed the formula for skewness as,

$$\text{ski.} = \frac{(\phi 16 + \phi 84 - 2\phi 50)}{(\phi 84 - \phi 16)} + \frac{(\phi 5 + \phi 95 - 2\phi 50)}{(\phi 95 - \phi 5)}$$

iv. Kurtosis : It is related to peakedness of a frequency curve. Kurtosis is a measure of the contrast between the sorting observed in the central part of the particle size distribution with that of the tails. It indicates the degree to which the particles are concentrated near the centre of the curve. It is computed by using formula proposed by Folk and Ward (1957), which is as,

$$\text{Kurtosis} = \frac{(\phi 95 - \phi 5)}{2.44\,(\phi 75 - \phi 25)}$$

All above discussed parameters for the Newara sand samples from southern, central and northern part of the beach representing low tide, high tide and dune are computed and are presented in table no. 4.4. Discussion of the sedimentary parameters from different regions is given in the following paragraphs.

In the low tide zone : On comparison of the relative mean size of south, central and north, it has been noticed that central part of the beach has relatively finer sediments, followed by southern and northern parts of Newara beach. The sorting of these sediments in the central and southern part is relatively higher than that of the northern part of the beach. This could be because of the greater surf zone in the southern and central part of the Newara beach. This is evident from the relatively lower standard deviation values of the sands from the above mention zones. The skewness values of the southern, central and northern part indicate that they are negatively skewed, reflecting beach environment.

TABLE NO. 4.4 : THE COMPARATIVE STUDY OF GRAIN SIZE PARAMETERS IN THE SOUTHERN, CENTRAL AND NORTHERN PARTS OF THE NEWARA BEACH HAVING LOW-TIDE, HIGH-TIDE AND DUNE SAMPLES.

A. LOW-TIDE	i) Mean size	Centre - 3.36 ∅	South - 3.32 ∅	North - 2.53 ∅
	ii) Standard Deviation	Centre - 0.38 ∅	South - 0.49 ∅	North - 0.70 ∅
	iii) Skewness	Centre - 0.50 ∅	South - 0.29 ∅	North - 0.50 ∅
B. HIGH-TIDE	i) Mean size	Centre - 3.07 ∅	South - 3.10 ∅	North - 3.33 ∅
	ii) Standard Deviation	Centre - 0.34 ∅	South - 0.54 ∅	North - 0.46 ∅
	iii) Skewness	Centre - 0.06 ∅	South - -0.20 ∅	North - 0.07 ∅
C. DUNE	i) Mean size	Centre - 2.90 ∅	North - 3.39 ∅	
	ii) Standard Deviation	Centre - 0.46 ∅	North - 0.34 ∅	
	iii) Skewness	Centre - 0.11 ∅	North - 0.03 ∅	

In the high-tide zone : The relative sizes of the sand in this zone from southern, central and northern parts of the beach indicate that the northern sediments are relatively finer than the southern and central region sediments. The relative coarser sediments in the southern and central part of the beach are due to the presence of creek, from which the streamlets emerge, bringing the sediment load and dumping in the high-tide zone. However, these sediments in the central zone are relatively more sorted than the northern and southern parts. This is because of the central zones which might be subjected to high energy conditions of the sea. The skewness values in the central and southern region reflect beach environment. The skewness values of northern region indicate dune environment and the mean size in this region being relatively finer than the southern and central region is because of the fact that this might be due to progression of the dune environment on the high tide zone. Therefore, relative finess of the sediments from the high tide zone of the northern part of the beach is because of the mixing of the dune environment with the high-tide environment. This is as well reflected by the presence of heavy minerals in the samples collected from the base of dune.

In the dune : The samples from the northern part are relatively much finer than the central part of the Newara beach. However, the relative sorting in the central region is higher than the northern region.

DISTRIBUTION OF HEAVY MINERALS : Representative samples from low-tide, high-tide, base of dune and dune were subjected to qualitative and quantitative determination of the relative weight percentages and population percentages of heavy minerals, light minerals and rock fragments in different size fractions. The samples are not only from different geomorphic features but also from different regions of the investigated area viz. southern, central and northern parts of the Newara beach.

The modal analysis adopted in the present investigation was carried on two broad catagories. The first one was to find the concentration of different minerals from the raw sand, for which 1000 grains were counted. Secondly, the concentration of individual heavy minerals was made by counting maximum 500 heavy mineral grains from each size fraction for 12 samples and wherever they are found less than 500 grains, all the grains were taken into account.

The tables 4.5a to 4.5d show the relavent data regarding the weight percentages and population percentages of different minerals in different size fractions from different environments. The graphic representation of different mineral concentration was made by using the above data and are shown in figures from 4.4a to 4.4d.

On examination of above said tables and figures in

TABLE NO. 4.5a : POPULATION PERCENTAGE OF DIFFERENT MINERALS IN

NEWARA SAND (LOW-TIDE ZONES)

Sample No.	Size Freq. (phi)	Weight Freq. (gms.)	Weight Per. (%)	Population Percentage Heavy Min.	Light Min.	Rock Frag.	Others
1. NW2	i.+1.75	00.2274	00.570	04.397	21.988	07.652	65.963
	ii.+2.75	05.9292	14.823	13.493	65.776	17.358	03.373
	iii.+3.25	28.1456	70.356	50.244	42.649	07.107	-
	iv.+3.75	05.1786	12.945	77.404	19.312	03.233	-
	v.+4.10	00.3129	00.782	95.880	-	-	-
	vi.+4.25	00.1847	00.462	100.000	-	-	-
	vii.+4.50	00.0349	00.0873	100.000	-	-	-
2. NW5	i.+1.75	01.3532	03.383	01.714	25.865	05.912	66.509
	ii.+2.75	03.1323	07.831	12.770	67.075	20.113	00.042
	iii.+3.25	24.1673	60.425	50.310	41.374	08.316	-
	iv.+3.75	08.3200	20.800	84.135	12.019	03.846	-
	v.+4.10	01.7845	04.460	95.265	04.735	-	-
	vi.+4.25	01.0200	02.550	100.000	-	-	-
	vii.+4.50	00.2200	00.550	100.000	-	-	-
3. NW9	i.+1.75	00.7222	01.880	04.154	30.462	09.693	55.691
	ii.+2.75	03.3139	08.290	15.088	60.352	24.258	00.308
	iii.+3.25	12.2251	30.560	50.921	40.899	08.180	-
	iv.+3.75	12.5566	31.390	79.639	15.928	04.433	-
	v.+4.10	09.3422	23.360	89.272	08.587	02.141	-
	vi.+4.25	01.8136	04.530	99.000	-	01.000	-
	vii.+4.50	00.0255	00.070	100.000	-	-	-
4. NW12	i.+1.75	06.2892	15.723	04.452	23.850	07.950	63.747
	ii.+2.75	16.0624	40.156	09.339	75.082	15.563	00.015
	iii.+3.25	14.3346	35.830	44.159	48.833	06.976	00.032
	iv.+3.75	02.4230	06.057	72.225	26.826	00.949	-
	v.+4.10	00.6149	01.537	83.738	06.505	09.758	-
	vi.+4.25	00.2758	00.690	100.000	-	-	-
	vii.+4.50	-	-	-	-	-	-

TABLE NO. 4.5b : POPULATION PERCENTAGE OF DIFFERENT MINERALS

IN NEWARA SAND (HIGH-TIDE ZONES)

Sample No.	Size Freq. (phi)	Weight Freq. (gms.)	Weight Per. (%)	Population Percentage Heavy Min.	Light Min.	Rock Frag.	Others
1. NW	i.+1.75	00.2757	05.900	10.881	50.780	10.954	27.385
3B	ii.+2.75	04.8808	12.204	20.488	79.495	00.016	-
	iii.+3.25	23.5149	58.796	53.158	42.590	04.253	-
	iv.+3.75	06.2884	15.720	95.414	01.406	03.180	-
	v.+4.10	03.8277	09.570	99.270	00.724	-	-
	vi.+4.25	01.0854	02.689	100.000	-	-	-
	vii.+4.50	00.1306	00.330	100.000	-	-	-
2. NW	i.+1.75	00.3173	00.793	09.455	31.516	18.909	40.120
6B	ii.+2.75	04.8232	12.062	16.794	62.407	20.733	00.066
	iii.+3.25	26.3904	65.995	50.397	45.774	03.829	-
	iv.+3.75	07.0997	17.754	84.520	14.212	01.268	-
	v.+4.10	01.0167	02.516	99.341	00.659	-	-
	vi.+4.25	00.3469	00.865	100.000	-	-	-
	vii.+4.50	00.0058	00.020	100.000	-	-	-
3. NW	i.+1.75	00.4941	01.235	06.072	48.573	14.572	30.783
10B	ii.+2.75	00.8697	02.174	09.199	75.888	13.798	01.115
	iii.+3.25	03.9814	09.953	47.722	50.234	02.245	-
	iv.+3.75	12.5318	31.330	84.040	03.192	12.768	-
	v.+4.10	19.4247	48.560	97.814	00.024	02.162	-
	vi.+4.25	02.6326	06.580	100.000	-	-	-
	vii.+4.50	00.0668	00.107	100.000	-	-	-
4. NW	i.+1.75	00.2918	00.729	03.427	51.405	10.898	34.270
13B	ii.+2.75	02.2178	05.540	06.763	68.437	13.526	11.272
	iii.+3.25	14.4661	36.180	41.476	55.302	03.222	-
	iv.+3.75	10.4115	26.030	80.680	04.817	14.503	-
	v.+4.10	10.5517	26.380	94.771	00.015	05.214	-
	vi.+4.25	02.0295	05.070	100.000	-	-	-
	vii.+4.50	00.0293	00.070	100.000	-	-	-

TABLE NO. 4.5c : POPULATION PERCENTAGE OF DIFFERENT MINERALS

IN NEWARA SAND (BASE OF DUNES)

Sample No.	Size Freq. (phi)	Weight Freq. (gms.)	Weight Per. (%)	Population Percentage Heavy Min.	Light Min.	Rock Frag.	Others
1. NW	i.+1.75	00.0649	00.162	06.163	69.183	15.408	09.245
4D	ii.+2.75	02.8758	07.189	13.068	69.546	17.386	-
	iii.+3.25	16.0413	40.100	43.637	56.105	00.257	-
	iv.+3.75	11.4208	28.550	82.488	07.005	10.507	-
	v.+4.10	07.8269	19.560	87.135	00.088	12.776	-
	vi.+4.25	01.5492	03.870	99.406	-	00.594	-
	vii.+4.50	00.2291	00.572	100.000	-	-	-
2. NW	i.+1.75	00.2423	00.060	12.381	62.856	16.508	08.254
7C	ii.+2.75	03.9307	09.830	15.264	63.602	19.081	02.053
	iii.+3.25	22.1053	55.780	50.238	45.238	04.524	-
	iv.+3.75	06.9985	17.500	84.304	01.407	14.289	-
	v.+4.10	05.8136	14.540	94.840	01.720	03.440	-
	vi.+4.25	00.8780	02.200	100.000	-	-	-
	vii.+4.50	00.0406	00.100	100.000	-	-	-
3. NW	i.+1.75	00.3918	01.000	12.762	51.046	25.523	10.669
14D	ii.+2.75	08.1231	20.310	12.311	75.094	12.595	-
	iii.+3.25	24.3006	60.250	49.381	49.381	01.237	-
	iv.+3.75	05.2817	13.650	95.026	00.974	04.000	-
	v.+4.10	01.4611	03.550	95.818	-	04.182	-
	vi.+4.25	00.4578	01.140	100.000	-	-	-
	vii.+4.50	00.0112	00.100	100.000	-	-	-
4. NW	i.+1.75	00.0064	00.020	10.938	68.750	15.625	04.688
17B	ii.+2.75	00.7298	01.820	13.702	82.214	02.740	01.343
	iii.+3.25	20.1273	50.320	47.200	50.316	02.484	-
	iv.+3.75	09.0399	22.600	88.606	00.332	11.062	-
	v.+4.10	07.7198	19.290	90.723	00.205	09.072	-
	vi.+4.25	02.3098	05.770	99.000	-	01.000	-
	vii.+4.50	00.0314	00.080	100.000	-	-	-
	viii.-4.50	00.0389	00.100	100.000	-	-	-

TABLE NO. 4.5d : POPULATION PERCENTAGE OF DIFFERENT MINERALS IN

NEWARA SAND (DUNES)

Sample No.	Size Freq. (phi)	Weight Freq. (gms.)	Weight Per. (%)	Population Percentage Heavy Min.	Light Min.	Rock Frag.	Others
1. NW	i.+1.75	00.0166	00.040	06.024	75.000	18.072	00.904
8B	ii.+2.75	05.8494	14.620	13.677	82.060	04.264	-
	iii.+3.25	28.3864	70.870	49.527	50.235	00.238	-
	iv.+3.75	04.0274	10.070	87.271	02.755	09.974	-
	v.+4.10	01.3273	03.320	94.176	-	05.824	-
	vi.+4.25	00.3853	00.963	99.739	-	00.261	-
	vii.+4.50	00.0076	00.120	100.000	-	-	-
2. NW	i.+1.75	00.0058	00.010	08.621	50.000	17.241	24.138
11B	ii.+2.75	01.5996	04.000	09.377	68.742	15.629	06.252
	iii.+3.25	16.3129	40.780	42.911	50.959	06.130	-
	iv.+3.75	09.5076	23.679	84.171	00.099	15.098	-
	v.+4.10	10.1080	25.270	95.902	-	04.098	-
	vi.+4.25	02.4402	06.100	99.009	-	00.990	-
	vii.+4.50	00.0101	00.030	100.000	-	-	-
	viii.-4.50	00.0158	00.040	100.000	-	-	-
3. NW	i.+1.75	00.0042	00.010	09.524	52.381	23.810	14.286
16G	ii.+2.75	00.8085	02.020	12.369	81.447	04.947	01.237
	iii.+3.25	14.0400	35.100	42.023	57.265	00.712	-
	iv.+3.75	09.2022	23.000	86.936	02.197	10.867	-
	v.+4.10	12.6400	31.600	94.937	00.316	04.787	-
	vi.+4.25	03.2892	08.220	99.720	-	00.280	-
	vii.+4.50	00.0186	00.052	100.000	-	-	-

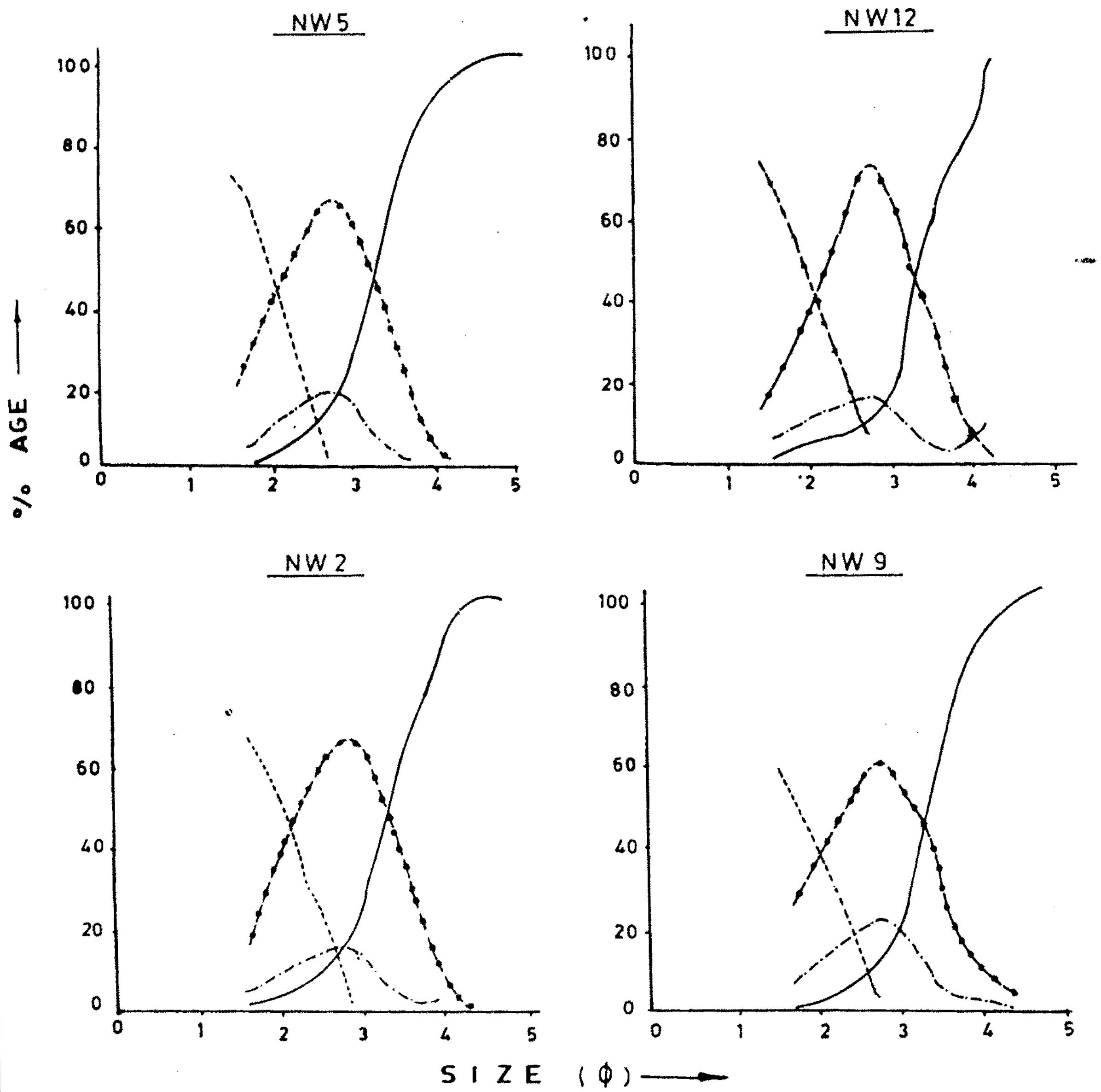


FIG. 4·4(a) DISTRIBUTION OF DIFFERENT MINERALS IN NEWARA SAND (LOW TIDE)

- HEAVY MINERALS
- LIGHT MINERALS
- ROCK FRAGMENTS
- OTHERS

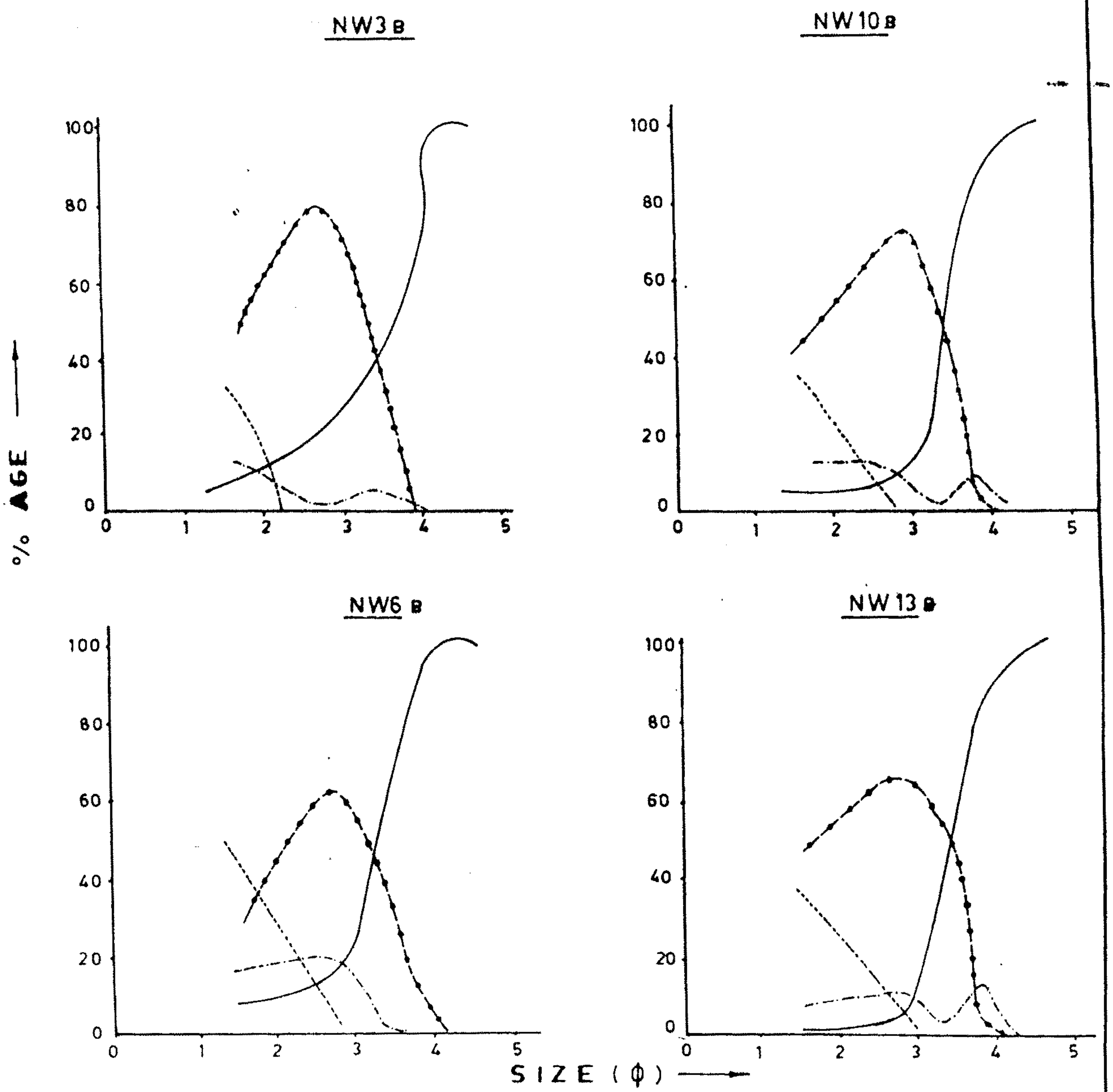


FIG 4·4b DISTRIBUTION OF MINERALS IN NEWARA SAND (HIGH TIDE)

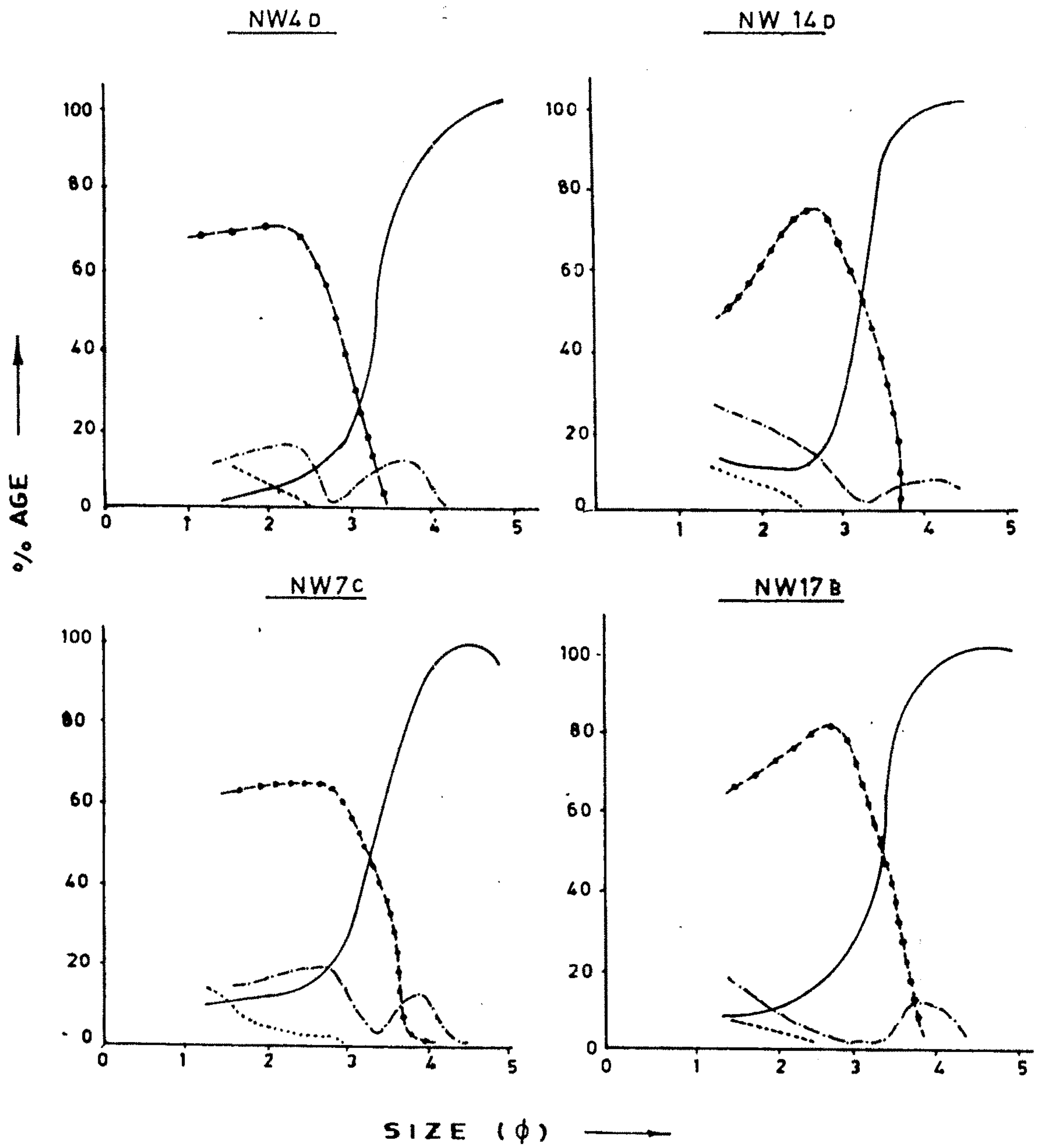


FIG. 4·4(c) DISTRIBUTION OF DIFFERENT MINERALS IN NEWARA SAND (BASE OF DUNE)

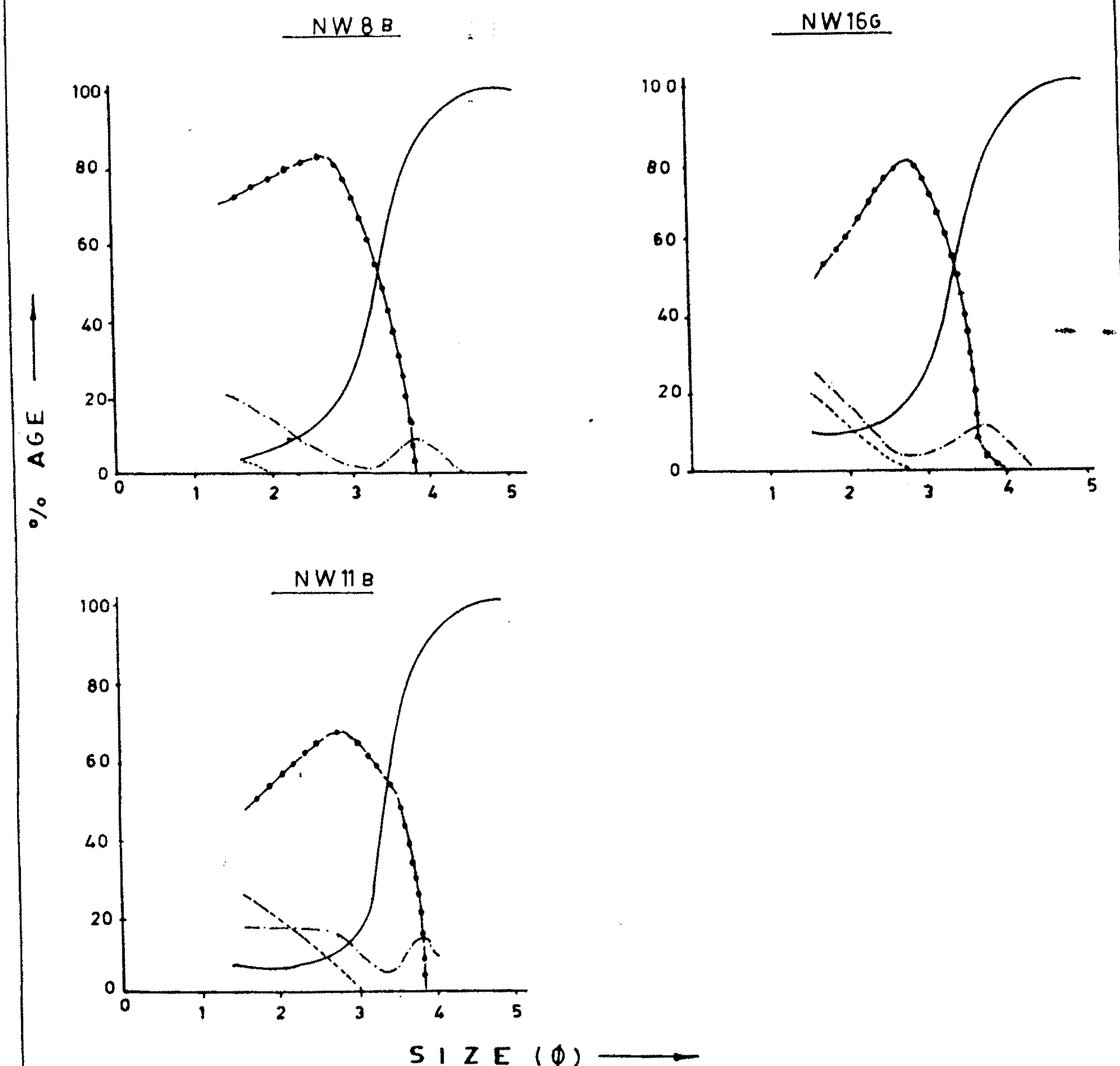


FIG. 4.4(d) DISTRIBUTION OF DIFFERENT MINERALS IN NEWARA SAND (DUNE)

most of the samples from different areas, it is noticed that the highest weight percentages of raw sand are found in plus 3.25 Ø size fraction. The population percentages of heavy minerals are noticed to be high with decrease in the grain-size and the light mineral population percentages are found to be relatively high in the coarse fraction. Considering the highest weight percentages in the size fraction plus 3.25 Ø and population percentages of heavy minerals in this size it can be inferred that this size fraction is most suitable for extracting the heavy minerals in large quantities.

The distribution of individual heavy minerals and their population weight percentages calculated are shown in the tables 4.6a to 4.6d. The figures 4.5a to 4.5g represent the distribution of these heavy minerals in different depositional environments.

On observation of the tables 4.6a to 4.6d and figures 4.5a to 4.5g, it is noticed that there is relatively greater concentration of ilmenite over the rest of the heavy minerals in all the sieve fractions and show a systematic increase in its concentration in the finer sieve fractions and decrease in the coarser sieve fraction. The heavy minerals with decreasing abundance are ilmenite, magnetite, hematite, limonite, laterite, leucoxene, rutile, tourmaline, zircon etc. It is found that the mineral of interest - ilmenite is less than 45% in plus 60 mesh fraction and about

TABLE NO.4.6a : THE FREQUENCY VARIATION OF DIFFERENT HEAVY MINERALS IN NEWARA BEACH SAND (LOW-TIDE ZONE)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
1) NW2	i) +1.75	Ilmenite	111	4.75	527.25	57.034
		Magnetite	45	5.20	234.00	25.312
		Hematite + Lat. + Limonite	18	5.00	90.00	9.736
		Rutile	6	4.20	25.20	2.726
		Others	12	4.00	48.00	5.920
			Σ(a)X(b) =		924.45	100.000
	ii) +2.75	Ilmenite	377	4.75	1790.75	74.147
		Magnetite	70	5.20	264.00	15.072
		Hematite + Lat. + Limonite	48	5.00	240.00	9.937
		Rutile	2	4.20	8.40	0.348
		Others	3	4.00	12.00	0.497
			Σ(a)X(b) =		2415.15	100.001
	iii) +3.25	Ilmenite	390	4.75	1852.50	76.737
		Magnetite	80	5.20	416.00	17.232
		Hematite + Lat. + Limonite	25	5.00	125.00	5.178
		Rutile	3	4.20	12.60	0.522
		Others	2	4.00	8.00	0.331
			Σ(a)X(b) =		2414.10	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
iv)	+3.75	Ilmenite	400	4.75	1904.00	78.675
		Magnetite	84	5.20	436.80	18.087
		Hematite + Lat. + Limonite	14	5.00	70.00	2.899
		Rutile	1	4.20	4.20	0.174
		Others	1	4.00	4.00	0.166
			Σ(a)X(b) =		2415.00	100.001
v)	+4.10	Ilmenite	410	4.75	1947.50	80.650
		Magnetite	87	5.20	452.40	18.730
		Hematite + Lat. + Limonite	3	5.00	15.00	0.620
		Rutile	-	4.20	-	-
		Others	-	4.00	-	-
			Σ(a)X(b) =		2414.90	100.000
vi)	+4.25	Ilmenite	411	4.75	1952.25	80.884
		Magnetite	86	5.20	447.20	18.528
		Hematite + Lat. + Limonite	2	5.00	10.00	0.414
		Rutile	1	4.20	4.20	0.174
		Others	-	4.00	-	-
			Σ(a)X(b) =		2413.65	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	vii) +4.50	Ilmenite	407	4.75	1933.25	80.043
		Magnetite	90	5.20	468.00	19.377
		Hematite + Lat. + Limonite	2	5.00	10.00	0.414
		Rutile	-	4.20	-	-
		Others	1	4.00	4.00	0.166
			Σ(a)X(b) =		2415.25	100.000
2)NW5	i) +1.75	Ilmenite	204	4.75	969.00	51.515
		Magnetite	84	5.20	436.80	23.222
		Hematite + Lat. + Limonite	54	5.00	270.00	14.354
		Rutile	6	4.20	25.20	1.340
		Others	45	4.00	180.00	9.569
			Σ(a)X(b) =		1881.00	100.000
	ii) +2.75	Ilmenite	407	4.75	1933.25	80.370
		Magnetite	63	5.20	327.60	13.619
		Hematite + Lat. + Limonite	24	5.00	120.00	4.989
		Rutile	3	4.20	12.60	0.524
		Others	3	4.00	12.00	0.500
			Σ(a)X(b) =		2405.45	100.002

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	iii) +3.25	Ilmenite	411	4.75	1952.25	81.104
		Magnetite	64	5.20	332.80	13.809
		Hematite + Lat. + Limonite	25	5.00	125.00	5.187
		Rutile	-	4.20	-	-
		Others	-	4.00	-	-
			Σ (a)X(b) =		2410.05	100.000
	iv) +3.75	Ilmenite	414	4.75	1966.50	81.798
		Magnetite	70	5.20	364.00	15.141
		Hematite + Lat. + Limonite	9	5.00	45.00	1.872
		Rutile	3	4.20	12.60	0.524
		Others	4	4.00	16.00	0.666
			Σ (a)X(b) =		2404.10	100.001
	v) +4.10	Ilmenite	422	4.75	2004.50	83.302
		Magnetite	73	5.20	379.60	15.775
		Hematite + Lat. + Limonite	2	5.00	10.00	0.416
		Rutile	1	4.20	4.20	0.175
		Others	2	4.00	8.00	0.332
			Σ (a)X(b) =		2406.30	100.002

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	vi) +4.25	Ilmenite	420	4.75	1995.00	82.581
		Magnetite	79	5.20	410.80	17.005
		Hematite + Lat. + Limonite	2	5.00	10.00	0.414
		Rutile	-	4.20	-	-
		Others	-	4.00	-	-
			Σ (a)X(b) =		2415.80	100.000
	vii) +4.50	Ilmenite	416	4.75	1976.00	81.424
		Magnetite	84	5.20	436.80	17.999
		Hematite + Lat. + Limonite	2	5.00	10.00	0.412
		Rutile	-	4.20	-	-
		Others	1	4.00	4.00	0.165
			Σ (a)X(b) =		2426.80	100.000
3) NW12	i) +1.75	Ilmenite	92	4.75	436.00	30.913
		Magnetite	84	5.20	436.80	30.970
		Hematite + Lat. + Limonite	81	5.00	405.00	28.715
		Rutile	3	4.20	12.60	0.893
		Others	30	4.00	120.00	8.508
			Σ (a)X(b) =		1410.40	99.999

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	ii) +2.75	Ilmenite	138	4.75	655.50	26.952
		Magnetite	149	5.20	774.80	31.857
		Hematite + Lat. + Limonite	149	5.00	745.00	30.632
		Rutile	4	4.20	16.80	0.691
		Others	60	4.00	240.00	9.868
			Σ (a)X(b) =		2432.10	100.000
	iii) +3.25	Ilmenite	393	4.75	1866.75	77.223
		Magnetite	92	5.20	478.40	19.790
		Hematite + Lat. + Limonite	12	5.00	60.00	2.482
		Rutile	1	4.20	4.20	0.174
		Others	2	4.00	8.00	0.331
			Σ (a)X(b) =		2417.35	100.000
	iv) +3.75	Ilmenite	404	4.75	1919.00	79.488
		Magnetite	89	5.20	462.80	19.170
		Hematite + Lat. + Limonite	4	5.00	20.00	0.828
		Rutile	2	4.20	8.40	0.348
		Others	1	4.00	4.00	0.166
			Σ (a)X(b) =		2414.20	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	v) +4.10	Ilmenite	420	4.75	1995.00	82.828
		Magnetite	76	5.20	395.20	16.408
		Hematite + Lat. + Limonite	2	5.00	10.00	0.415
		Rutile	2	4.20	8.40	0.349
		Others	-	4.00	-	-
			Σ(a)X(b) =		2408.60	100.000
	vi) +4.25	Ilmenite	421	4.75	1999.75	83.214
		Magnetite	69	5.20	358.80	14.930
		Hematite + Lat. + Limonite	4	5.00	20.00	0.832
		Rutile	3	4.20	12.60	0.524
		Others	3	4.00	12.00	0.499
			Σ(a)X(b) =		2403.15	99.999

TABLE NO.4.6b : THE FREQUENCY VARIATION OF DIFFERENT HEAVY MINERALS IN NEWARA BEACH SAND (HIGH-TIDE ZONE)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
1) NW3B	i) +1.75	Ilmenite	199	4.75	945.25	38.458
		Magnetite	166	5.20	863.20	35.120
		Hematite + Lat. + Limonite	108	5.00	540.00	21.970
		Rutile	7	4.20	29.40	1.196
		Others	20	4.00	80.00	3.255
			Σ(a)X(b) =		2457.85	99.999
	ii) +2.75	Ilmenite	380	4.75	1805.00	75.517
		Magnetite	69	5.20	358.80	15.001
		Hematite + Lat. + Limonite	21	5.00	105.00	4.393
		Rutile	7	4.20	29.40	1.230
		Others	23	4.00	92.00	3.849
			Σ(a)X(b) =		2390.20	99.990
	iii) +3.25	Ilmenite	400	4.75	1900.00	78.989
		Magnetite	73	5.20	379.60	15.781
		Hematite + Lat. + Limonite	17	5.00	85.00	3.534
		Rutile	4	4.20	16.80	0.698
		Others	6	4.00	24.00	0.998
			Σ(a)X(b) =		2405.40	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	iv) +3.75	Ilmenite	403	4.75	1949.25	79.421
		Magnetite	73	5.20	379.60	15.749
		Hematite + Lat. + Limonite	20	5.00	100.00	4.149
		Rutile	2	4.20	8.40	0.349
		Others	2	4.00	8.00	0.332
			Σ(a)X(b) =		2410.25	100.000
	v) +4.10	Ilmenite	411	4.75	1952.25	80.958
		Magnetite	80	5.20	416.00	17.251
		Hematite + Lat. + Limonite	7	5.00	35.00	1.451
		Rutile	1	4.20	4.20	0.174
		Others	1	4.00	4.00	0.166
			Σ(a)X(b) =		2411.45	100.000
	vi) +4.25	Ilmenite	430	4.75	2042.50	84.924
		Magnetite	68	5.20	353.60	14.702
		Hematite + Lat. + Limonite	1	5.00	5.00	0.208
		Rutile	-	4.20	-	-
		Others	1	4.00	4.00	0.166
			Σ(a)X(b) =		2405.10	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	vii) +4.50	Ilmenite	429	4.75	2037.75	84.668
		Magnetite	70	5.20	364.00	15.124
		Hematite + Lat. + Limonite	1	5.00	5.00	0.208
		Rutile	-	4.20	-	-
		Others	-	4.00	-	-
			Σ (a)X(b) =		2406.75	100.000
2) NW6B	i) +1.75	Ilmenite	171	4.75	812.25	39.718
		Magnetite	119	5.20	618.80	30.258
		Hematite + Lat. + Limonite	101	5.00	505.00	24.694
		Rutile	5	4.20	21.00	1.027
		Others	22	4.00	88.00	4.303
			Σ (a)X(b) =		2045.05	100.000
	ii) +2.75	Ilmenite	333	4.75	1581.75	5.014
		Magnetite	139	5.20	722.80	29.709
		Hematite + Lat. + Limonite	16	5.00	80.00	3.288
		Rutile	2	4.20	8.40	0.345
		Others	10	4.00	40.00	0.644
			Σ (a)X(b) =		2432.95	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
iii)	+3.25	Ilmenite	417	4.75	1980.75	83.171
		Magnetite	29	5.20	150.80	6.332
		Hematite + Lat. + Limonite	33	5.00	165.00	6.928
		Rutile	5	4.20	21.00	0.882
		Others	16	4.00	64.00	2.687
			Σ(a)X(b) =		2381.55	100.000
iv)	+3.75	Ilmenite	427	4.75	2028.25	84.834
		Magnetite	32	5.20	166.40	6.960
		Hematite + Lat. + Limonite	32	5.00	160.00	6.692
		Rutile	1	4.20	4.20	0.176
		Others	8	4.00	32.00	1.338
			Σ(a)X(b) =		2390.85	100.000
v)	+4.10	Ilmenite	428	4.75	2033.00	84.821
		Magnetite	39	5.20	202.80	8.461
		Hematite + Lat. + Limonite	29	5.00	145.00	6.050
		Rutile	-	4.20	-	-
		Others	4	4.00	16.00	0.668
			Σ(a)X(b) =		2396.80	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	vi) +4.25	Ilmenite	428	4.75	2033.00	85.170
		Magnetite	37	5.20	192.40	8.060
		Hematite + Lat. + Limonite	21	5.00	105.00	4.399
		Rutile	3	4.20	12.60	0.528
		Others	11	4.00	44.00	1.843
			Σ(a)X(b) =		2387.00	100.000
	vii) +4.50	Ilmenite	431	4.75	2047.25	85.867
		Magnetite	33	5.20	171.60	7.197
		Hematite + Lat. + Limonite	21	5.00	105.00	4.404
		Rutile	2	4.20	8.40	0.352
		Others	13	4.00	52.00	2.181
			Σ(a)X(b) =		2384.25	100.001
3) NW 13B	i) +1.75	Ilmenite	190	4.75	902.50	46.653
		Magnetite	111	5.20	577.20	29.837
		Hematite + Lat. + Limonite	62	5.00	310.00	16.025
		Rutile	4	4.20	16.80	0.868
		Others	32	4.00	128.00	6.617
			Σ(a)X(b) =		1934.50	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	ii) +2.75	Ilmenite	222	4.75	1054.50	44.119
		Magnetite	112	5.20	582.40	24.367
		Hematite + Lat. + Limonite	89	5.00	445.00	18.618
		Rutile	1	4.20	4.20	0.175
		Others	76	4.00	304.00	12.719
			Σ(a)X(b) =		2390.10	99.998
	iii) +3.25	Ilmenite	389	4.75	1847.75	76.431
		Magnetite	88	5.20	457.60	18.928
		Hematite + Lat. + Limonite	20	5.00	100.00	4.136
		Rutile	1	4.20	4.20	0.174
		Others	2	4.00	8.00	0.331
			Σ(a)X(b) =		2417.55	100.000
	iv) +3.75	Ilmenite	401	4.75	1904.75	78.794
		Magnetite	99	5.20	483.60	20.006
		Hematite + Lat. + Limonite	5	5.00	25.00	1.034
		Rutile	-	4.20	-	-
		Others	1	4.00	4.00	0.165
			Σ(a)X(b) =		2417.35	99.999

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	v) +4.10	Ilmenite	413	4.75	1961.75	81.375
		Magnetite	79	5.20	410.80	17.040
		Hematite + Lat. + Limonite	6	5.00	30.00	1.244
		Rutile	1	4.20	4.20	0.174
		Others	1	4.00	4.00	0.166
			Σ(a)X(b) =		2410.75	99.999
	vi) +4.25	Ilmenite	422	4.75	2004.50	83.233
		Magnetite	74	5.20	384.80	15.978
		Hematite + Lat. + Limonite	3	5.00	15.00	0.623
		Rutile	-	4.20	-	-
		Others	1	4.00	4.00	0.166
			Σ (a)X(b) =		2408.30	100.000
	vii) +4.50	Ilmenite	418	4.75	1985.50	82.492
		Magnetite	71	5.20	369.20	15.339
		Hematite + Lat. + Limonite	8	5.00	40.00	1.662
		Rutile	1	4.20	4.20	0.174
		Others	2	4.00	8.00	0.332
			Σ(a)X(b) =		2406.90	99.999

TABLE NO.4.6c : THE FREQUENCY VARIATION OF DIFFERENT HEAVY MINERALS IN NEWARA BEACH SAND (BASE OF DUNE)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
1) NW4D	i) +1.75	Ilmenite	205	4.75	973.75	46.699
		Magnetite	89	5.20	462.80	22.195
		Hematite + Lat. + Limonite	72	5.00	360.00	17.265
		Rutile	3	4.20	12.60	0.604
		Others	69	4.00	276.00	13.236
			Σ(a)X(b) =		2085.15	99.999
	ii) +2.75	Ilmenite	390	4.75	1825.50	77.348
		Magnetite	66	5.20	343.20	14.542
		Hematite + Lat. + Limonite	15	5.00	75.00	3.178
		Rutile	2	4.20	8.40	0.356
		Others	27	4.00	108.00	4.576
			Σ(a)X(b) =		2360.10	100.000
	iii) +3.25	Ilmenite	402	4.75	1909.50	79.619
		Magnetite	71	5.20	369.20	15.394
		Hematite + Lat. + Limonite	11	5.00	55.00	2.293
		Rutile	3	4.20	12.60	0.525
		Others	13	4.00	52.00	2.168
			Σ(a)X(b) =		2398.30	99.999

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	iv) +3.75	Ilmenite	403	4.75	1914.25	79.859
		Magnetite	67	5.20	348.40	14.535
		Hematite + Lat. + Limonite	14	5.00	70.00	2.923
		Rutile	2	4.20	18.40	0.350
		Others	14	4.00	56.00	2.336
			Σ(a)X(b) =		2395.05	100.003
	v) +4.10	Ilmenite	413	4.75	1961.75	81.416
		Magnetite	78	5.20	405.60	16.833
		Hematite + Lat. + Limonite	6	5.00	30.00	1.245
		Rutile	1	4.20	4.20	0.174
		Others	2	4.00	8.00	0.332
			Σ(a)X(b) =		2409.55	100.000
	vi) +4.25	Ilmenite	421	4.75	1999.75	83.318
		Magnetite	61	5.20	317.20	13.216
		Hematite + Lat. + Limonite	11	5.00	55.00	2.292
		Rutile	1	4.20	4.20	0.175
		Others	6	4.00	24.00	0.999
			Σ(a)X(b) =		2400.15	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	vii) +4.50	Ilmenite	433	4.75	2056.75	85.578
		Magnetite	63	5.20	327.60	13.631
		Hematite + Lat. + Limonite	3	5.00	15.00	0.624
		Rutile	-	4.20	-	-
		Others	1	4.00	4.00	0.166
			Σ (a)X(b) =		2403.35	99.999
2) NW7C	i) +1.75	Ilmenite	191	4.75	907.25	36.796
		Magnetite	120	5.20	624.00	25.308
		Hematite + Lat. + Limonite	178	5.00	890.00	36.096
		Rutile	2	4.20	8.40	0.341
		Others	9	4.00	36.00	1.460
			Σ (a)X(b) =		2465.65	100.001
	ii) +2.75	Ilmenite	359	4.75	1705.25	70.289
		Magnetite	101	5.20	525.20	21.648
		Hematite + Lat. + Limonite	35	5.00	175.00	7.213
		Rutile	3	4.20	12.60	0.519
		Others	2	4.00	8.00	0.330
			Σ (a)X(b) =		2426.05	99.999

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
iii)	+3.25	Ilmenite	408	4.75	1938.00	80.448
		Magnetite	69	5.20	358.80	14.894
		Hematite + Lat. + Limonite	20	5.00	100.00	4.151
		Rutile	1	4.20	4.20	0.174
		Others	2	4.00	8.00	0.332
			Σ(a)X(b) =		2409.00	99.999
iv)	+3.75	Ilmenite	411	4.75	1952.25	81.322
		Magnetite	60	5.20	312.00	12.996
		Hematite + Lat. + Limonite	20	5.00	100.00	4.166
		Rutile	2	4.20	8.40	0.350
		Others	7	4.00	28.00	1.166
			Σ(a)X(b) =		2400.65	100.000
v)	+4.10	Ilmenite	416	4.75	1976.00	82.189
		Magnetite	66	5.20	343.20	14.275
		Hematite + Lat. + Limonite	13	5.00	65.00	2.704
		Rutile	-	4.20	-	-
		Others	5	4.00	20.00	0.832
			Σ(a)X(b) =		2404.20	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	vi) +4.25	Ilmenite	425	4.75	2018.75	84.081
		Magnetite	60	5.20	312.00	12.995
		Hematite + Lat. + Limonite	10	5.00	50.00	2.083
		Rutile	1	4.20	4.20	0.175
		Others	4	4.00	16.00	0.666
			Σ(a)X(b) =		2400.95	100.000
	vii) +4.50	Ilmenite	423	4.75	2009.25	83.794
		Magnetite	62	5.20	322.40	13.445
		Hematite + Lat. + Limonite	6	5.00	30.00	1.251
		Rutile	1	4.20	4.20	0.175
		Others	8	4.00	32.00	1.335
			Σ(a)X(b) =		2397.85	100.000
3) NW 17B	i) +1.75	Ilmenite	131	4.75	622.25	26.299
		Magnetite	118	5.20	613.60	25.934
		Hematite + Lat. + Limonite	125	5.00	625.00	26.415
		Rutile	6	4.20	25.20	1.065
		Others	120	4.00	480.00	20.287
			Σ(a)X(b) =		2366.05	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	ii) +2.75	Ilmenite	268	4.75	1273.00	52.962
		Magnetite	102	5.20	530.00	22.067
		Hematite + Lat. + Limonite	79	5.00	395.00	16.434
		Rutile	6	4.20	25.20	1.048
		Others	45	4.00	180.00	7.489
			Σ(a)X(b) =		2403.60	100.000
	iii) +3.25	Ilmenite	358	4.75	1700.50	69.873
		Magnetite	131	5.20	681.20	27.990
		Hematite + Lat. + Limonite	8	5.00	40.00	1.644
		Rutile	-	4.20	-	-
		Others	3	4.00	12.00	0.493
			Σ(a)X(b) =		2433.70	100.000
	iv) +3.75	Ilmenite	388	4.75	1823.60	75.718
		Magnetite	102	5.20	530.40	22.023
		Hematite + Lat. + Limonite	6	5.00	30.00	1.246
		Rutile	2	4.20	8.40	0.349
		Others	4	4.00	16.00	0.664
			Σ(a)X(b) =		2408.40	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
v)	+4.10	Ilmenite	396	4.75	1881.00	77.979
		Magnetite	96	5.20	499.20	20.695
		Hematite + Lat. + Limonite	-	5.00	-	-
		Rutile	-	4.20	-	-
		Others	8	4.00	32.00	1.327
			Σ(a)X(b) =		2412.20	100.001
vi)	+4.25	Ilmenite	404	4.75	1919.00	79.972
		Magnetite	71	5.20	369.20	15.386
		Hematite + Lat. + Limonite	11	5.00	55.00	2.292
		Rutile	2	4.20	8.40	0.350
		Others	12	4.00	48.00	2.000
			Σ(a)X(b) =		2399.60	100.000
vii)	+4.50	Ilmenite	399	4.75	1895.25	78.875
		Magnetite	72	5.20	374.40	15.581
		Hematite + Lat. + Limonite	17	5.00	85.00	3.537
		Rutile	1	4.20	4.20	0.175
		Others	11	4.00	44.00	1.831
			Σ(a)X(b) =		2402.85	99.999

TABLE NO.4.6d : THE FREQUENCY VARIATION OF DIFFERENT HEAVY MINERALS IN NEWARA BEACH SAND (DUNE)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
1) NW8B	i) +1.75	Ilmenite	103	4.75	489.25	33.984
		Magnetite	90	5.20	468.00	32.508
		Hematite + Lat. + Limonite	66	5.00	330.00	22.922
		Rutile	2	4.20	8.40	0.583
		Others	36	4.00	144.00	10.002
			Σ(a)X(b) =		1439.65	99.999
	ii) +2.75	Ilmenite	189	4.75	897.75	37.064
		Magnetite	127	5.20	660.40	27.265
		Hematite + Lat. + Limonite	127	5.00	635.00	26.216
		Rutile	5	4.20	21.00	0.867
		Others	52	4.00	208.00	8.587
			Σ(a)X(b) =		2422.15	99.999
	iii) +3.25	Ilmenite	301	4.75	1429.75	60.425
		Magnetite	114	5.20	529.80	22.391
		Hematite + Lat. + Limonite	66	5.00	330.00	13.947
		Rutile	3	4.20	12.60	0.533
		Others	16	4.00	64.00	2.705
			Σ(a)X(b) =		2366.15	100.001

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
iv)	+3.75	Ilmenite	361	4.75	1714.75	71.551
		Magnetite	77	5.20	400.40	16.707
		Hematite + Lat. + Limonite	33	5.00	165.00	6.885
		Rutile	2	4.20	8.40	0.351
		Others	27	4.00	108.00	4.506
			Σ(a)X(b) =		2396.55	100.000
v)	+4.10	Ilmenite	396	4.75	1881.00	78.329
		Magnetite	68	5.20	353.60	14.725
		Hematite + Lat. + Limonite	22	5.00	110.00	4.581
		Rutile	4	4.20	16.80	0.700
		Others	10	4.00	40.00	1.666
			Σ(a)X(b) =		2401.40	100.001
vi)	+4.25	Ilmenite	401	4.75	1904.75	79.004
		Magnetite	66	5.20	343.20	14.235
		Hematite + Lat. + Limonite	31	5.00	155.00	6.429
		Rutile	-	4.20	-	-
		Others	2	4.00	8.00	0.332
			Σ(a)X(b) =		2410.95	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	vii) +4.50	Ilmenite	400	4.75	1900.00	79.305
		Magnetite	44	5.20	228.80	9.550
		Hematite + Lat. + Limonite	43	5.00	215.00	8.974
		Rutile	-	4.20	-	-
		Others	13	4.00	52.00	2.170
			Σ(a)X(b) =		2395.80	99.999
2) NW 11B	i) +1.75	Ilmenite	116	4.75	551.00	49.649
		Magnetite	77	5.20	400.40	36.079
		Hematite + Lat. + Limonite	26	5.00	130.00	11.714
		Rutile	2	4.20	8.40	0.757
		Others	5	4.00	20.00	1.802
			Σ(a)X(b) =		1109.80	100.001
	ii) +2.75	Ilmenite	268	4.75	1273.00	52.750
		Magnetite	129	5.20	670.08	27.766
		Hematite + Lat. + Limonite	57	5.00	285.00	11.810
		Rutile	6	4.20	25.20	1.044
		Others	40	4.00	160.00	6.630
			Σ(a)X(b) =		2413.28	100.000

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
iii)	+3.25	Ilmenite	361	4.75	1714.75	69.707
		Magnetite	115	5.20	598.00	24.309
		Hematite + Lat. + Limonite	21	5.00	105.00	4.268
		Rutile	1	4.20	4.20	0.171
		Others	2	4.00	8.00	0.545
			Σ(a)X(b) =		2459.95	100.000
iv)	+3.75	Ilmenite	366	4.75	1738.50	72.062
		Magnetite	72	5.20	374.40	15.519
		Hematite + Lat. + Limonite	51	5.00	255.00	10.570
		Rutile	3	4.20	12.60	0.522
		Others	8	4.00	32.00	1.326
			Σ(a)X(b) =		2412.50	99.999
v)	+4.10	Ilmenite	388	4.75	1843.00	76.517
		Magnetite	61	5.20	1317.20	13.169
		Hematite + Lat. + Limonite	44	5.00	220.00	9.134
		Rutile	2	4.20	8.40	0.349
		Others	5	4.00	20.00	0.830
			Σ(a)X(b) =		2408.60	99.999

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
	vi) +4.25	Ilmenite	397	4.75	1885.75	78.151
		Magnetite	71	5.20	369.20	15.301
		Hematite + Lat. + Limonite	30	5.00	150.00	6.216
		Rutile	-	4.20	-	-
		Others	2	4.00	8.00	0.332
			Σ(a)X(b) =		2412.95	100.000
	vii) +4.50	Ilmenite	427	4.75	2028.25	84.452
		Magnetite	47	5.20	244.40	10.176
		Hematite + Lat. + Limonite	25	5.00	125.00	5.205
		Rutile	-	4.20	-	-
		Others	1	4.00	4.00	0.167
			Σ(a)X(b) =		2401.65	100.000
3) NW 16G	i) +1.75	Ilmenite	101	4.75	479.75	41.879
		Magnetite	81	5.20	421.20	36.768
		Hematite + Lat. + Limonite	32	5.00	160.00	13.967
		Rutile	3	4.20	12.60	1.100
		Others	18	4.00	72.00	6.285
			Σ(a)X(b) =		1145.55	99.999

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
ii)	+2.75	Ilmenite	250	4.75	1187.50	48.594
		Magnetite	139	5.20	722.80	29.578
		Hematite + Lat. + Limonite	89	5.00	445.00	18.210
		Rutile	2	4.20	8.40	0.344
		Others	20	4.00	80.00	3.274
			Σ(a)X(b) =		2443.70	100.000
iii)	+3.25	Ilmenite	322	4.75	1529.70	62.829
		Magnetite	128	5.20	665.60	27.338
		Hematite + Lat. + Limonite	39	5.00	195.00	8.009
		Rutile	2	4.20	8.40	0.345
		Others	9	4.00	36.00	1.479
			Σ(a)X(b) =		2434.70	100.000
iv)	+3.75	Ilmenite	342	4.75	1624.50	66.904
		Magnetite	117	5.20	608.40	25.057
		Hematite + Lat. + Limonite	31	5.00	155.00	6.384
		Rutile	1	4.20	4.20	0.173
		Others	9	4.00	36.00	1.483
			Σ(a)X(b) =		2428.10	100.001

(Cont...)

Sample No.	Sieve Size (Phi)	Mineral Variety	Grain Count (a)	Relative Density (b)	(a)X(b) (c)	% of Fraction
v)	+4.10	Ilmenite	371	4.75	1762.25	72.699
		Magnetite	99	5.20	514.80	21.237
		Hematite + Lat. + Limonite	27	5.00	135.00	5.569
		Rutile	-	4.20	-	-
		Others	3	4.00	12.00	0.495
			Σ(a)X(b) =		2424.05	100.000
vi)	+4.25	Ilmenite	386	4.75	1833.50	76.152
		Magnetite	76	5.20	395.20	16.414
		Hematite + Lat. + Limonite	27	5.00	135.00	5.607
		Rutile	-	4.20	-	-
		Others	11	4.00	44.00	1.827
			Σ(a)X(b) =		2407.70	100.000
vii)	+4.50	Ilmenite	389	4.75	1847.75	76.640
		Magnetite	66	5.20	343.20	14.235
		Hematite + Lat. + Limonite	40	5.00	200.00	8.295
		Rutile	-	4.20	-	-
		Others	5	4.00	20.00	0.830
			Σ(a)X(b) =		2410.95	100.000

FIG.45(a) HEAVY MINERAL DISTRIBUTION IN DIFFERENT LEVELS (60 #)

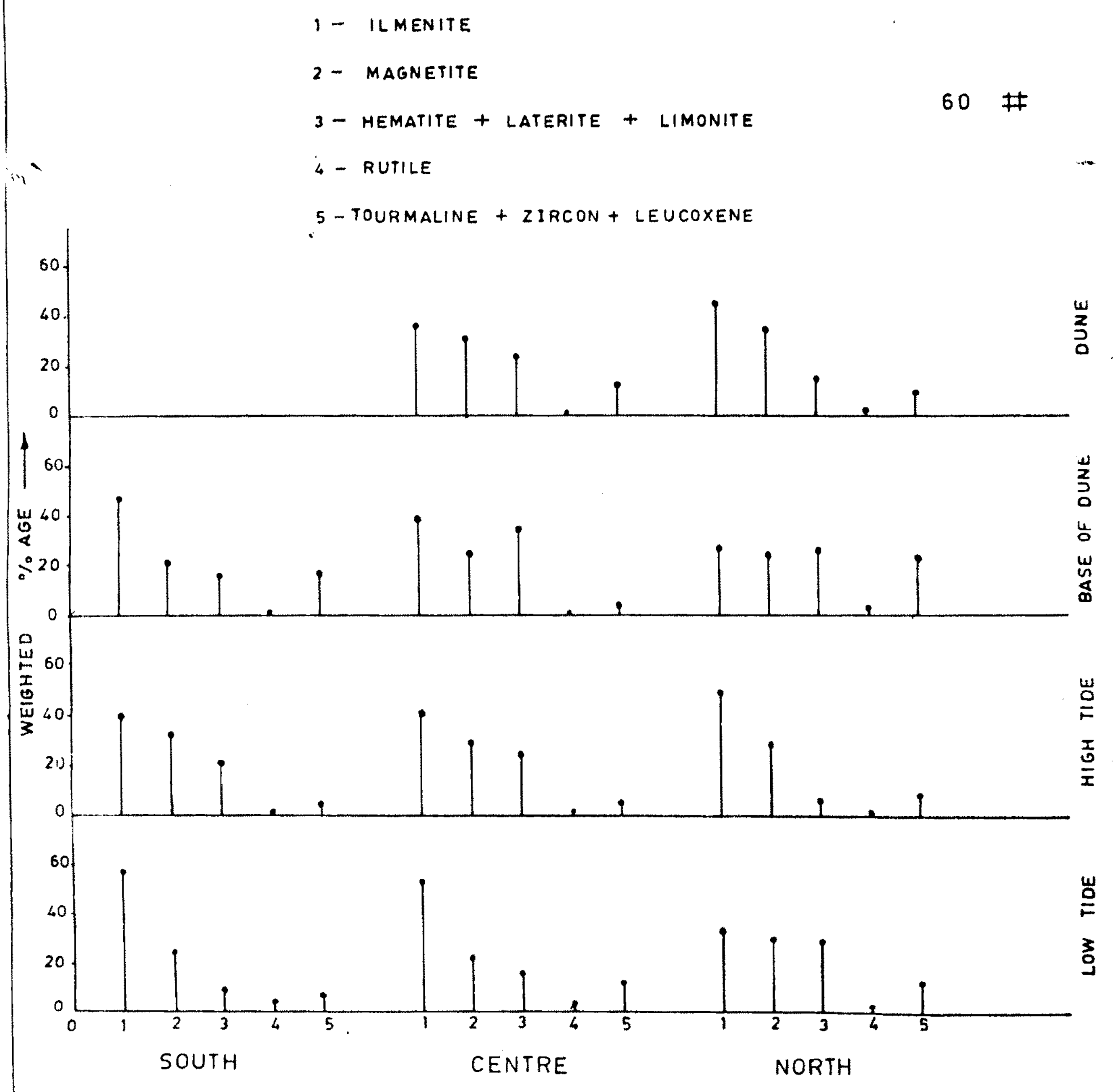


FIG 4·5(b) HEAVY MINERAL DISTRIBUTION IN DIFFERENT LEVELS (100 #)

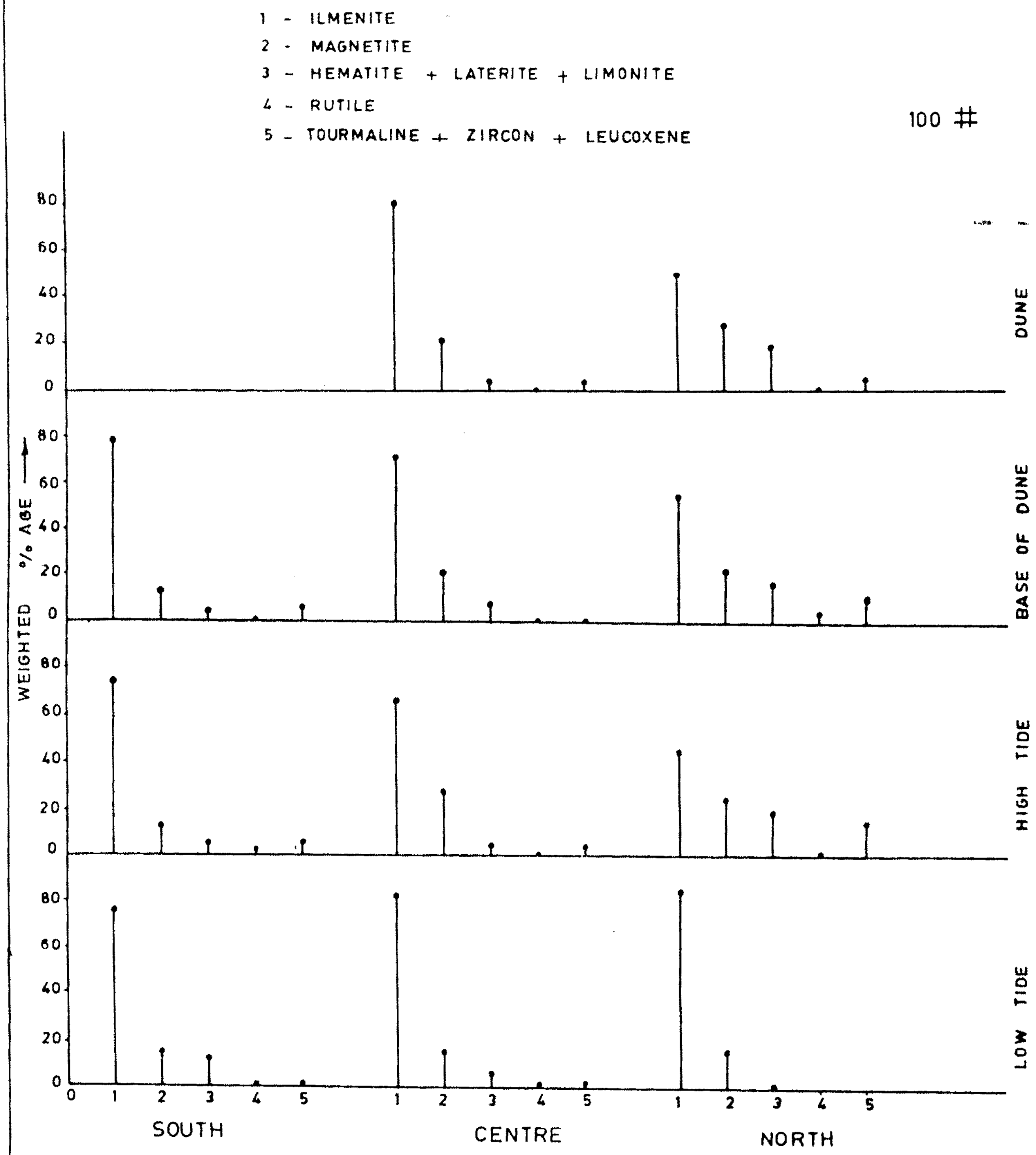
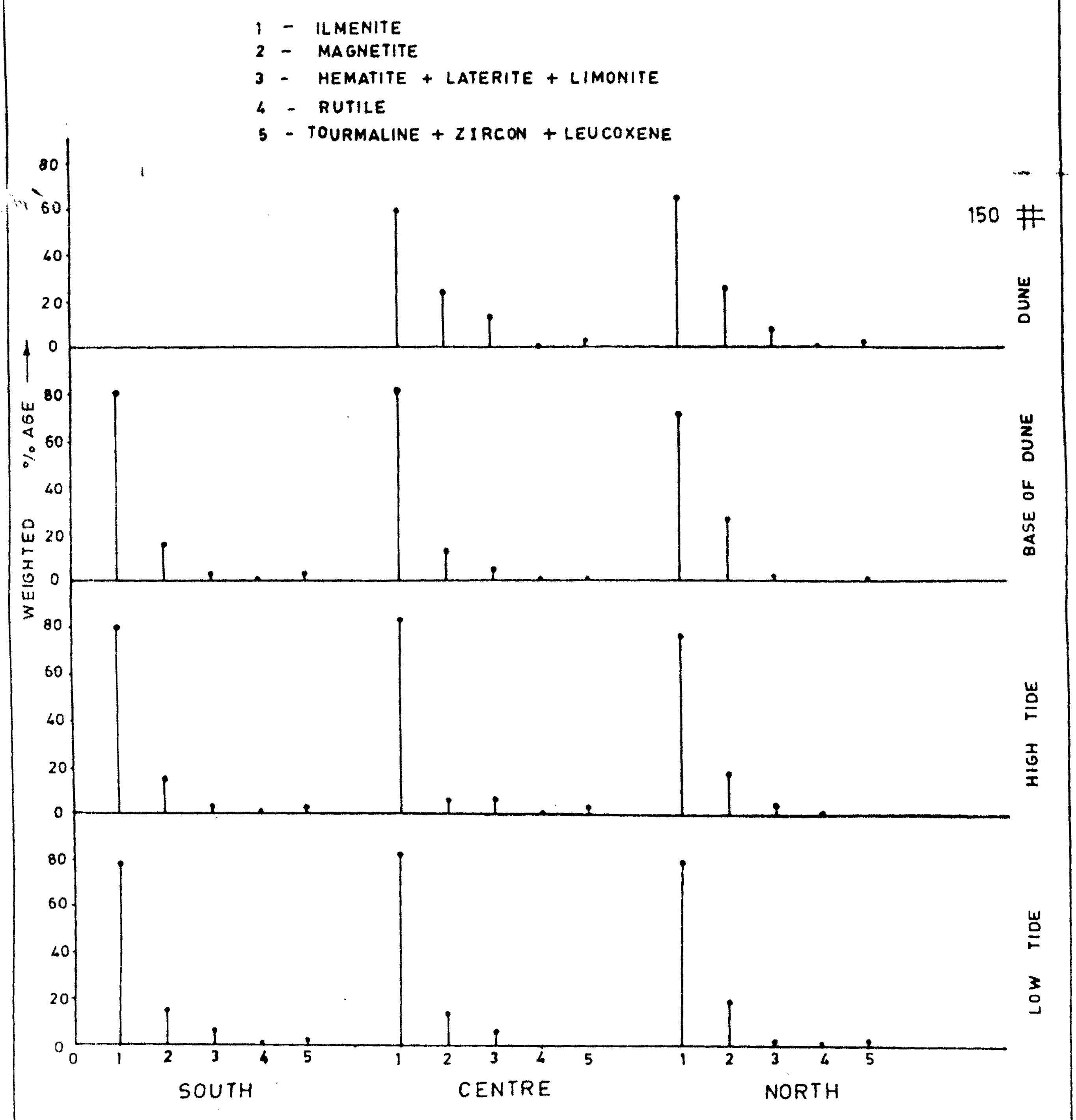


FIG.4·5(c)HEAVY MINERAL DISTRIBUTION IN DIFFERENT LEVELS (150 #)



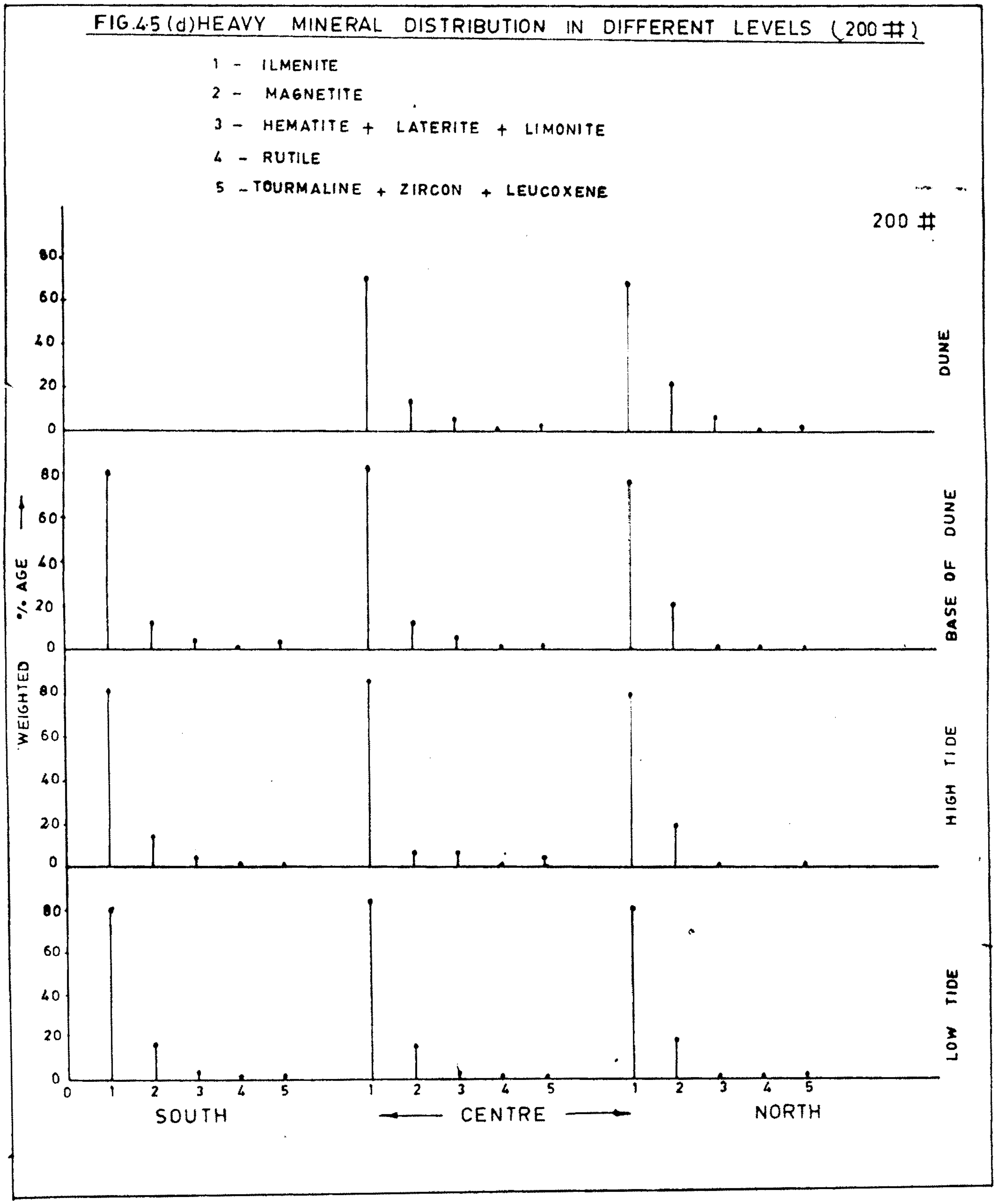
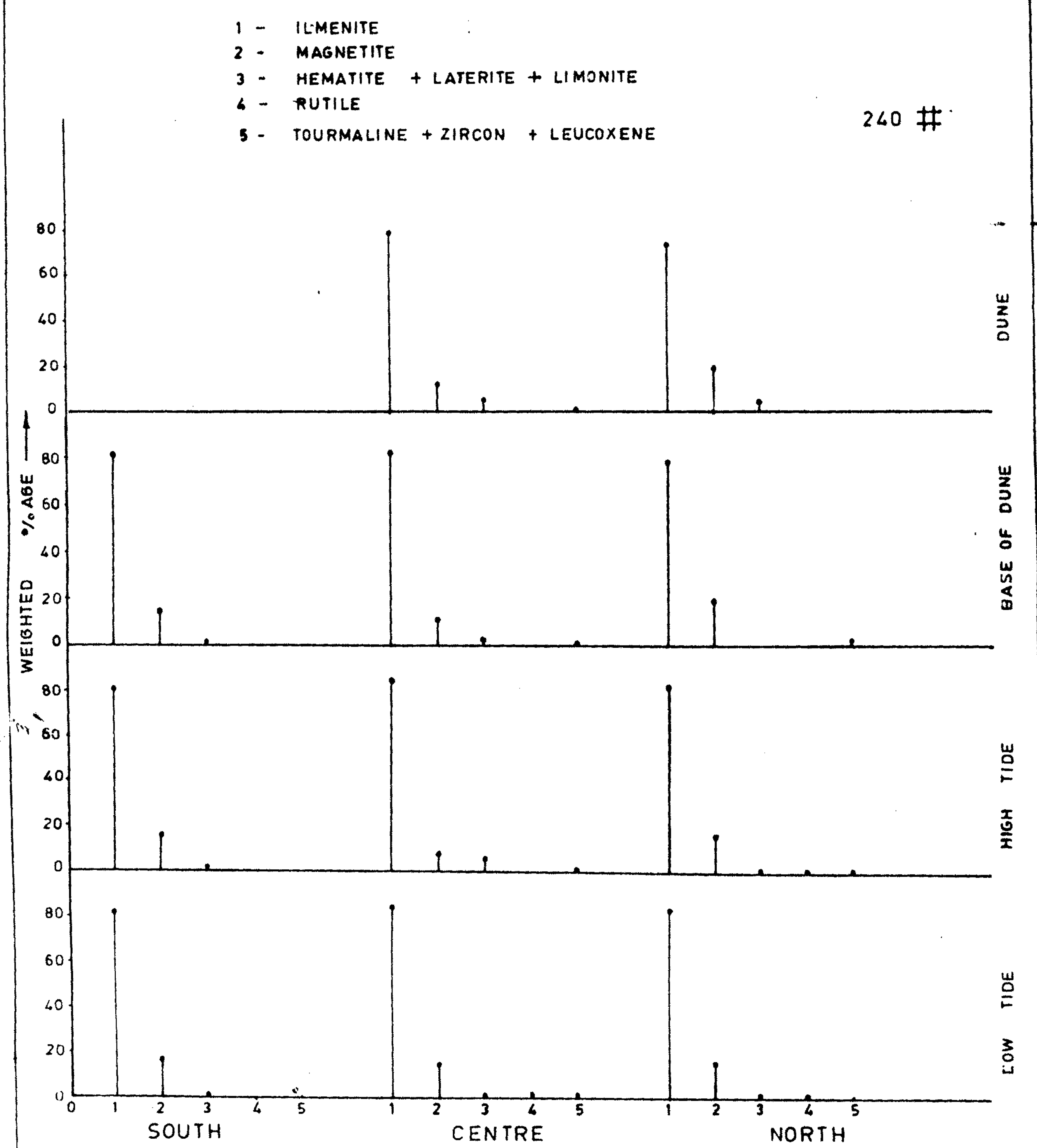


FIG.4.5 (d) HEAVY MINERAL DISTRIBUTION IN DIFFERENT LEVELS (200 #)
1 - ILMENITE
2 - MAGNETITE
3 - HEMATITE + LATERITE + LIMONITE
4 - RUTILE
5 - TOURMALINE + ZIRCON + LEUCOXENE
200 #
WEIGHTED % AGE
DUNE
BASE OF DUNE
HIGH TIDE
LOW TIDE
0
20
40
60
80
1
2
3
4
5
SOUTH
CENTRE
NORTH

FIG. 4.5(e) HEAVY MINERAL DISTRIBUTION IN DIFFERENT LEVELS (240#)



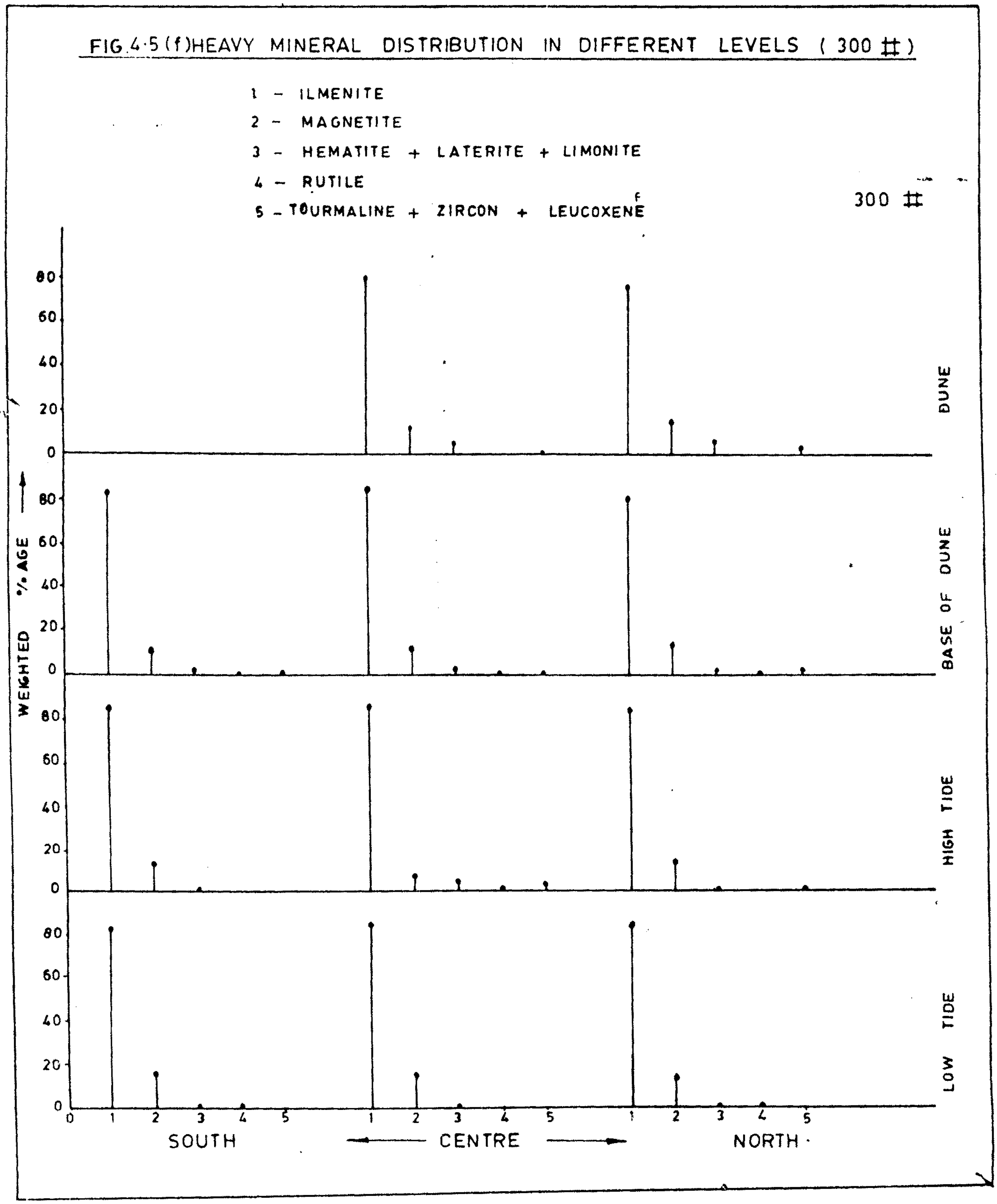
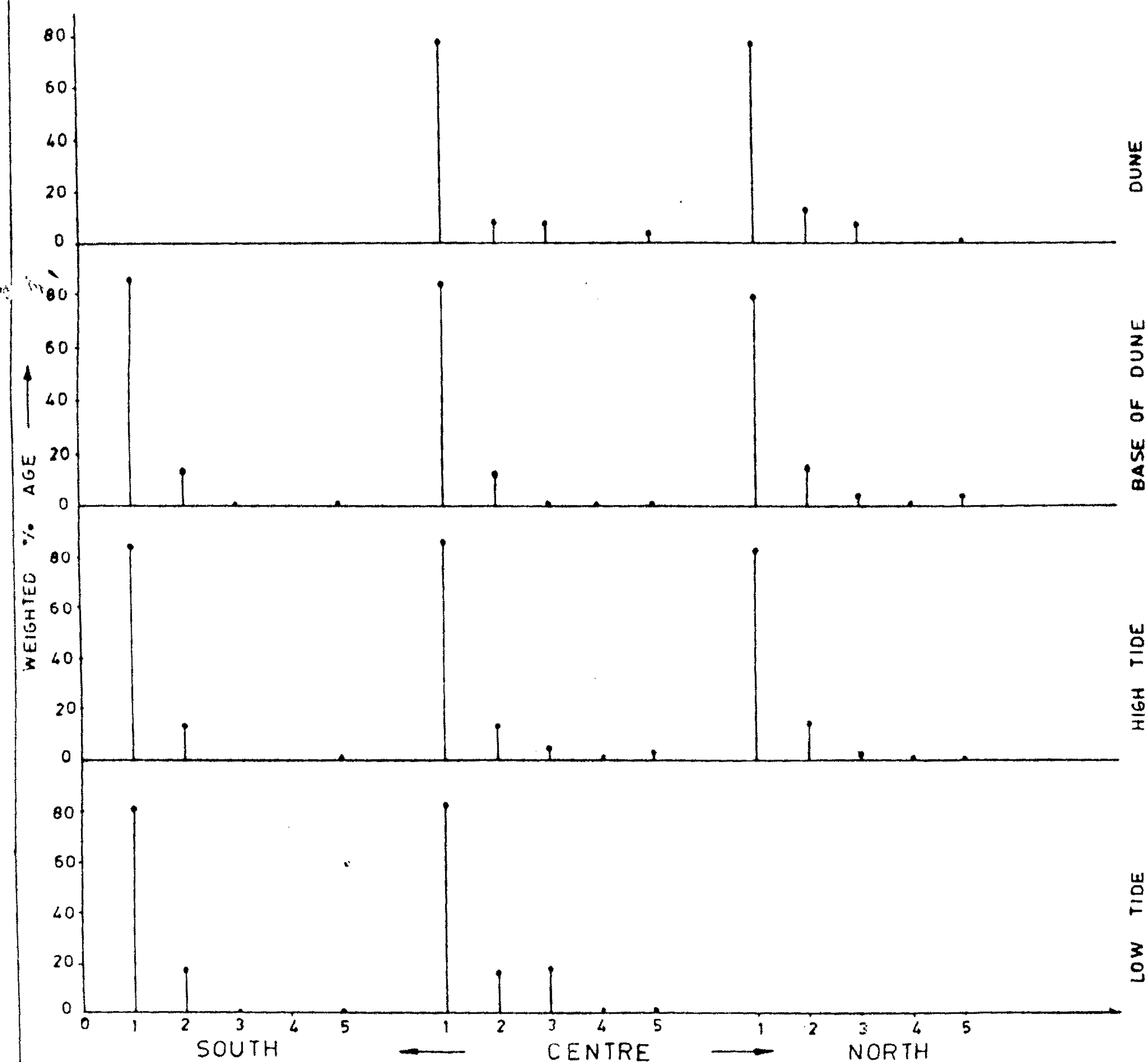


FIG.4·5(f)HEAVY MINERAL DISTRIBUTION IN DIFFERENT LEVELS (300 #)
1 - ILMENITE
2 - MAGNETITE
3 - HEMATITE + LATERITE + LIMONITE
4 - RUTILE
5 - TOURMALINE + ZIRCON + LEUCOXENE
300 #
WEIGHTED %AGE
80
60
40
20
0
DUNE
BASE OF DUNE
HIGH TIDE
LOW TIDE
0 1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
SOUTH
CENTRE
NORTH

FIG. 4·5(g) HEAVY MINERAL DISTRIBUTION IN DIFFERENT LEVELS (350 #)

1 – ILMENITE
2 – MAGNETITE
3 – HEMATITE + LATERITE + LIMONITE
4 – RUTILE
5 – TOURMALINE + ZIRCON + LEUCOXENE

350 #



80% in the other finer fractions. No systematic relationship could be established for the other heavy minerals.

On observation of the pie diagrams (Fig. 4.6 and 4.7) it is also found that the ilmenite shows the higher concentration in the southern and the central regions of the Newara beach. This observation is supported by higher bulk density measurements of the raw sands of these regions. It may be recalled that the bulk density measurements have indicated the productive zone of the strike length of 1300 meters and width of 80 meters in the region of higher ilmenite and magnetite concentration. The concentration of ilmenite in the northern region is relatively less than the southern region of the Newara beach. Apart from such observations, it is also noticed that the ilmenite shows a progressive decrease from low tide to the dune environments in the central and the vicinity of central zone towards south, thereby, indicating the selective deposition and enrichment of ilmenite in the regions of low tide to base of dune.

SOURCE FOR THE HEAVY MINERALS : In the present investigation, attempt has been made in not only demarkating the area of heavy mineral concentration in the Newara beach but also in understanding the source and processes responsible for their enrichment.

As mentioned earlier in the chapter III, Deccan

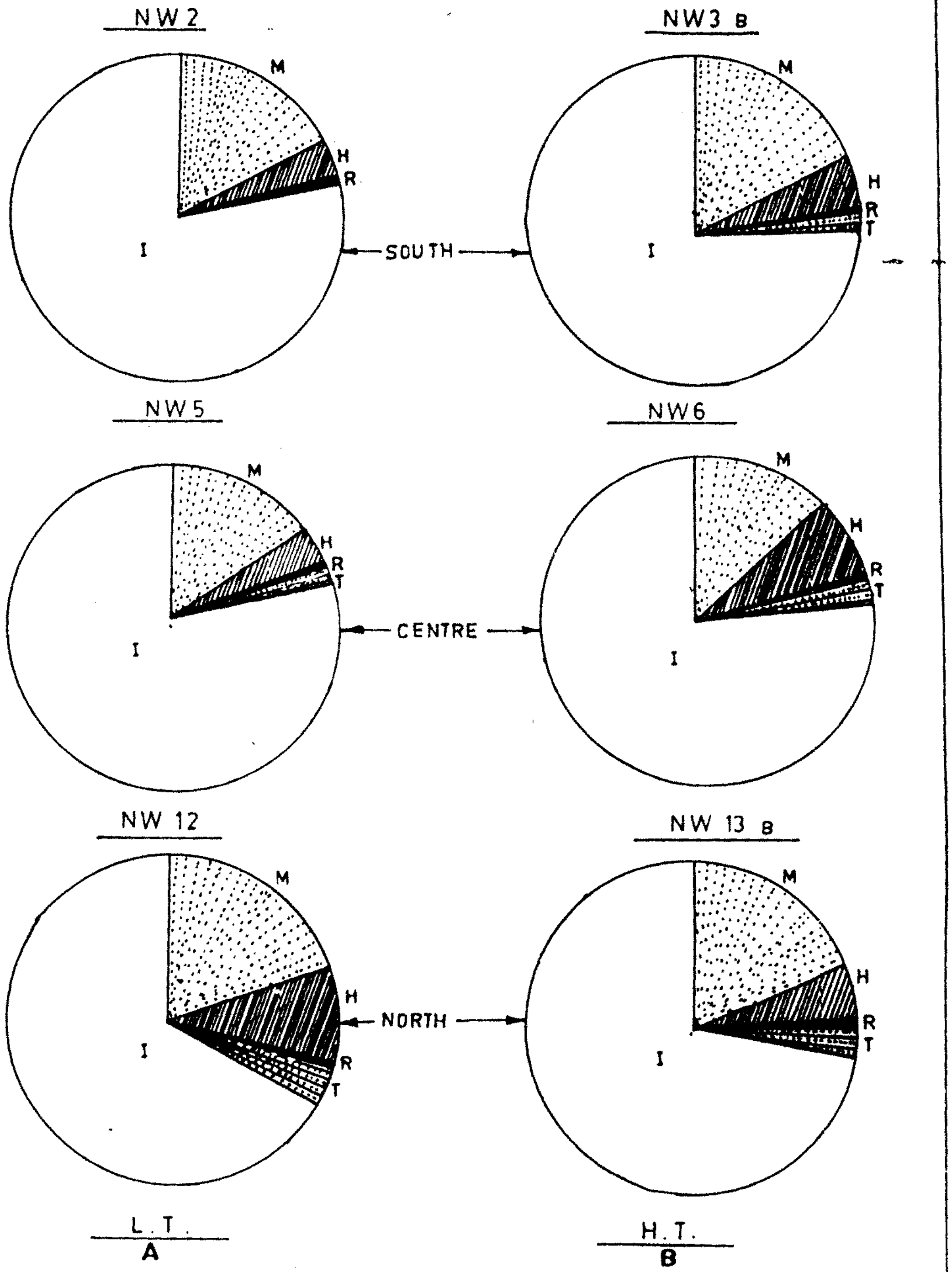


FIG.4-6 FREQUENCY DESTRIBUTION OF HEAVY MINERALS.

A – LOW TIDE B – HIGH TIDE

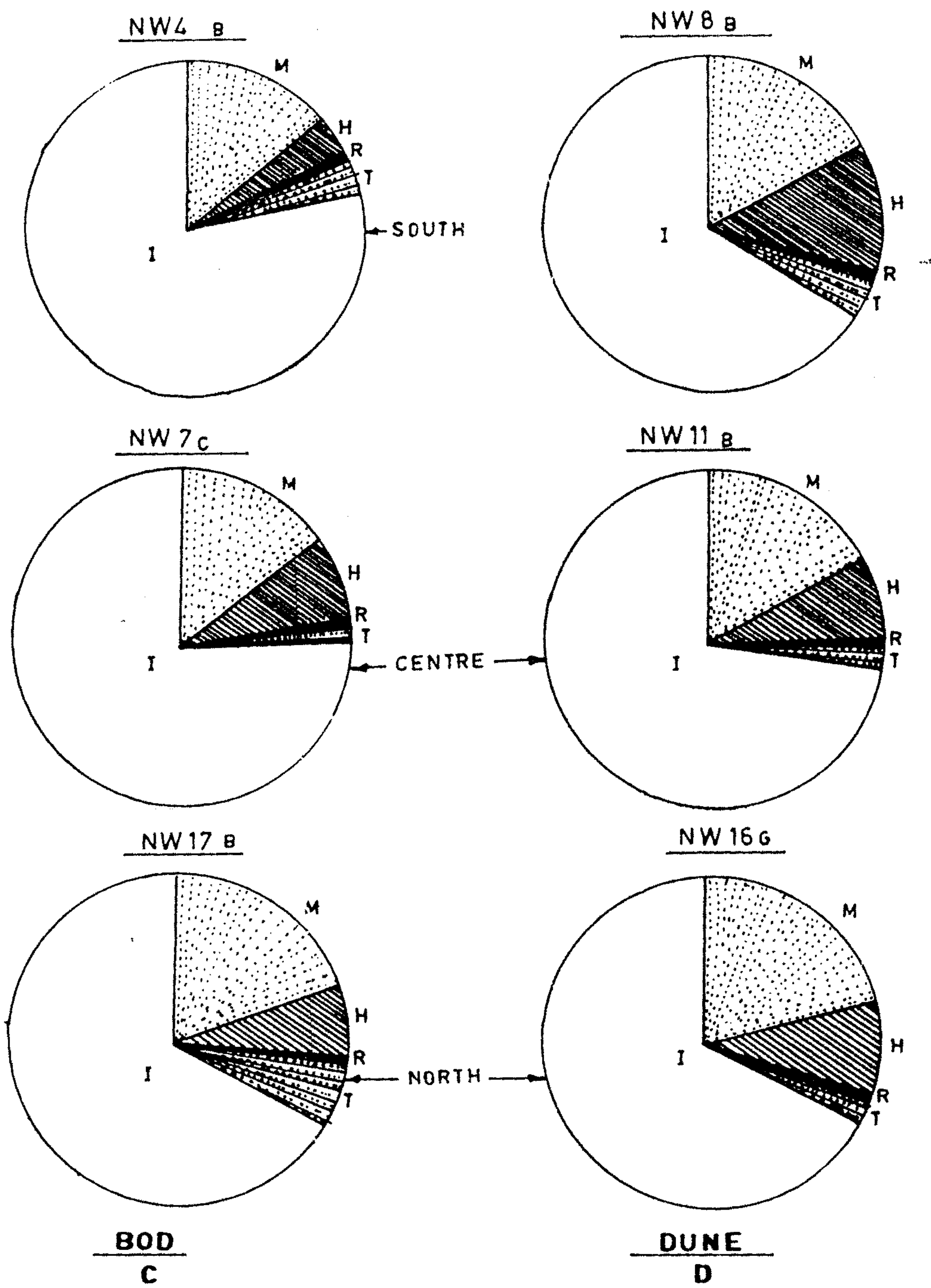


FIG. 4·7 FREQUENCY DISTRIBUTION OF HEAVY MINERALS

C — BASE OF DUNE D — DUNE

basalts, found in the hinterlands have principle minerals like augite, plagioclase etc and the accessory minerals like opaque oxides - ilmenite, magnetite etc. From the petrographic and mineralogical studies of these basalts and the laterites capping the basalts, it has been found that some of the primary minerals have undergone various degree of alterations and some others have retained the primary properties. On detailed examinations of few thin sections of basalts and the laterites, it was noticed that the opaque minerals such as magnetite and ilmenite, which appear as dusty patches have retained their primary properties. However, in some of the thin sections, it was also noticed that these opaque oxide minerals have to some extent undergone alterations. Similar observations were made for lateritic fragments found in the beach sands under the binocular microscope which showed unliberated fine opaques. Thus it can be inferred that the heavy minerals - ilmenite and magnetite could have been derived from the adjoining areas of the Newara beach.

The other heavy minerals such as zircon, tourmaline etc. found to be less than 2%, might have been derived from the areas of Precambrian terrain consisting of acid igneous rocks, occuring far away from the Newara beach. However, a detailed investigation in this regard is necessary.

In light of the present investigation, the studies by Prabhakar Rao (1974), Sengupta and Rao (1976) and

Siddiquie et.al (1979) of the placer deposits and the provenance, have opined unanimously that the source of the heavy minerals could be from the Deccan trap terrain and the laterites capping them.

FACTORS RESPONSIBLE FOR ENRICHMENT OF HEAVY MINERALS : The formation of placer deposits is dependant on the gamut of factors like favorable geology, geomorphology / physiography of the hinterland and the coast, drainage pattern, neo-tectonics and favorable zones of the deposition of heavy minerals. Apart from these, the other process variables operative at the site of deposition are yet another factors for the heavy mineral enrichment. The following paras summarise systematically the processes involved in the formation of the heavy mineral placer deposits.

The hinterland of the Newara beach consists of flood basalts rich in iron-titanium oxides. It has been inferred from the petrographic and mineralogical studies that these basalts could be effective source for the heavy minerals - ilmenite and magnetite.

As mentioned earlier, the physiography of the Newara beach is signified by two closely spaced promontories of high altitude, of which northern promontory projects to greater extent into the sea giving arcuate shape to the beach. Since, this area falls under the active zone of south-west monsoon receiving an aggreegate rainfall of 300 cm experiencing alternate temperature variations, high humid climate and prolific growth of vegetation, the rate of physical disintegration and chemical decomposition of Deccan basalts is high. The initial stages of the weathering of Deccan basalts are followed by the formation of insitu laterites. The heavy minerals such as ilmenite and magnetite, which form the opaques of these basalts, are found to be left behind as resistates in the laterites.

The drainge on the basalts and the laterites is subdentritic to subparallel and is mostly controlled by joints and fractures. The majority of the streamlets in this region are west flowing and descend at some places over steep slopes of the escarpments facing the sea. Such physiographic setting accelerates the fluvial cycle with rapid erosion, transportation and deposition of weathered material consisting of laterites and heavy minerals. On reaching the sea-front, most of the streams empty their sediment load at the foot of the hills and in the creek found at the central part of the investigated area.

The central and southern parts of the investigated beach are the favorable zones for the deposition of the fluvial sediments, since these areas had experienced block faulting and was relatively down-thrown (Prabhakar Rao 1974). The sediments at this stage are subjected to the surf action between the low-tide and high-tide zones. Since, the surf zone in the southern part of the Newara creek is broader and wider as compaired to the northern part, there is a selective deposition of the heavy minerals.

The oscillatory changes of the sea levels during the past might have played an active role in the progression and regression of the surf zone. thereby, helping in sorting and selective deposition of heavy mineral bearing sediments. As mentioned earlier, the presence of alternate horizontal laminations and cross - trough stratifications in the dug-well sections of the Newara beach, support the oscillatory sea-level changes during the past. It has also been mentioned in the introductory chapter that a paleo-beach has been located in the vicinity of Newara beach towards north supports the sea level changes.

Apart from the factors summarised above, the other important and vital factors are different process variables viz.wind,waves, different oceanic currents, tides etc.

In the west coast, waves generated by wind and gravity are of two types i.e. west and south - west waves (Reddy 1968) which have an important role in the natural sorting of the sediments in the foreshore region. During the process of swash, the waves bring sand consisting of heavy minerals rapidly in the foreshore region and during back wash, the lighter fractions of the sand are taken back leaving behind mostly the heavy minerals. Since these processes are active in the southern and central part of the beach due to presence of wider and broader foreshore region, the heavy minerals are found to be selectively deposited in these regions. While in the area north of the Newara beach, the surf zone is narrow resulting in relatively less degree of sediment sorting. The wind, which plays more active role in this region, carries lighter fractions for the formation of the dunes leaving heavy minerals at the base of dune (plate 4.1). Local tides and currents may also supplement the selective deposition of heavy minerals and transportation of lighter minerals.