CHAPTER - 7

HYDRODYNAMICS AND BEDFORMS STUDY

CHAPTER - SEVEN

HYDRODYNAMICS AND BEDFORMS STUDIES

INTRODUCTION

In the study of the motion of the water of the open sea of the study area, each form of a motion can be separately analysed and described, as is done, for example in Berezkin's Dynamics of the Sea (1938) and Zubov's Dynamic Oceanography (1947). The condition is quite different here near the shoreline of the study area, on account of continual interaction of different movements. Thus, the piling up of water produced by waves leds to the development of a current that imparts specific kinetic features to the whole water column affected by the disturbance. The littoral currents produced by waves react with tidal currents, and so on. All the movements of the water are subject to variaitons over a short distances. When the shoreline is intricate, pulsating currents (rip currents, for example) are formed and given rise to spatial and temporal heterogeneity in the wave field. Since the study of these and many other phenomena is extremely complicated, it is impossible to find in contemporary literature any definition of the hydrodynamic features of the shore zone as a whole or even of its separate elements.

The main objective of this chapter is to study (i) Coastal Processes, (ii) Bedforms (iii) Ripple marks analysis and (iv) Patterns of sediment transport to evaluate the recent hydrodynamic conditions prevailing on the shore zone of the study area.

COASTAL PROCESSES

There are three important dynamic processes which affect beach form : these are wave action, wind and tide of these the most important is wave action. The actual effect of waves depends on their dimensions, especially their steepness or height to length ratio, on the time interval between waves (the period) and on their direction of approach. An additional influence on the effect of waves on the shore is the relief character of the offshore zone, for this directly influences the depth of the water, which, in turn, influences the refractiuon of the waves. The relationship between beach form in the plane and the nature of the offshore area can be illustrated by the author's analysis of different beaches on the west coast of India between Agashi Bay in the south and Dahanu in the north. This is an indented coast with several creeks. The data analysed consist of :

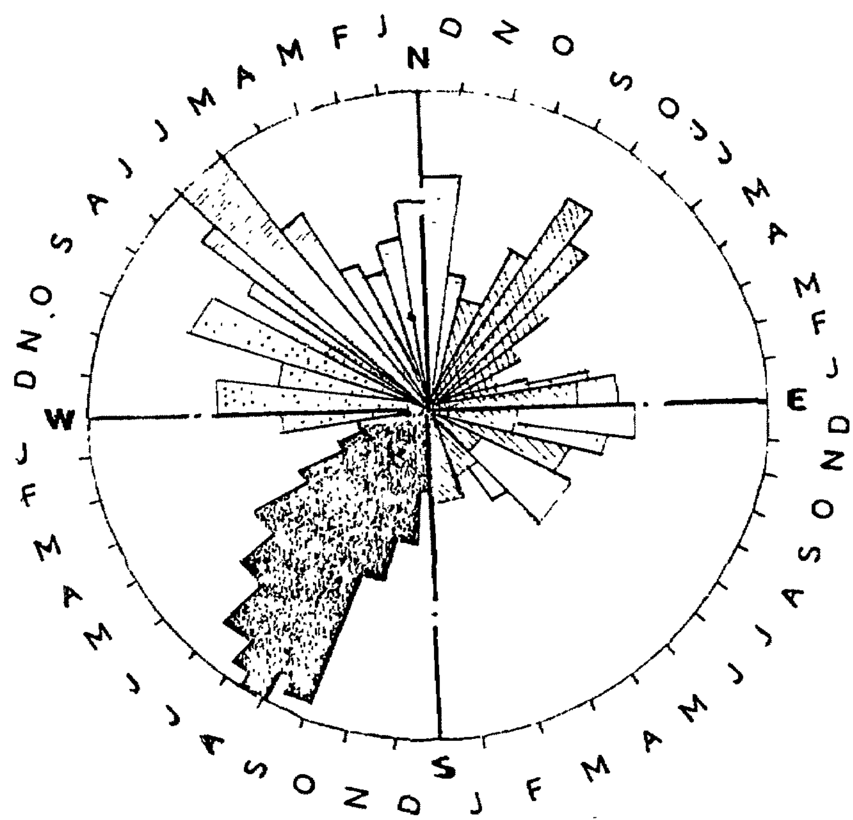
1. The orientation of the beaches
2. The orientation of 5 Fathom (approx 10m) depth contour.
3. The exposure of the beach, as measured by the angle, in degrees, between the orientation of the beach and the direction from which the longest swells and most effective waves are expected to come.

The direction of dominant wave approach for this study is considered 225 (S.W.) (Fig. VII.1)

The author has used numerical techniques (Dorn Kamp, 1971) for the present study on Dahanu-Kora coastlines. The author for study the orientation of Dahanu-Kora beaches, has divided the coastline in to four different segments as Dahanu-Vadhavan; Vadhavan-Akarpada; Akarpata-Muramba and Satpati-Mahim segment. The numbers of beach orientation measures are 18,34,15 and 18 from the segments 1,2,3 and 4 respectively (Table VII.1,2,3 & 4). These values were converted in to their sine and cosine values, each of which were sum up for all orientations. Each of these values are used to relate the original reading 18,34,15 and 18 to a single cartesian coordinate system (Fig. VII.2,3,4 & 5). The main objective of this is to find the position of the vector or line which provides a mean value for all of the measurements. This is done by dividing both cos , and sin , by the number of observations (n) and result of that are X and Y, coordinates. By using pythagorus's theorem the length (r) and the orientation of the mean vector are calculated (Table.VII.5).

FIG. VII-1

PERCENTAGE OF WINDS BLOWING THROUGHOUT THE YEAR



Dominated by South-Wersterlies & NW-therlies

TABLE VII.1

WEST COAST BEACH ORIENTATION DATA (Dahanu-Vadhavan Coast)

S.NO.	BEACH	ORIENTATION AT COAST IN DEGREE	ORIENTATION AT 10 M DEPTH CONTOUR
1.	Dahanu	3	7
2.	Dahanu	19	35
3.	Tadyalpada	94	20
4.	Tadyalpada	47	357
5.	Tadyalpada	33	333
6.	Tadyalpada	58	108
7.	Gungvada	116	310
8.	Gungvada	71	310
9.	Gungvada	92	310
10.	Gungvada	56	325
11.	Gungvada	26	339
12.	Vadapakhran	39	16
13.	Vadapakhran	58	16
14.	Vadhavan	53	5
15.	Vadhavan	64	5
16.	Vadhavan	58	5
17.	Vadhavan	81	5
18.	Vadhavan	58	5

TABLE VII.2

WEST COAST BEACH ORIENTATION DATA

(Vadhavan-Akarpata Coast)

S.NO.	BEACH	ORIENTATION AT COAST IN DEGREE	ORIENTATION AT 10 M DEPTH CONTOUR
1.	Vadhavan	354	2
2.	Vadhavan	337	2
3.	Vadhavan	327	2
4.	Vadhavan	313	2
5.	Vadhavan	265	2
6.	Vadhavan	319	0
7.	Vadhavan	327	0
8.	Vadhavan	324	0
9.	Vadhavan	326	0
10.	Vadhavan	339	350
11.	Vadhavan	3	358
12.	Mangalpada	2	358
13.	Mangalpada	22	9
14.	Mangalpada	1	1
15.	Mangalpada	327	350
16.	Mangalpada	329	347
17.	Mangalpada	270	346
18.	Dandepada	24	358
19.	Dandepada	358	358
20.	Dandepada	331	358
21.	Dandepada	2	358
22.	Dandepada	327	0
23.	Dandepada	4	0
24.	Dandepada	357	0
25.	Dandepada	6	3
26.	Chinchani	5	14
27.	Chinchani	335	17
28.	Chinchani	19	354
29.	Chinchani	343	354
30.	Chinchani	14	354
31.	Chinchani	344	354
32.	Chinchani	7	0
33.	Chinchani	11	6
34.	Chinchani	6	6

TABLE VII.3

WEST COAST BEACH ORIENTATION DATA

(Akarpata - Muramba Coast)

S.NO.	BEACH	ORIENTATION AT CAST IN DEGREE	ORIENTATION AT 10 M DEPTH CONTOUR
1.	Akarpata	297	330
2.	Akarpata	323	327
3.	Akarpata	337	6
4.	Navapur	333	6
5.	Navapur	347	6
6.	Navapur	20	350
7.	Alevadi	9	350
8.	Alevadi	2	350
9.	Alevadi	351	350
10.	Alevadi	5	350
11.	Alevadi	16	350
12.	Muramba	29	350
13.	Muramba	353	0
14.	Muramba	4	0
15.	Muramba	344	0

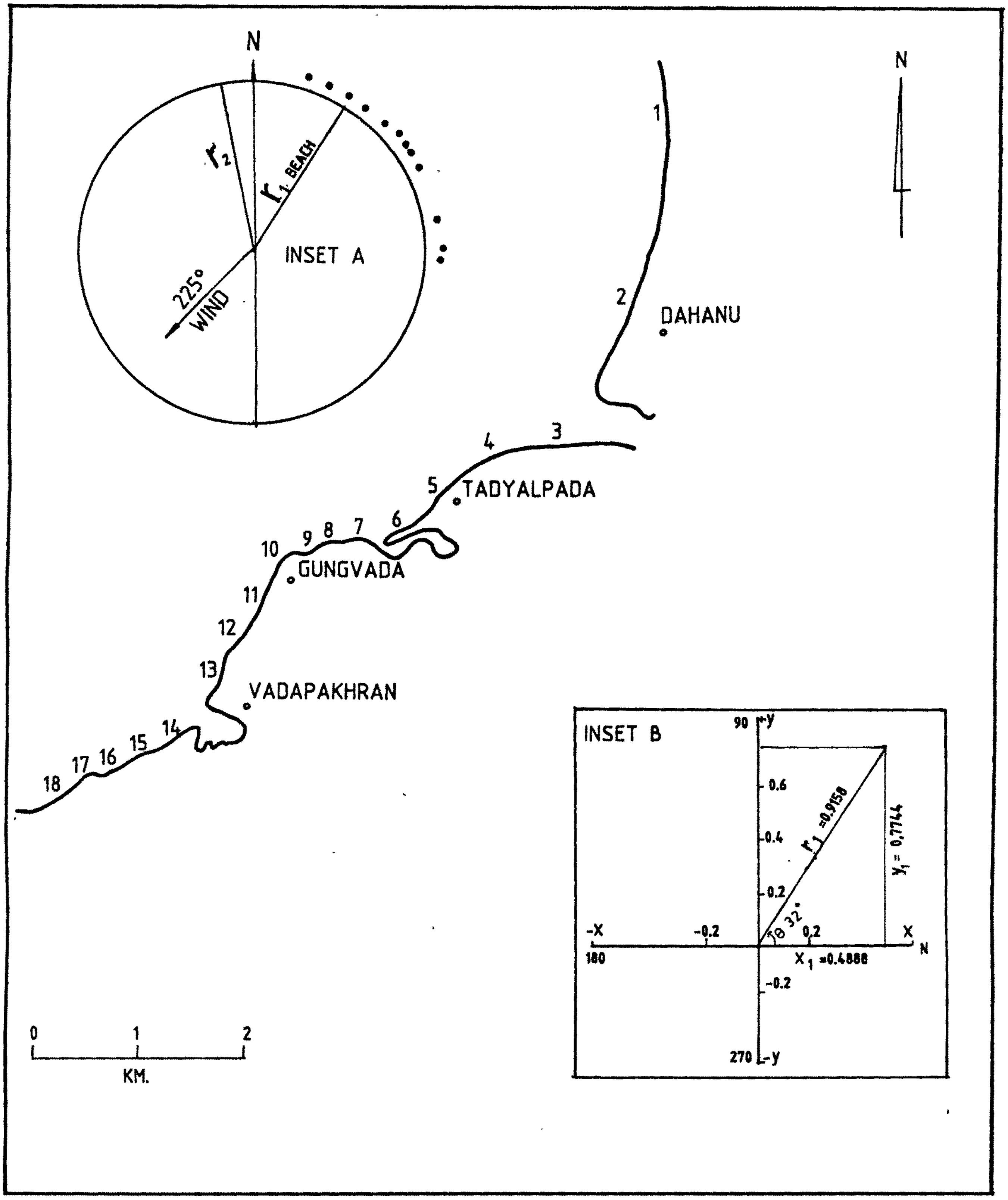
TABLE VII.4

WEST COAST BEACH ORIENTATION DATA

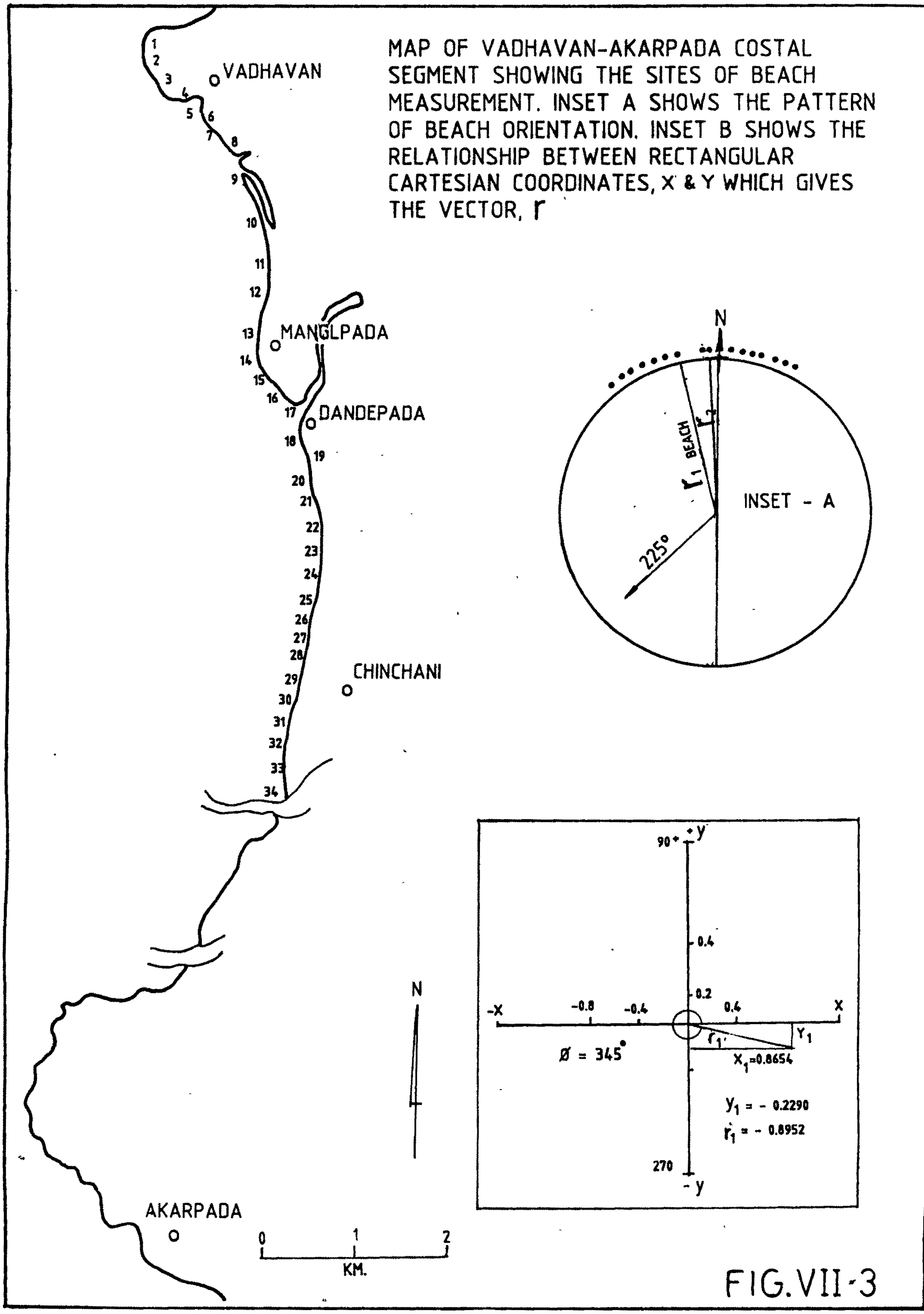
(Satpati-Mahim Coast)

S.NO.	BEACH	ORIENTATION AT COAST IN DEGREE	ORIENTATION AT 10 M DEPTH CONTOUR
1.	Satpati	352	0
2.	Satpati	328	0
3.	Satpati	317	0
4.	Satpati	323	0
5.	Satpati	342	0
6.	Shirgaon	354	0
7.	Shirgaon	32	40
8.	Shirgaon	21	40
9.	Shirgaon	12	40
10.	Shirgaon	7	40
11.	Shirgaon	349	340
12.	Shirgaon	351	340
13.	Vadra	329	340
14.	Vadra	36	340
15.	Vadra	6	340
16.	Mahim	6	340
17.	Mahim	347	340
18.	Mahim	334	40

FIG. VII·2



MAP OF DAHANU-VADHAVAN COASTAL SEGMENT SHOWING THE SITES OF BEACH MEASURMENT. INSET A SHOWS THE PATTERN OF BEACH ORIENTATION. INSET B SHOWS THE RELATIONSHIP BETWEEN RECTANGULAR CARTESIAN COORDINATES, X AND Y, WHICH GIVES THE VECTOR, r



MAP OF VADHAVAN-AKARPADA COSTAL SEGMENT SHOWING THE SITES OF BEACH MEASUREMENT. INSET A SHOWS THE PATTERN OF BEACH ORIENTATION. INSET B SHOWS THE RELATIONSHIP BETWEEN RECTANGULAR CARTESIAN COORDINATES, X & Y WHICH GIVES THE VECTOR, r

FIG.VII-3

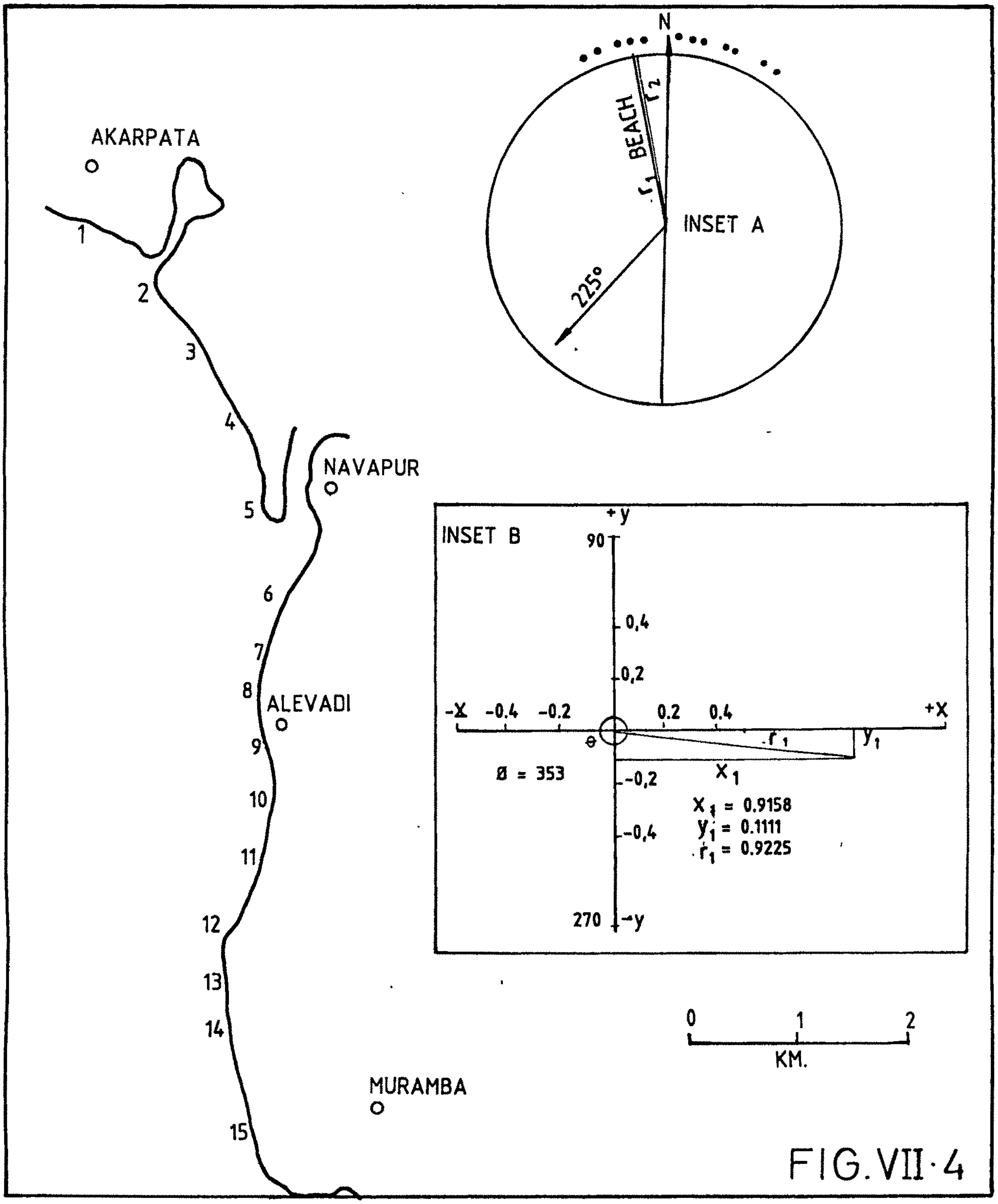
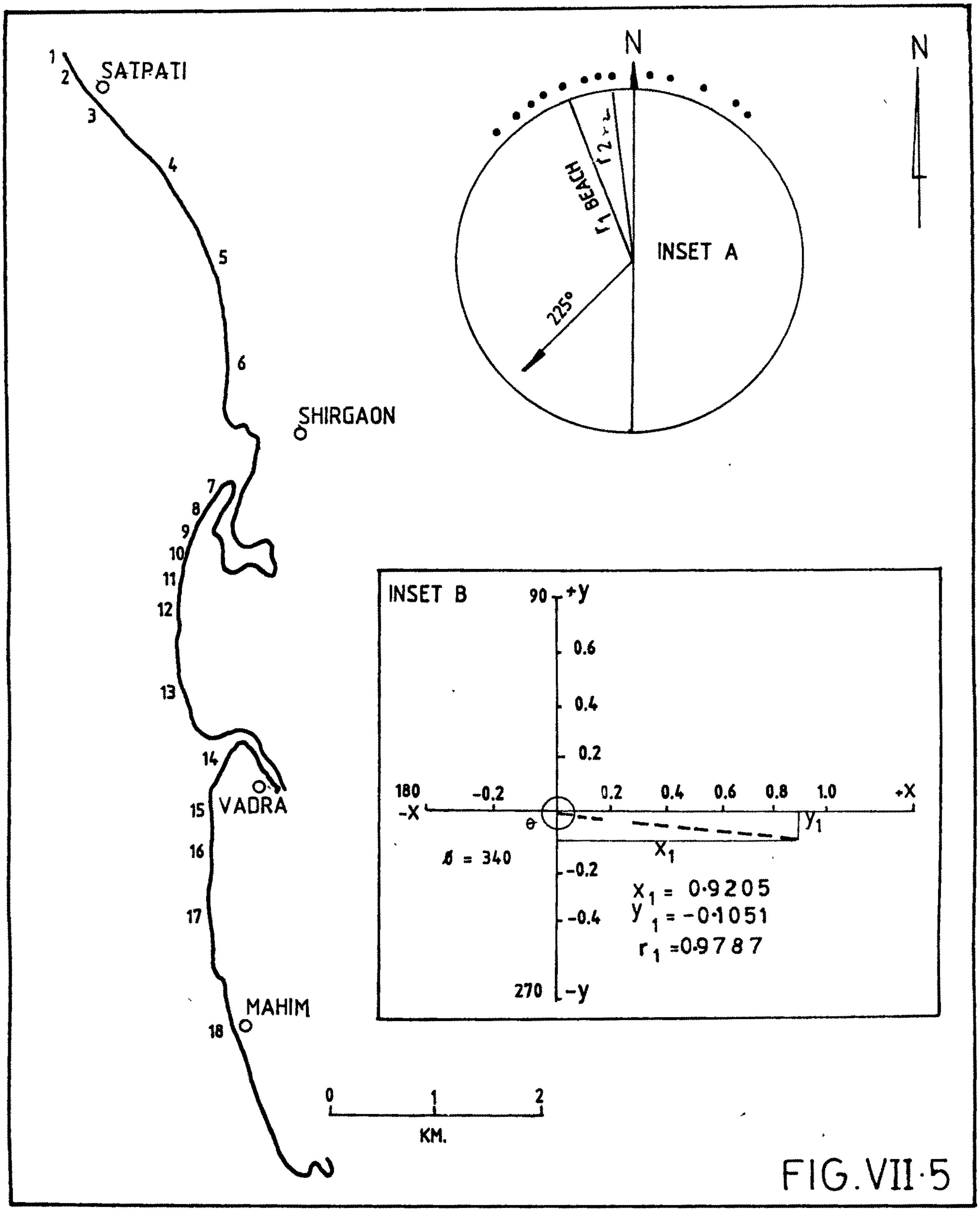


FIG.VII·4

MAP OF AKARPATA-MURAMBA COASTAL SEGMENT SHOWING THE SITES OF BEACH MEASURMENT. INSET A SHOWS THE PATTERN OF BEACH ORIENTATION. INSET B SHOWS THE RELATIONSHIP BETWEEN RECTANGULAR CARTESIAN COORDINATES, X AND y, WHICH GIVES THE VECTOR, r



MAP OF SATPATI-MAHIM COASTAL SEGMENT SHOWING THE SITES OF BEACH MEASUREMENT INSET A SHOWS THE PATTERN OF BEACH ORIENTATION INSET B SHOWS THE RELATIONSHIP BETWEEN RECTANGULAR CARTESIAN COORDINATES, X. AND y, WHICH GIVES THE VECTOR r

TABLE VII.5

COMPUTATION OF ORIENTATIONAL STATISTICS OF THE BEACHES AND (APPROX 10M) DEPTH CONTOUR "DAHANU-KORA COAST"

S.NO.	Sin	Cos	X	Y	r	Sin A	A
1.	13.9396	8.7986	0.4888	0.7744	0.9158	0.5337	32
2.	-2.6967	15.3993	0.8555	-0.1498	0.8685	0.9850	80
3.	-7.7844	29.4227	0.8654	-0.2290	0.8952	0.9667	75
4.	-0.4021	32.7930	0.9645	-0.0118	0.9646	0.9999	89
5.	-1.6665	13.7365	0.9158	-0.1111	0.9225	0.9927	83
6.	-1.9466	14.5819	0.9721	-0.1298	0.9807	0.9912	82
7.	-1.891	16.5693	0.9205	-0.1051	0.9787	0.9787	70
8.	-1.7514	16.4081	0.9116	-0.0973	0.9168	0.9943	84

A similar analysis is also performed on data relating to the orientation of the 10m depth contours.

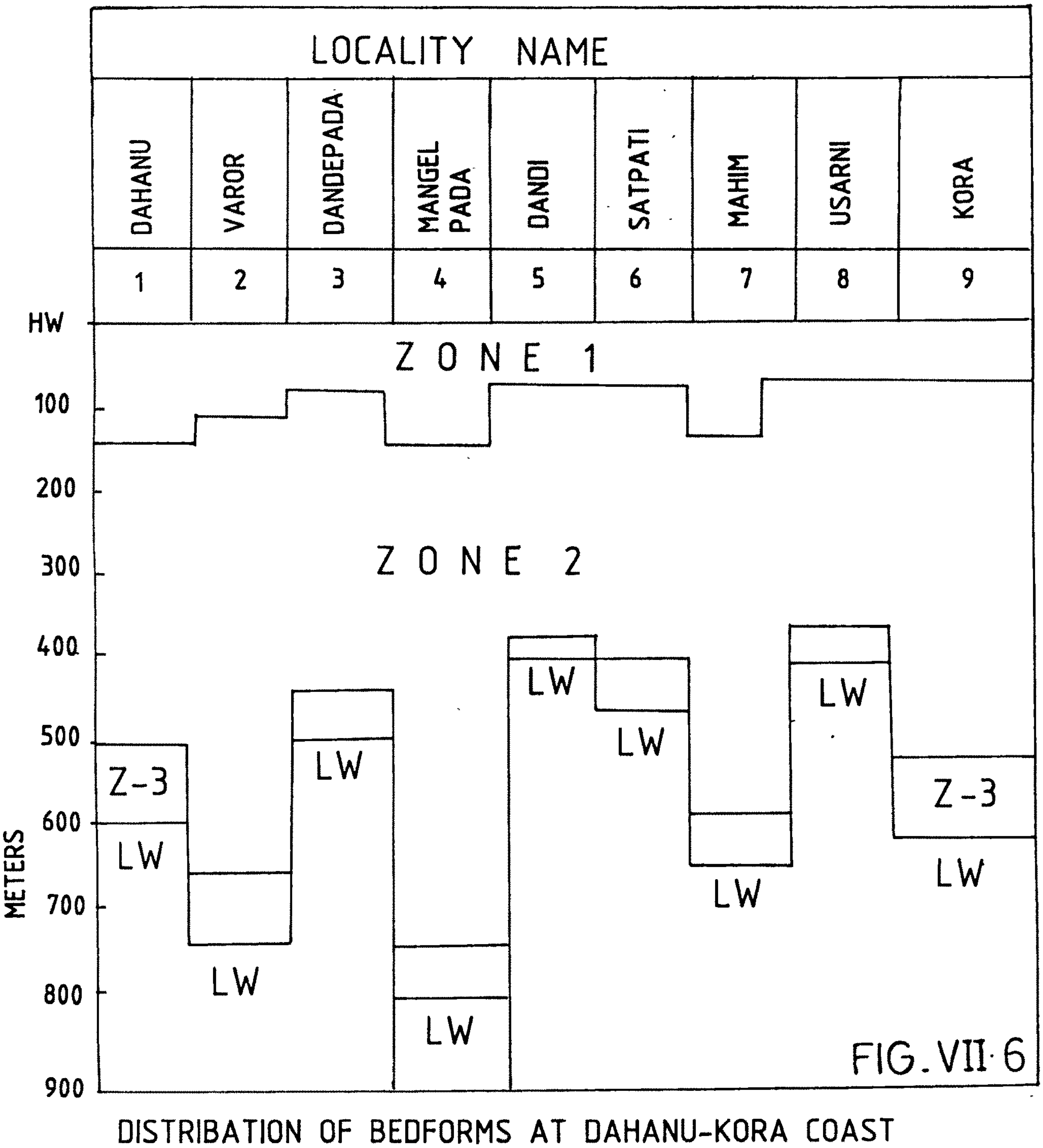
From the above analysis it is concluded that there is a close relationship between (Akarapta-Muramba) beach orientation and that of the 10m depth contour. It also supports the view that sandy beaches are built up to face the direction from which the refracted swells arrive.

In the other 3 segments additional refraction takes place after the 10m depth contour has been passed by the swell. This additional refraction is due to huge amount of rocky platforms present in shore-zone of the study area. The rocky beaches of the study area are built up to face the direction of secondary refraction.

BEDFORMS STUDIES

Bedforms are the features formed on the bed during sedimentation by currents. Important bedforms observed on the Dahanu-Kora coast are ripple makrs , swash marks, backwash marks and rill marks.

These bedforms are studied in three zones across the different beaches of the study area (Fig. VII.6). Swash, backwash and rhomboid marks are the important features of zone one. Zone two is characterised by various types of ripple marks while zone three is having mainly rill marks.



DISTRIBATION OF BEDFORMS AT DAHANU-KORA COAST (MAHARASHTRA). "HW". DENOTES HIGH-WATER MARK. "LW", LOW-WATER MARK AND "Z", ZONE

Zone-1

This zone is extended from the high-water mark to the last occurrence of rhomboid ripples. It is varied in width from 90 m to over 150 m. The sand in this zone is usually coarse to medium in size. This zone is characterized by the presence of swash, backwash and rhomboid marks. The details of each marks is given as follows :-

(i) Swash Marks

During the wave uprush, hydrodynamically lighter materials such as shell fragments, micaflakes, wood particles, fine sands and seed weeds etc. are carried up the beach and deposited there to form tiny ridges of 1-10 mm high in the form of thin irregular wavylines. During low tides, a succession of swash marks are seen on the beach surface formed by the retreating waves. At the next higher tide, old swash marks are washed away, and new ones are formed as the tide recedes. Their irregularity is due to local wave height and beach topography, and it increased because the swash marks of one wave are partly obliterated by a later swah result that only a portion is preserved. Emery and Gale (1951) reported that swash marks are formed only on the upper part of the beach which is fairly dry. The author's observations in the study area coincides with the above view. At the low beach face, a thin glassy film of water which prevents surface tension from driving the sands forward by moving water edge and the down slope flow of the water percolating out of the beach face also tends to wash away any swash that are formed. Swash marks are very well developed and are observed all along the beach in the study area.

(ii) Backwash Marks

Careful observations are made to study the formation of backwash marks in the swash zone of the study area. Wave lengths of backwash ripples range betwen 40 and 70 cm. Their heights are very low (> 1 cm), so that the ripple index, ranges between 50 and 100, which is much larger than for other water-formed ripples. Backwash ripples are generally observed to migrate slowly down slope and are found to be asymmetrical (Plate VII.1). Their leading edges are often bisected by small rills and sometimes show small-scale rhomboid marks superimposed. This concentrates heavy, dark minerals just behind a narrow leading edge of quartz grains, so that the low-height ripples appear as colour banding parallel to the length of the beach (Plate VII.2). Heavies and darker minerals are left in the troughts and the lighter quartz and feldspar sand grains form the crests.

Observations of the formation of the backwash ripples and measurements of their wavelengths were made at Varor, Dandepada, Navapur, Alevadi, Usarni and Kora beach. Due to the high concentrations of heavy minerals in Varor and Usarni beach, the backwash ripples are very apparent.

Field observations on several beaches at Dahanu-Kora coast verified that backwash ripples are generated beneath the wavelets of undular hydraulic jumps formed by supercritical backwash colliding with wave bores approaching the shoreline.

PLATE : VII.1 Asymmetrical backwash ripples at Dahanu coast.

PLATE : VII.2 Backwash ripples showing colour banding parallel to the length of the beach.

The ripples are formed on account of the horizontal variation of water-flow velocity beneath the Jump, which give a pattern of variable sand transport (Broome & Kumar, 1979).

(iii) Rhomboid Marks

Considerable literature is available on the rhomboid marks. These marks have been studied since the begining of this century by different workers. Various hypotheses have been suggested to explain their origin (Engels, 1905, Bucher, 1919, Johnson, 1919; Woodford, 1935; Demarest, 1947; Hoyt and Henry 1963; Otves, 1964, Kumar, 1976 and Allen 1980).

The rhomboid marks of the study area are formed mainly due to deflection of the sheet flow from its normal course straight down the beach face into a pattern that produce the rhomboid design. It is also observed that rhomboid marks are formed due to crossing or overlapping backwash. A shell or pebble placed on the beach face deflects the backwash flow, producing a scour cresentic in shape surrounding it and a characterisitc V-shape structure is produced (Plate VII.3). Due to a large number of such objects existed on the Dahanu, Navapur, Muramba and Kora coast, individual v-shaped lee flow patterns interfere with one another and ultamately give rise to a rhomboid pattern (Plate VII.4).

PLATE : VII.3 V-Shape structure formed due to deflection of backwash flow.

PLATE : VII.4 Well developed rhomboid marks at Mahim coast.

At Mahim coast such rhomboid marks are seen formed due to the minor irregularities in the grain surface texture. The thin sheet of water returning down the beach slope appeared to be spill into diverging minor currents by every patch of more compact sand or particle of coarse material which impeded its progress and the crossing of these minor currents resulted in the criss-cross pattern in the sand. Woodford (1935) has suggested that rather than resulting from deflecting currents, the pattern is produced by the interference of the waves that propagate down current from the objects (obstacles) or irregularities when the flow is supercritical, i.e. when the Froude Number.

$$F_r = U/\sqrt{gh}$$

is greater than unity, where (U) is the velocity and (h) is the flow depth and (g) is the acceleration of gravity which is equal to (= 981 $Cm^{-sec.2}$). With the supercritical flow the wave impulses produced by the irregularities on the bottom cause a V-shape pattern whose upstream acute angle (α) is given by :

$$\sin \alpha = \sqrt{gh} /U = 1/F_r$$

Field observations indicate that the thin swash water sheet that is thrown upward on the beach slope, after the major waves break, carry or shift the sediment particles up in a linear motion in the direction of upthrow water movement due to inertia of the waves. When the gravity force of the upthrow thin sheet of water becomes greater than the inertia force of the waves, the water tends to flow back to the breaker zone. This backflow of water sheet interestingly does not follow the sloping direction of the beach. Obviously the forces driving this water sheet at this stage are not purely gravitational but the existence of some inertia force, though considerably reduced, continues to be operative. This backflow of the water sheet is also a linear motion type and nearly half the amount of the upcarried sediment grains return downward but in the different direction. The arrangement of grains of these down shifting sediments also forms another set of linear rill structures, across the former set of rill structures formed during the up-throw of thin water sheet. The interference of these two rill sets forms beautiful rhomboid rill marks, which are better recognised where the concentrations of black heavy minerals and the light coloured quartz grains and miscovite are nearly equal.

The author has also come across rhomboid marks which Demarest (1947) called "dimple water ripples", produced by water percolating out of the beach face under the receding backwash.

Zone-2

This zone has maximum extent (600 m) on days with large spring tides. Wave height does not affect the extent of this zone. On all the beaches of study area ripple marks are the most predominant bedforms of this zone. About 60% of beach ripple marks of the study area are symmetrical and are oriented with their crests parallel to the shoreline, it is also observed various riples having highly sinuous crests with a strongly three dimensional shape forming asymmetrical profiles. The details of these ripple marks are given in the foregoing paces under ripple mark analysis.

Zone-3

This zone is extended from the seaward limit of zone-2 to the low-water mark. This zone is usually devoid of bedforms except few rill marks. Rill marks are generally formed by water seeping from the beach face at low tide or following a storm. The water percolates out from the beach and accumulates into small rills which join to form larger rills. The largest rills are seen at Dahanu coast near creek mouth. The dendritic patterns of these rill marks closely resemble branching plant stems and are seen associated with symmetrical hummocks ripples (Plate VII.5). They are common on steeper beach at Navapur and Muramba coast and also on Dahanu, Vadhavan, Mahim and Kora beach where the middle foreshore comprises fine sand to silty clay. Depending upon grain size, slope, width of beach as well as depth of water table, they vary in size and shape. These structures are observed all along the coastline, especially where the beach is muddy. The Dahanu beach is riddled with these structures, some of which have attained sizes as long as 10-15 m with trunk width of about 10-50 cm. Heavy concentration of dark minerals also are seen on various rill marks of the study area (Plate VII.6).

PLATE : VII.5 Symmetrical hummocks ripple associated with rill mark at Dahanu.

PLATE : VII.6 Heavy concentration of dark minerals on rill marks at Dahanu coast.

RIPPLE MARKS ANALYSIS

Ripples are the smallest sedimentary structures formed on sand by moving fluids. In the past, they have been interpreted only as current - formed or wave - formed. This Interpretation is significantly extended by careful examination of several aspects of ripples on Dahanu - Kora coast. Such as Ripple Geometry, Ripple Formation and Ripple lures.

Ripple Geometry

The field data collected from Dahanu-Kora coast, shows, the ripple spacing of small ripples range between 3-20 cm, ripple height 0.5-5 cm and ripple steepness ranges between 3-10 (Table VII.6,Fig. VII.7). Mega ripples of study area shows ripple spacing ranges between 40-70 cm, ripple height ranges between 0.4-1 cm and ripple steepness ranges between 52-100 (Table VII.7).

After analysing the grain size of various ripple marks and measurement of ripple spacing and height with vertical form-index (λ /H), the author has used Allen Plot (1979) with these data to obtain values of Umax that could have existed when the structures were formed. These values, combined with the data on ripple wave length and orbital diameter lead the author to estimate the wave period as follows :

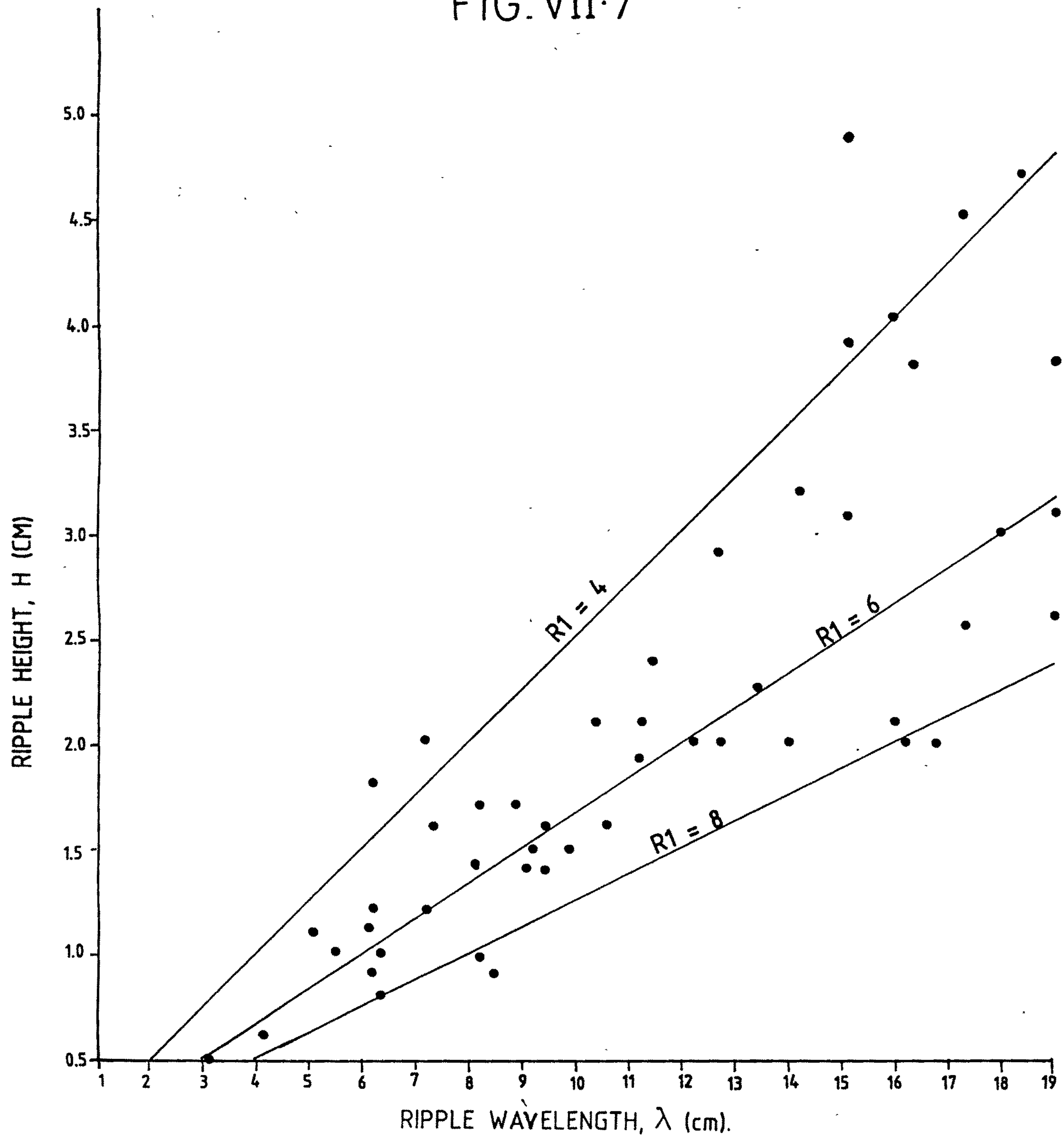
The measurement of the non-demensional wave length (λ /D) and vertical form-index characteristic, plot 2 (Allen 1979) are

TABLE VII.6

RIPPLE MARK DATA COLLECTED FROM
WEST COAST OF INDIA (DAHANU-KORA COAST)

NO.	LOCALITY	RIPPLE Spacing in cm.	RIPPLE Height in cm.	RIPPLE Form index	GRAIN Dia. in mm.	ORBITAL Velocity Um cm/sec.	ORBITAL Diameter in cm.	λ/D	d_0/D	Period T, Sec.
1.	Dahanu	17.3	4.5	3.8	0.42	23	25	412	600	3
		9.1	1.4	6.5	0.125	30	86	728	7000	9
2.	Tadalpada	9.2	1.5	6.1	0.177	27	25	520	1400	3
		8.5	0.9	9.4	0.125	42	75	680	6000	6
3.	Gungwada	15.1	3.9	3.9	0.42	23	25	360	600	3
		9.9	1.5	6.6	0.088	30	-	1225	-	-
4.	Vadapokhron	19.2	2.6	7.4	0.35	62	74	549	2100	4
		8.2	1	8.2	0.125	40	113	656	9000	7
		7.2	2	3.6	0.105	-	-	686	-	-
5.	Vadhavan	21.5	3.1	6.9	0.35	50	140	614	4000	9
		16.2	2	8.1	0.149	40	-	1087	-	-
6.	Varor	18.4	4.7	3.9	0.42	23	25	438	600	3
		9.4	1.4	6.7	0.105	31	-	895	-	-
		3.2	0.5	6.4	0.063	29	131	512	2100	14
7.	Dandapada	17.3	2.3	7.5	0.35	63	151	494	4300	8
		15.1	3.1	4.9	0.30	28	45	503	1500	5
8.	Tarapur	11.4	2.4	4.8	0.210	22	32	543	1500	5
		7.3	1.6	4.6	0.177	20	15	412	800	2
9.	Navapur	12.7	2.9	4.4	0.35	23	21	363	600	3
		8.9	1.7	5.2	0.177	21	18	503	1000	3
		5.1	1.1	4.6	0.105	20	9	486	900	1
10.	Alevadi	16.3	3.8	4.3	0.30	20	21	543	700	3
		3.2	0.5	6.4	0.074	29	10	432	1400	1
11.	Muramba	15.1	4.9	3.1	0.30	-	-	503	-	-
		4.1	0.6	6.8	0.088	32	18	466	2000	2
12.	Satpati	20.2	3.8	5.3	0.42	35	34	481	800	3
		9.1	1.5	6	0.125	28	10	728	4000	1
13.	Vadrai	12.7	2	6.4	0.30	41	33	423	1100	3
		6.1	1.1	5.5	0.177	25	-	345	-	-
		5.5	1	5.5	0.074	24	-	743	-	-
14.	Shirgaon	9.4	1.6	5.9	0.074	28	74	1270	10000	8
15.	Mahim	11.2	2.1	5.3	0.30	27	27	373	900	3
		6.2	0.9	6.9	0.149	32	27	416	1800	3
16.	Mangalvad	11.2	1.9	5.9	0.30	28	30	373	1000	3
		6.2	1.8	3.4	0.177	-	-	350	-	-
		13.4	2.5	5.4	0.088	24	47	1523	5300	6
17.	Usarni	14	2	7	0.50	71	40	280	800	2
		6.4	1	6.4	0.105	29	32	610	3000	3
		6.2	1.2	5.2	0.105	21	15	590	1400	2
18.	Mathana	10.4	2.1	5	0.210	23	31	495	1000	4
		8.1	1.4	5.8	0.105	27	27	771	2600	3
19.	Yedvan	16.8	2	8.4	0.5	76	55	336	1100	2
		14.2	3.2	4.4	0.42	28	25	338	600	3
20.	Kora	12.2	2	6.1	0.35	38	21	349	600	3
		16	2.1	7.6	0.30	56	96	533	3200	5
		7.2	1.2	6	0.177	28	18	407	1000	2

FIG. VII·7



CORRELATION BETWEEN THE WAVELENGTH AND HEIGHT OF WAVE RIPPLES OF DAHANU-KORA COAST WITH THE VERTICAL FORM-INDEX (λ/H) AS A PARAMETER

TABLE VII.7

BACKWASH RIPPLES DATA COLLECTED FROM

WEST COAST OF INDIA (DAHANU-KORA COAST)

S.NO.	LOCALITY	Y	H	Y/H	D50	UM	REMARK
1.	Vadhavan	45	0.6	77	0.42	80	Y= Wave length in cm.
		40	0.4	100	0.42	80	H= Height in cm
		47	0.9	52	0.42	80	Y/H= Ripple index
2.	Dandepada	55	0.7	79	0.35	75	D50= Diameter in mm.
		52	0.6	87	0.35	75	
		54	0.9	60	0.35	75	Um= Maximum orbital velocity in cm/sec.
3.	Navapur	70	1	70	0.35	75	
		45	0.6	92	0.30	70	
		59	0.7	84	0.30	70	
4.	Alevadi	45	0.7	64	0.30	70	
		50	0.8	63	0.30	70	
		48	0.7	69	0.30	70	
5.	Usarni	50	0.9	56	0.50	85	
		48	0.7	69	0.50	85	
		46	0.6	77	0.50	85	
6.	Kora	53	0.8	66	0.35	75	
		56	0.9	62	0.35	75	
		50	0.6	83	0.35	75	

used to estimate the range of possible water particle orbital diameters that prevailed when the ripples were formed. These results are combined with those from plot 1 (Allen 1979) and are used to estimate the wave periods that could have been associated with the formation of ripple marks. Wave period is obtained in the Formulae as T = do/Umax (Komar, 1976) in which T is the wave period, do is the orbital diameter and Umax is the maximum orbital velocity

RIPPLE FORMATION

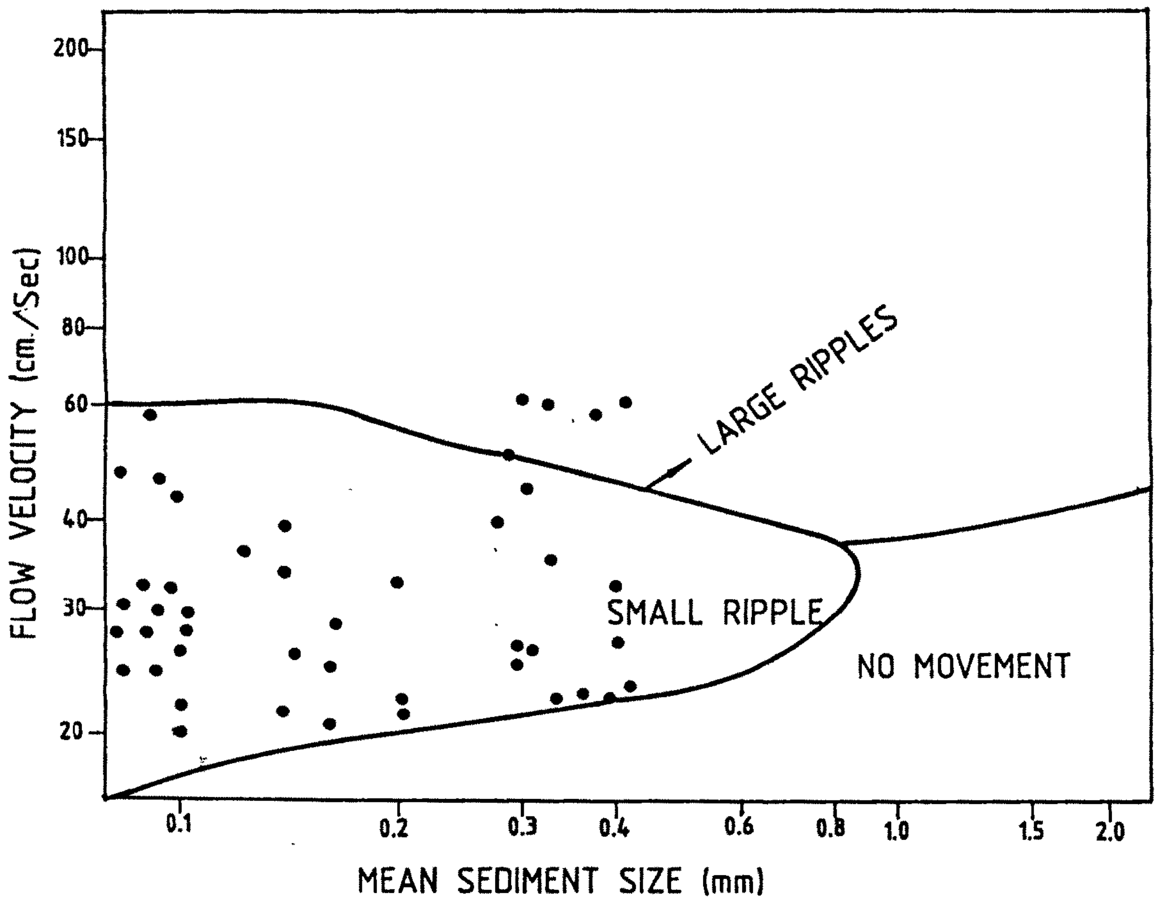
The initiation of ripple marks under unidirectional flow and oscilatory flow has been a subject of many investigations (Allen, 1968; Komar, 1976; Yalin, 1977). There is still some controversy as to the basis cause of the formation of sand ripples from the fluid flow (Folk, 1976). The author has attempted to study the different factors responsible for the formation of ripple marks in different shorezones of the study area. Ripple formation in different parts of the beach of the study area are considerably influenced and controlled by wind, waves, water movement, topographic position, flow velocity and grain size.

Wind-generated waves cause orbital movement of water and inturn cause the formation of oscillation ripples. Water movement over a sand bed, as unidirectional currents, oscillatory waves or a combination of both may give rise to ripples. Variation of ripples of the study area with topography is expressed in ripple size. Mega ripple (> 20 cm wave length) are formed mainly in the troughs between two bars, good example of such relationship is seen at Navapur and Muramba coast. Mega ripples are also found on back flow channels of Dahanu, Tarapur, Muramba and Maham coast (Plate VII.7).

Flow velocity is also playing important role in formation of ripple marks. When the velocity of water flowing over a sand bed exceeds a certain critical value, grains begin to move with wide spread movement of grains finer than about 0-6 mm in diamter ripples begin to form. When the flow velocity increases in sand having (0.3-0.6 mm) diameter large ripples begin to form (Fig.VII.8). The earliest ripples are usually rather straight and continuously crested but with gradually increased velocity the ripple change to a move three-dimensional pattern resulting in linguoid forms (Plate VII.8). Wave ripples and backwash ripples occur in two separate zones when they are plotted in terms of maximum near - bed oribital velocity and sediment particle diamters. Wave ripples of Dahanu-Kora coast are formed mainly by water velocity ranges between 20 to 45 cm/sec. They are having a diameter ranges between 0-0.45 mm. Backwash ripples are formed mainly by water velocity greater than 60 cm/sec, they are having a diameter ranges between 0.3 to 0.6 mm (Fig. VII.9).

Work of several authors on relation between ripple length and grain size suggests grain size as a factor in determing the wave length of ripples (Forel, 1883; Kindle, 1917). The grain size is the single most important factor in determing the size of ripples (Inman, 1957). The observations of present author also tend to confirm the above view.

FIG. VII·8



CONTROLS OF RIPPLE FORMATION BY MEAN SEDIMENT SIZE AND VELOCITY OF FLOW FOR ACONSTANT DEPTH OF FLOW.

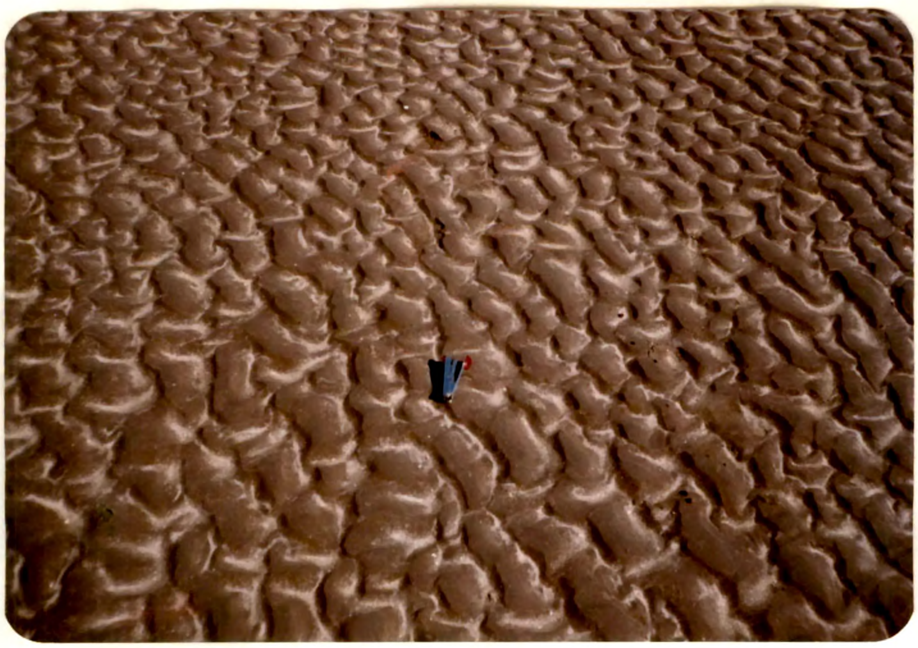
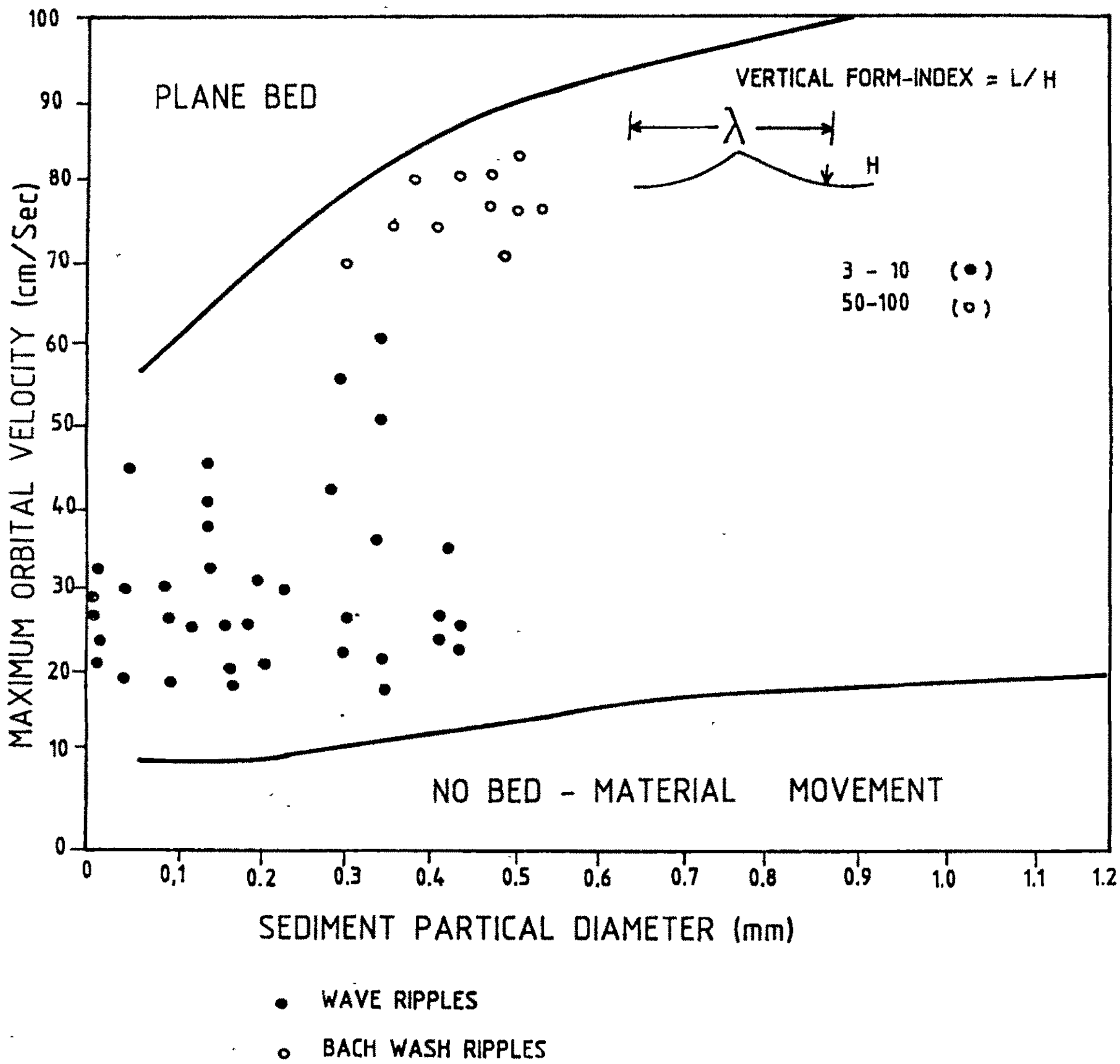


PLATE : VII.7 Linguoid ripples showing three dimensional pattern (locality : Muramba).

PLATE : VII.8 Mega ripples on back flow channels of Mahim coast.

FIG. VII·9



OCCURRENCE OF WAVE RIPPLES, BACK WASH RIPPLES IN TERMS OF MAXIMUM NEAR-BED ORIBITAL VELOCITY AND SEDIMENT PARTICLE DIAMETER

Observations and sediment analysis of different types of ripples at Dahanu-Kora Coast reveal the following factors :

1 - The small ripples of Mahim coast are found mainly in very fine sand while mega ripples are found mainly in fine to medium sand. It is also observed that median diameter decrease towards mega ripples which indicate grain size difference (Fig.VII.10).

2 - The Small ripples of Dahanu coast are found mainly in very fine sand while mega ripple are formed mainly in fine sand (Fig. VII.11).

3 - It is also revealed after calculating orbital diameter that the ripple spacing is controled mainly by grain size factor, such as ripple marks having wave length less than 10 cm are formed mainly in sand having diameter 62-5-210 micron while ripple marks having wave length greater than 10 cm are formed mainly on sand having diameter 300-500 micron (Fig. VII.12).

4 - Flow velocity and rocky platforms at Usarni coast are seen to be important factors controling ripple wave length. The very high flow velocity causes destruction in rocky platforms and finally giving rise mega ripples (Plate VII.9). When the flow velocity is not very high, rocky platforms remain intact and only small ripples are formed (Plate VII.10).

CUMULATIVE CURVES OF SMALL AND LARGE RIPPLES
ON MAHIM COAST

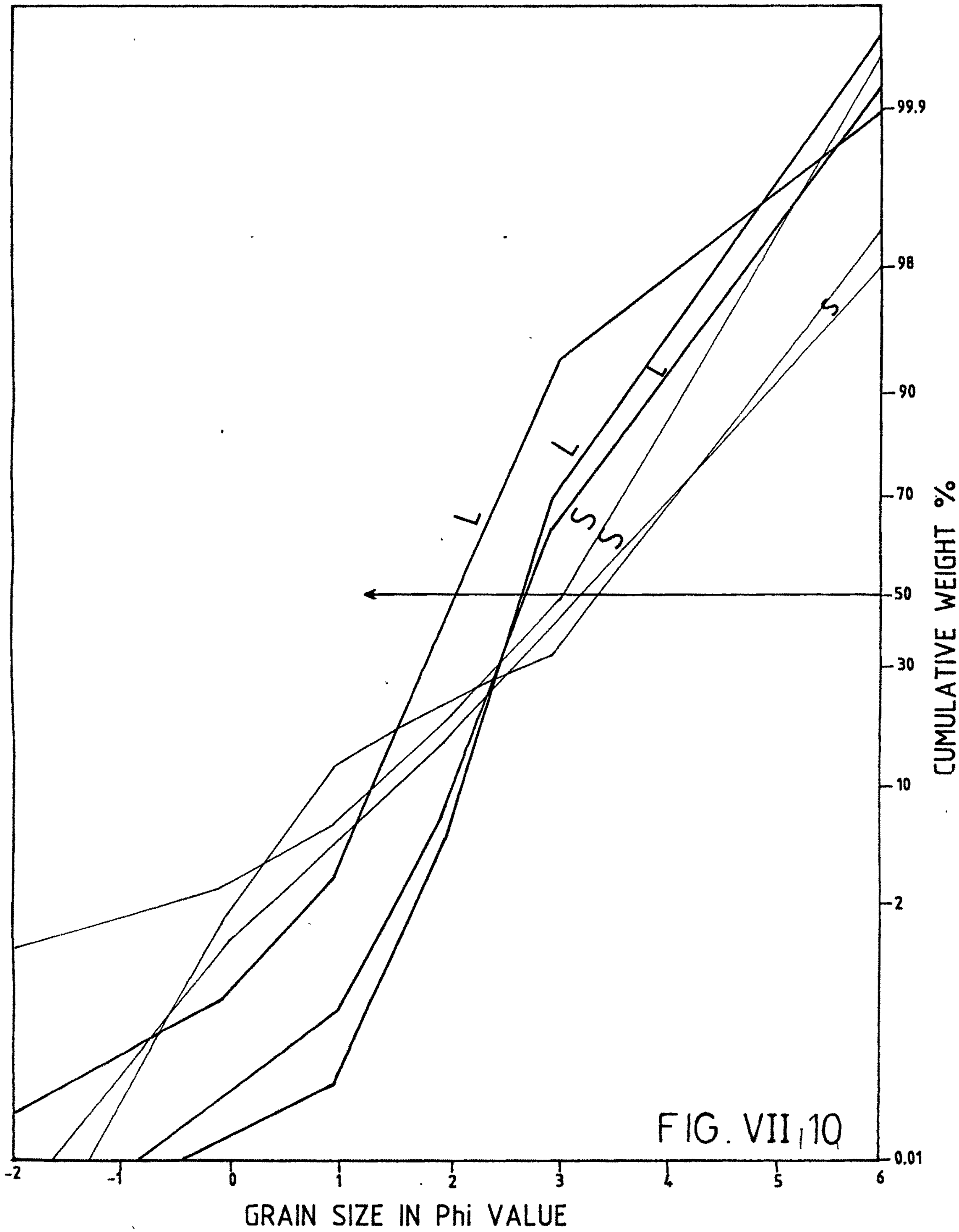


FIG. VII.10

CUMULATIVE CURVES OF SMALL AND LARGE RIPPLES ON DAHANU COAST

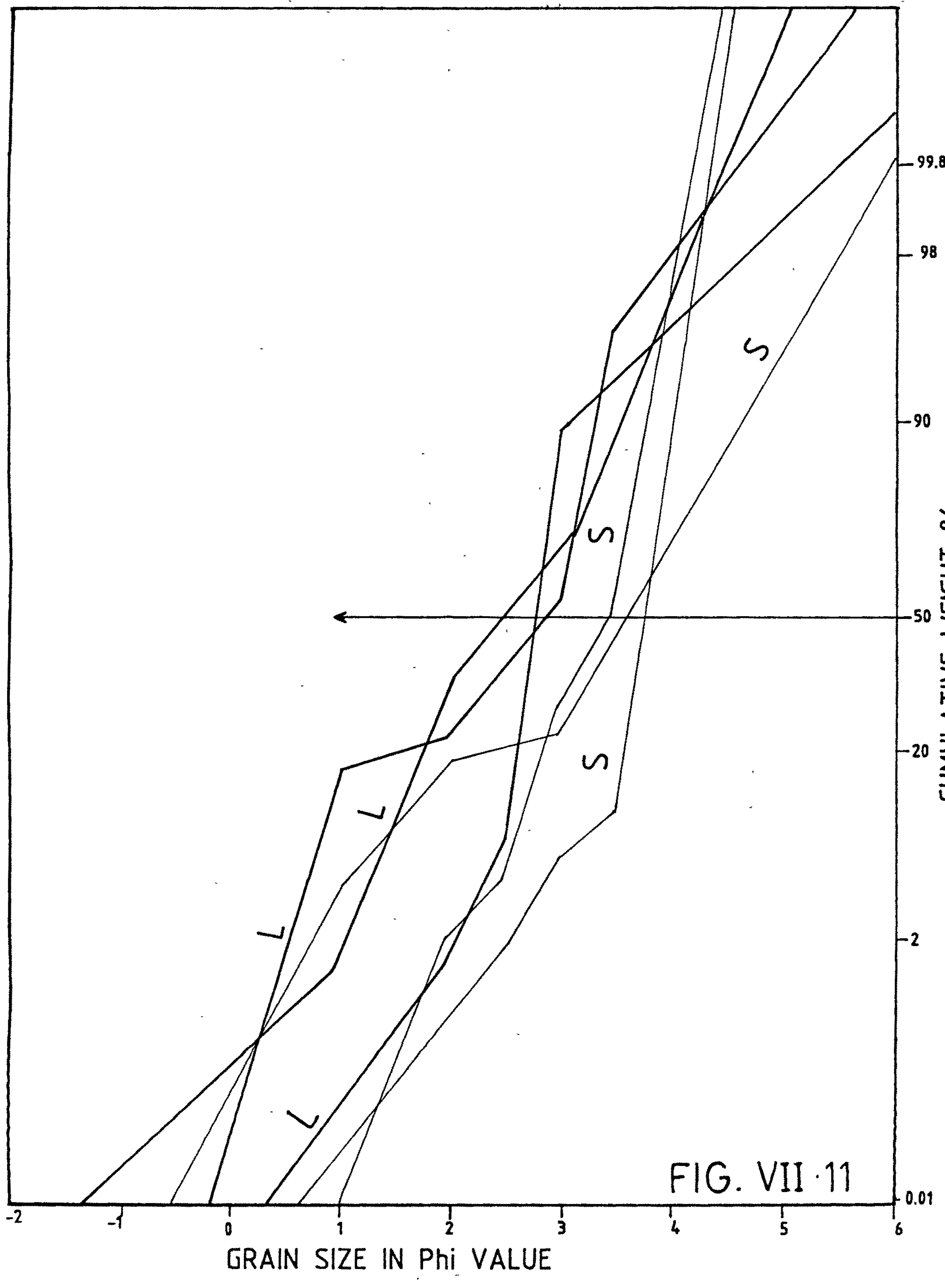
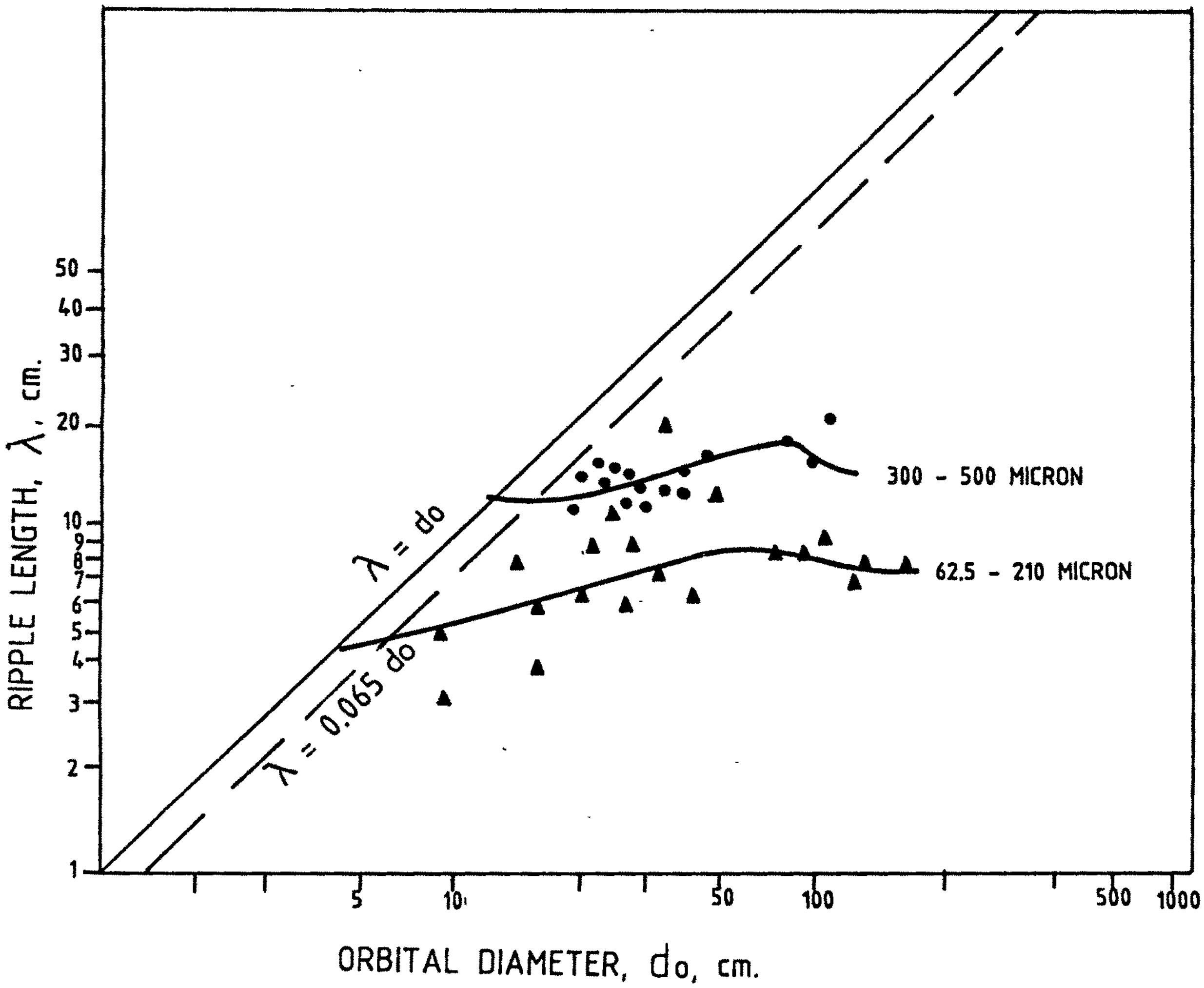


FIG. VII·11

FIG VII.12



RIPPLE SPACING VERSCES ORBITAL DIAMETER IN NORMAL RIPPLES OF DAHANU-KORA COAST.

PLATE : VII.9 Mega ripples formed due to high velocity of flow as result destruction of rocky platform.

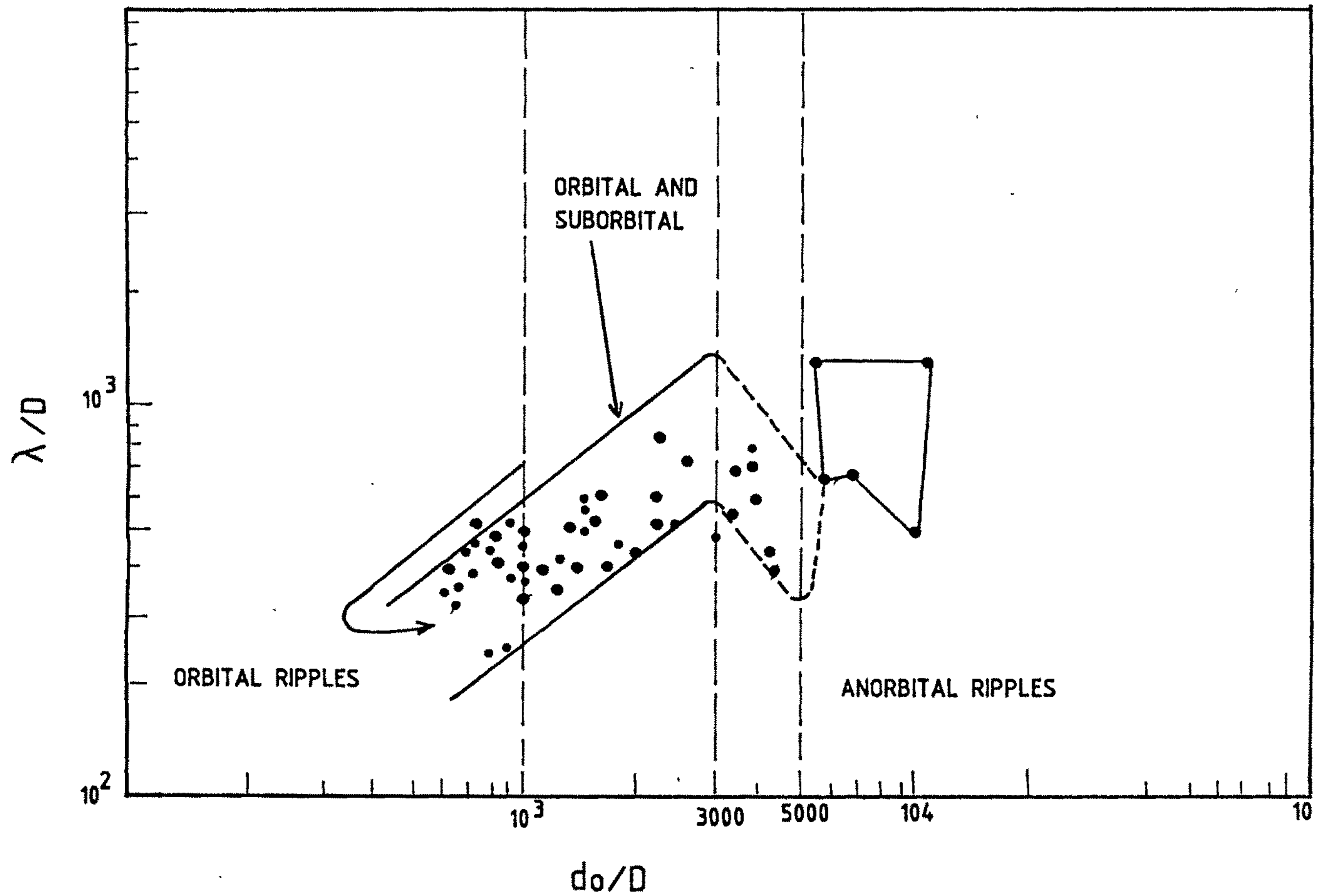
PLATE : VII.10 Small ripples formed on backside of rocky platform (locality : Usarni).

It is interesting to note the arrangement and distribution of light and heavies while forming the ripples of various shapes and sizes, by the wave and current actions on the beach surfaces. While the heavy minerals occupy the crestal areas of the ripples, a mixture of heavies and quartz grains comprise the flanks of the ripple crests. The higher concentrations of quartz grains overlain by thin layer of flaky minerals occupy the trough areas of the ripples. The swash and backwash action shift the sediment particles up and down the beach adjusting the sandy and silty sediment grains to find their appropriate reaches where the attraction force between them is greater than the friction stress produced by the waves so that they are no longer able to drag them free and to put them back into motion. The ripples that have been built under such conditions are observed to remain stable, even when they have been affected by subsequent medium rough stormy waves.

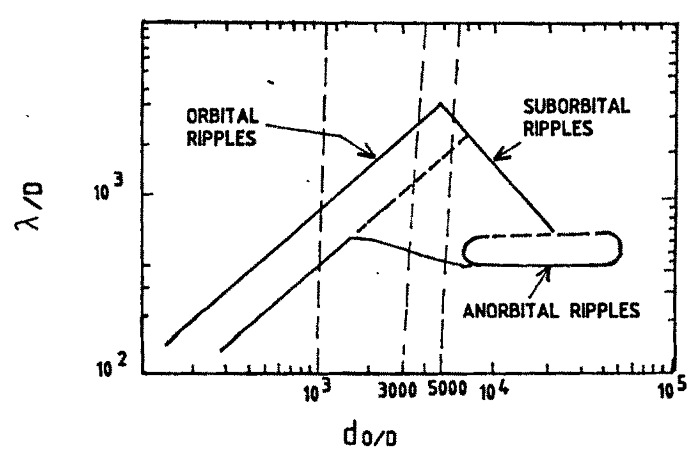
RIPPLE TYPES

The distinction between different types of ripples depends on the ratio between orbital diameter and grain size (do/D) (Clifton, 1976). The orbital ripples are formed at do/D values from 100 to 3000 (Plate VII.11). This requires relatively short orbital diamters, so orbital ripples are generally formed by short-period waves in shallow water. The wave period of orbital ripples of the study area ranges between 1 to 5 second. When the do/D ratios reach 1000 to 3000, the suborbital ripples are formed and at values above 5000, an orbital ripples form (Fig. VII.13,

FIG. VII·13



RIPPLE TYPES OF DAHANU-KORA COAST



RIPPLE TYPES. FROM H.E. CLIFTON AND J.R. DINGLER, 1984, MARINE GEOLOGY, 60, FIG. 5, p. 177. REPRINTED BY PERMISSION OF ELSEVIER SCIENCE PUBLISHERS, B.V.

Plate VII.12). Wave periods of anorbital ripples of the study area ranges between 5 to 9 second except at few places. Current ripples, current dominated ripples, wave dominated ripples and oscillation ripples are common in shore zone of the study area. They are found to form under combined oscillatory and unidirectional flow.

In the deeper areas where symmetrical oscillatory currents move the sediments, symmetrical ripples are formed. As the waves shoal and break, the ripples become asymmetrical.

At most places along shore zone of the study area minor ripples abound in various degree of branching, some of which are quite complicated. on top pertions of the elevated areas in shorezone show complex branching ripples are formed. These branching ripples occur along the crestal zone of the elevated portions of the flat as here, the ripples are more exposed to the wind during low tide. The branching of the ripples is found to have been controlled by several factors;; viz. (1) the fluctuation in the direction, intensity and frequency of waves acting on the beach surfaces (2).the changing direction of winds which blow over the ripples during the low tide destroys some of the ripple crests and shifting the loose sediments longitudinally along the troughs of the ripples which finally pile up along the wind destroyed areas of the ripples; and (3) The escape of water along such broken ripple crests scooping some particles of sediments and carrying them downward to join with the adjacent crest of the ripples.

PLATE : VII.11 Small orbital ripples showing symmetrical type.

PLATE : VII.12 Anorbital ripples showing mega types.

Detailed observations reveal that the factor above mentioned (2) in combination with (3), is very effective in branching out the minor ripples, whereas the factor (1) plays a subordinate role. So far as the backwash ripple branching is concerned, the factor (1) is more effective. The branching process is quite complex but can be generalised as below. The above this process occurs during the receding tide. This process is at its maximum during the strong southwesterly monsoon winds blowing over the rippled surfaces. The direction of this wind is oblique to the trends of the ripple crests, causes landward pushing of water sheet. This landward pushing of water sheet, destroys some part of the ripple crests.

During the rising tide, the partly destroyed and branched ripple crests are finally shaped by a process of selective shifting of sandy, silty and muddy fractions and then they subsequently settle into a more or less permanent positions. This is brought about by the induction of smaller fractions into the voids between coarser particles. The following period of tide recession leaves a part of these intact, while other may get disturbed by the process described above. Repeated activity of this nature would ultimately give rise to vast stretches of branches ripple marks. At many places, along the elevated areas of the beach flat, the above process is seen to have reached its maximum and resulted a highly complicated branching patterns. But the geometric modification of swash return, quite often given rise to asymmetric ripples with their lee-face pointing towards the sea. These are associated with the formation of rhomboid rill marks. The authors observation also indicate that these inverse ripples have developed only during the receding tides as the swash water sheets carry back the sediments to the depth from the upper reach of the beach. The swashop of thin sheet of water, carry the sediments upward and on their return to the depth again carry back some amount of sediments, which are finally deposited along the trough zones of the ripples. This process, thus consists of erosion of the earlier formed ripple crests and subsequently deposited in the troughs. The path of sediments shifting by this process is from the coastline towards the sea. A repetition of this process during every low tide stablizes the inverse ripples.

The stablisataion of the ripples is seen to have been brought about by a process of shifting and adjustment of different sizes of sandy, silty and clayey materials resulting into a compaction brought about by filling up of voids by finer sediments leaving behind considerably less percentage of voids between the grains. Thus the unsorted beach sands are more amenable to this process of stabilisation of the ripples. This appears to be an example of typical marine sand beach compaction. This leads to conclude that well sorted beach sand generally do not form stabilised ripple marks because they cannot be compacted and the ripples keep on changing from tide to tide and season to season.

Pattern of Sediment Transport

INTRODUCTION

McLaren 1981 has adopted a satistical approach to determine the transport direction by examining all possible pairs in a sample suite. Given a sequence of n samples there are $(n^2 - n)/2$ directionally oriented pairs that may exhibit a trend suggesting transport in one direction and an equal number of pairs in the opposite direction . When any two samples are compared with respect to their mean size sorting, and skewness eight possible trends exist. (1) finer (F) better sorted (B) and more negatively skewed (-); (2) coarser (c) more poorly sorted (P) and more positively skewed (+); (3) C,B -; (4) F,P,-; (5) C,P -; (6) F,B, +; (7) C,B, +; or (8) F, P, +. Of these trends, only two are indicative of transport, namely F,B, - (Case B) and C,B, + (Case C) for which there is a one eighth probability of either occurring at random ($p = 0.125$).

The author used the Z-score (Spiegel 1961) to for determine the level of significance as :

$Z = (x - Np)/Npq > 1.645$ (0.05 level of significance)

or

> 2.33 (0.01 level of significance)

where x = observed number of pairs representing a particular case in one of the two opposing directions; and N - total number of possible unidirectional pairs. $N = (n^2 - n)/2$ where n = number of samples in the sequence $p = 0.125$; and $q = 1.0 - p = 0.875$.

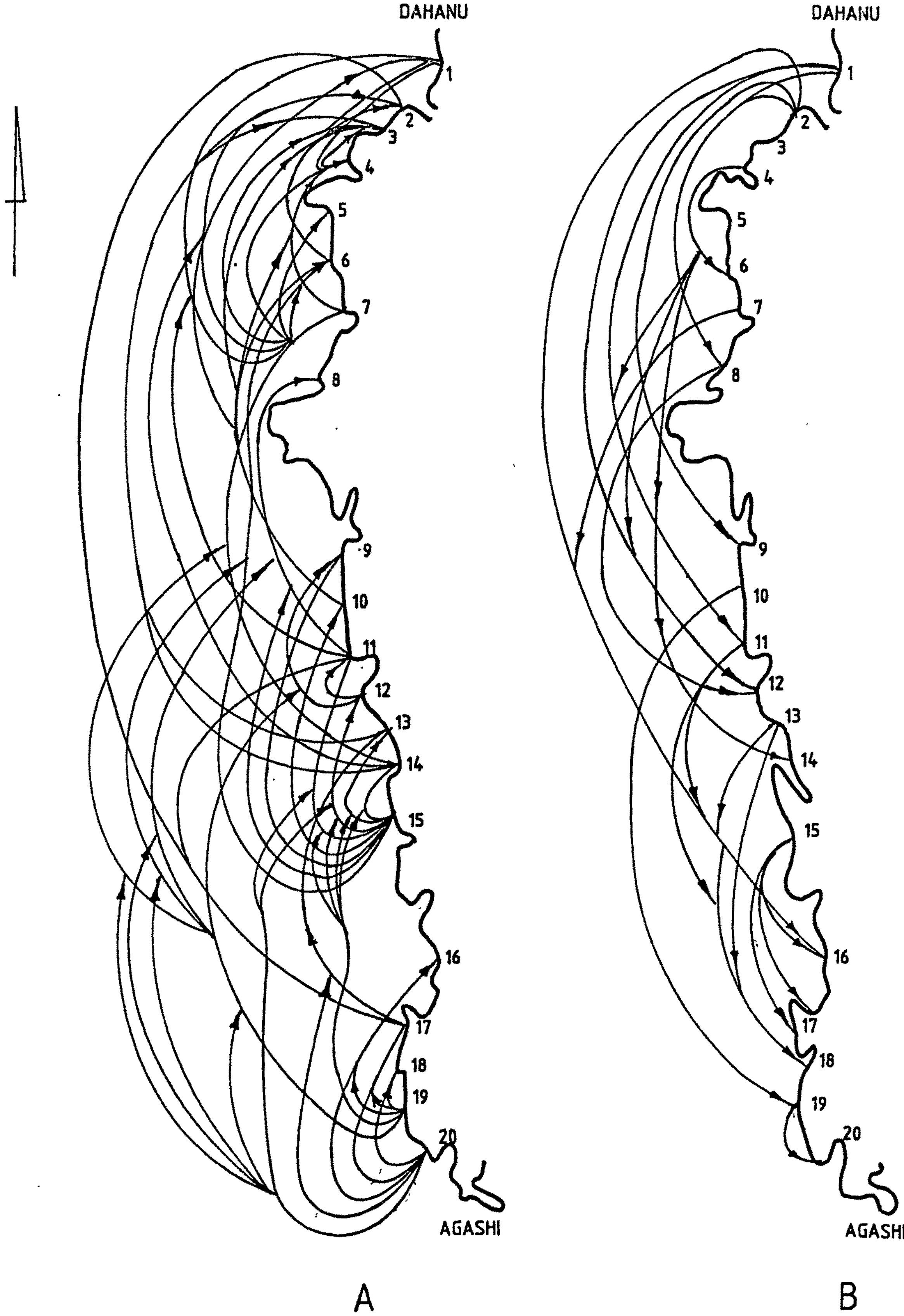
TREND OF SEDIMENT TRANSPORT

The theory of trends in grain size measures as suggested by McLaren (1981) has been applied to the intertidal zone sediments of the study area under the present study, to decipher sediment transport directions, nature of sedimentary process and the pattern of erosion and depositions.

In understanding the sedimentary processes, mean, standard deviation and skewness parameters have been considered; while another measure kurtosis has not been considered as it does not provide any additional information for the interpretation of grain size distribution (Blatt el al., 1980). Accordingly, the sediment-trend matrix for beach sediemnts has been constructed and sediment source-deposit relationship has been deciphered and is presented diagrammatically in (Fig.VII.14, a & b). This figure shows the transport directions for the sediment movement along the beach face. To avoid confusion, the transport directions have been presented separately, indicating southward current and northward current directions. In general, the grain-size mean, standard deviation and skewness - have been used to construct sediment trend matrix and thereby the major transport directions along the coast. The trends summarized in the matrix (Fig.VII.15), (Table VII. 8 & 9) suggest the following : -

1. Profile 1 is not a source for any of the others.
2. Profile 2 could be a source for profiles 8,9,11,13,16 & 18.

FIG · VII·14



SEDIMENT TRANSPORT DIRECTIONS (a) NORTHWARD (b) SOUTHWARD AS INFERRED FROM SEDIMENT-TREND MATRIX

FIG. VII·15

SEDIMENT SOURCE

SEDIMENT DEPOSIT

PROFILE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	/	FB+		FB+		CB+	CB+	FB+		CB+	CB+	FB+	CB+	CB+	FB−	FB+	FB+	FB+	FB−	FB+
2		/					CB+					FB+			FB−		CB+		FB−	FB−
3	FB+	FB+	/	FB+		CB+	CB+	FB+		CB+	FB+	FB+	CB+	CB+	FB−	FB+	FB+	FB+	FB−	FB+
4		FB+		/			CB+			CB+		FB+			FB−				FB−	FB+
5					/					FB+					FB−					
6		FB+		FB−		/	FB+	FB+		FB−	FB+	FB+	FB+	FB−	FB−	FB+	FB+	FB+	FB−	FB−
7							/					FB+			FB−				FB−	FB−
8		FB−						/			CB+	FB+			FB−				FB−	FB−
9		FB−							/			FB−			FB−				FB−	FB−
10										/					FB−					
11		FB−		FB−							/	FB−			FB−		FB−		FB−	FB−
12												/			FB−				FB−	FB−
13		FB−		FB−				FB−			FB+		/		FB−		FB−		FB−	FB−
14		FB+		FB−				FB+			FB+	FB+	FB+	/	FB−	FB+	FB+		FB−	
15															/					
16		FB−					CB+	FB+			CB+	FB++	CB+		FB−	/			FB−	FB−
17												FB+			FB−		/		FB−	FB−
18		FB−									CB+	FB+	CB+		FB−			/	FB−	FB−
19										CB+									/	
20																			FB−	/

F = FINE

C = COARSE

B = BETTER SORTED

SEDIMENT TREND MATRIX FOR BEACH SAMPLES IN DAHANU - KORA COAST

TABLE VII.8

POSSIBLE PAIRS AND POSSIBLE TRENDS

OF WEST COAST SAMPLE (DAHANU COAST)

NORTH TREND

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
1.	20 and 19	NO	2.	19 and 18	FB-	3.	18 and 17	NO
	20 & 18	FB-		19 & 17	FB-		18 & 16	NO
	20 & 17	FB-		19 & 16	FB-		18 & 15	NO
	20 & 16	FB-		19 & 15	NO		18 & 14	NO
	20 & 15	NO		19 & 14	FB-		18 & 13	NO
	20 & 14	NO		19 & 13	FB-		18 & 12	NO
	20 & 13	FB-		19 & 12	FB-		18 & 11	NO
	20 & 12	FB-		19 & 11	FB-		18 & 10	NO
	20 & 11	FB-		19 & 10	NO		18 & 9	NO
	20 & 10	NO		19 & 9	FB-		18 & 8	NO
	20 & 9	FB-		19 & 8	FB-		18 & 7	NO
	20 & 8	FB-		19 & 7	FB-		18 & 6	FB+
	20 & 7	FB-		19 & 6	FB-		18 & 5	NO
	20 & 6	FB-		19 & 5	NO		18 & 4	NO
	20 & 5	NO		19 & 4	FB-		18 & 3	FB+
	20 & 4	FB+		19 & 3	FB-		18 & 2	NO
	20 & 3	FB+		19 & 2	FB-		18 & 1	FB+
	20 & 2	FB-		19 & 1	FB-			
	20 & 1	FB+						

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
4	17 and 16	NO	5.	16 and 15	NO	6.	15 and 11	FB-
	17 & 15	NO		16 & 14	FB+		15 & 10	FB-
	17 & 14	FB+		16 & 13	NO		15 & 14	FB-
	17 & 13	FB-		16 & 12	NO		15 & 13	FB-
	17 & 12	NO		16 & 11	NO		15 & 12	FB-
	17 & 11	FB-		16 & 10	NO		15 & 11	FB-
	17 & 10	NO		16 & 9	NO		15 & 10	FB-
	17 & 9	NO		16 & 8	NO		15 & 9	FB-
	17 & 8	NO		16 & 7	NO		15 & 8	FB-
	17 & 7	NO		16 & 6	FB+		15 & 7	FB-
	17 & 6	FB+		16 & 5	NO		15 & 6	FB-
	17 & 5	NO		16 & 4	NO		15 & 5	FB-
	17 & 4	NO		16 & 3	FB+		15 & 4	FB-
	17 & 3	FB+		16 & 2	NO		15 & 3	FB-
	17 & 2	CB+		16 & 1	FB+			
	17 & 1	FB+						

POSSIBLE PAIRS AND POSSIBLE TRENDS

OF WEST COAST SAMPLE (DAHANU COAST)

NORTH TREND

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
7.	14 and 13	NO	8.	13 and 12	NO	9.	12 and 11	FB-
	14 & 12	NO		13 & 11	NO		12 & 10	NO
	14 & 11	NO		13 & 10	NO		12 & 9	FB-
	14 & 10	NO		13 & 9	NO		12 & 8	FB+
	14 & 9	NO		13 & 8	NO		12 & 7	FB+
	14 & 8	NO		13 & 7	NO		12 & 6	FB+
	14 & 7	NO		13 & 6	FB+		12 & 5	NO
	14 & 6	FB-		13 & 5	NO		12 & 4	FB+
	14 & 5	NO		13 & 4	NO		12 & 3	FB+
	14 & 4	NO		13 & 3	CB+		12 & 2	FB+
	14 & 3	CB+		13 & 2	NO		12 & 1	FB+
	14 & 2	NO		13 & 1	CB+			
	14 & 1	CB+						

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
10.	11 and 10	NO	11.	10 and 9	NO	12.	9 and 8	NO
	11 & 9	NO		10 & 8	NO		9 & 7	NO
	11 & 8	CB+		10 & 7	NO		9 & 6	NO
	11 & 7	NO		10 & 6	FB-		9 & 5	NO
	11 & 6	FB+		10 & 5	FB+		9 & 4	NO
	11 & 5	NO		10 & 4	CB+		9 & 3	NO
	11 & 4	NO		10 & 3	CB+		9 & 2	NO
	11 & 3	FB+		10 & 2	NO		9 & 1	NO
	11 & 2	NO		10 & 1	CB+			
	11 & 1	CB+						

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
13.	8 and 7	NO	14.	7 and 6	FB+	15.	6 and 5	NO
	8 & 6	FB+		7 & 5	NO		6 & 4	NO
	8 & 5	NO		7 & 4	CB+		6 & 3	CB+
	8 & 4	NO		7 & 3	CB+		6 & 2	NO
	8 & 3	FB+		7 & 2	CB+		6 & 1	CB+
	8 & 2	NO		7 & 1	CB+			
	8 & 1	FB+						

POSSIBLE PAIRS AND POSSIBLE TRENDS

OF WEST COAST SAMPLE (DAHANU COAST)

NORTH TREND

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
16.	5 and 4	NO	17.	4 and 3	FB+	18.	3 and 2	NO
	5 & 3	NO		4 & 2	NO		3 & 1	NO
	5 & 2	NO		4 & 1	FB+			
	5 & 1	NO						
19.	2 & 1	FB+						

F : FINE

B : BETTER SORTED

NO : IT IS NOT FB -, FB+, AND CB+

1 - 20 : PROFILE NUMBERS

TABLE VII.9

POSSIBLE PAIRS AND POSSIBLE TRENDS

OF WEST COAST SAMPLE (DAHANU COAST)

SOUTH TREND

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
1	1 and 2	NO	2.	2 and 3	FB+	3.	3 and 4	NO
	1 & 3	FB+		2 & 4	FB+		3 & 5	NO
	1 & 4	NO		2 & 5	NO		3 & 6	NO
	1 & 5	NO		2 & 6	FB+		3 & 7	NO
	1 & 6	NO		2 & 7	NO		3 & 8	NO
	1 & 7	NO		2 & 8	FB-		3 & 9	NO
	1 & 8	NO		2 & 9	FB-		3 & 10	NO
	1 & 9	NO		2 & 10	NO		3 & 11	NO
	1 & 10	NO		2 & 11	FB-		3 & 12	NO
	1 & 11	NO		2 & 12	NO		3 & 13	NO
	1 & 12	NO		2 & 13	FB-		3 & 14	NO
	1 & 13	NO		2 & 14	FB+		3 & 15	NO
	1 & 14	NO		2 & 15	NO		3 & 16	NO
	1 & 15	NO		2 & 16	FB-		3 & 17	NO
	1 & 16	NO		2 & 17	NO		3 & 18	NO
	1 & 17	NO		2 & 18	FB-		3 & 19	NO
	1 & 18	NO		2 & 19	NO		3 & 20	NO
	1 & 19	NO		2 & 20	NO			
	1 & 20	NO						

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
4.	4 and 5	NO	5.	5 and 6	NO	6.	6 and 7	NO
	4 & 6	FB-		5 & 7	NO		6 & 8	NO
	4 & 7	NO		5 & 8	NO		6 & 9	NO
	4 & 8	NO		5 & 9	NO		6 & 10	NO
	4 & 9	NO		5 & 10	NO		6 & 11	NO
	4 & 10	NO		5 & 11	NO		6 & 12	NO
	4 & 11	FB-		5 & 12	NO		6 & 13	NO
	4 & 12	NO		5 & 13	NO		6 & 14	NO
	4 & 13	FB-		5 & 14	NO		6 & 15	NO
	4 & 14	FB-		5 & 15	NO		6 & 16	NO
	4 & 15	NO		5 & 16	NO		6 & 17	NO
	4 & 16	NO		5 & 17	NO		6 & 18	NO
	4 & 17	NO		5 & 18	NO		6 & 19	NO
	4 & 18	NO		5 & 19	NO		6 & 20	NO
	4 & 19	NO		5 & 20	NO			
	4 & 20	NO						

POSSIBLE PAIRS AND POSSIBLE TRENDS

OF WEST COAST SAMPLE (DAHANU COAST)

SOUTH TREND

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
7.	7 and 8	NO	8.	8 and 9	NO	9.	9 and 10	NO
	7 & 9	NO		8 & 10	NO		9 & 11	NO
	7 & 10	NO		8 & 11	NO		9 & 12	NO
	7 & 11	NO		8 & 12	NO		9 & 13	NO
	7 & 12	NO		8 & 13	FB-		9 & 14	NO
	7 & 13	NO		8 & 14	FB+		9 & 15	NO
	7 & 14	NO		8 & 15	NO		9 & 16	NO
	7 & 15	NO		8 & 16	FB+		9 & 17	NO
	7 & 16	CB+		8 & 17	NO		9 & 18	NO
	7 & 17	NO		8 & 18	NO		9 & 19	NO
	7 & 18	NO		8 & 19	NO		9 & 20	NO
	7 & 19	NO		8 & 20	NO			
	7 & 20	NO						

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
10.	10 and 11	NO	11.	11 and 12	NO	12.	12 and 13	NO
	10 & 12	NO		11 & 13	FB+		12 & 14	FB+
	10 & 13	NO		11 & 14	FB+		12 & 15	NO
	10 & 14	NO		11 & 15	NO		12 & 16	FB+
	10 & 15	NO		11 & 16	CB+		12 & 17	FB+
	10 & 16	NO		11 & 17	NO		12 & 18	FB+
	10 & 17	NO		11 & 18	CB+		12 & 19	NO
	10 & 18	NO		11 & 19	NO		12 & 20	NO
	10 & 19	CB+		11 & 20	NO			
	10 & 20	NO						

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
13.	13 and 14	FB+	14.	14 and 15	NO	15.	15 and 16	FB-
	13 & 15	NO		14 & 16	NO		15 & 17	FB-
	13 & 16	CB+		14 & 17	NO		15 & 18	FB-
	13 & 17	NO		14 & 18	NO		15 & 19	NO
	13 & 18	CB+		14 & 19	NO		15 & 20	NO
	13 & 19	NO		14 & 20	NO			
	13 & 20	NO						

POSSIBLE PAIRS AND POSSIBLE TRENDS

OF WEST COAST SAMPLE (DAHANU COAST)

SOUTH TREND

NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS	NO.	POSSIBLE PAIRS	POSSIBLE TRENDS
16.	16 and 17	NO	17.	17 and 18	NO	18.	18 and 19	NO
	16 & 18	NO		17 & 19	NO		19 & 20	NO
	16 & 19	NO		17 & 20	NO			
	16 & 20	NO						
19.	19 & 20	FB-						

FB - : FINE BETTER SORTED NEGATIVE

B : BETTER SORTED

NO : IT IS NOT FB -,FB+, CB+

1 - 20 : PROFILE NUMBERS

3. Profile 3 is not a source for any of the others.
4. Profile 4 could be a source for profiles 6,11,13, & 14.
5. Profile 5 is not a source for any of the others.
6. Profile 6 could be a source for profiles 1 & 3.
7. Profile 7 could be a source for profiles 1,2,3,4 & 16.
8. Profile 8 could be a source for profile 13.
9. Profile 9 is not a source for any of the others.
10. Profile 10 could be a source for profiles 1,3,4,5,6, & 19.
11. Profile 11 could be a source for profiles 1,8, 16 & 18.
12. Profile 12 could be a source for profiles 9, 11.
13. Profile 13 could be a source for profiles 1,3,16 & 18.
14. Profile 14 could be a source for profiles 1,3, & 6.
15. Profile 15 could be a source for profiels 1 to 18.
16. Profile 16 is not a source for any of the others.
17. Profile 17 could be a source for profiles 2,11 & 13.
18. Profile 18 is not a source for any of the others.
19. Profile 19 could be a source for profiles 1,2,3,4,6,7,8,9,11, 12, 13, 14, 16, 17, 18, & 20.
20. Profile 20 could be a source for profiles 2,6,7,8,9,11,12,13, 16,17 & 18.

The mechanism by which a deposit is derived from the source are illustrated in three separate cases.

1 - Case 1 (Total deposition) FB-

2 - Case 2 (Selective deposition) FB+

in which process not capable of eroding coarser than m(Ø) of source.

3 - Case 3 (Selective deposition) CB+, in which process capable of eroding coarser than m(Ø) of source.

Pairs showing case 1, case 2, and case 3 are presented in Table VII.10, VII.11 and VII.12 respectively.

TABLE VII.10

Table showing various pairs of complete deposition (Case 1)

No. of Profile	Pairs showing case 1 (complete deposition)
2	2 & 8, 2 & 9, 2 & 11, 2 & 13, 2 & 16, 2 & 18,
4	4 & 6, 4 & 11, 4 & 13, 4 & 14,
8	8 & 13,
10	10 & 6,
12	12 & 9, 12 & 11,
14	14 & 6,
15	15 & 1, 15 & 2, 15 & 3, 15 & 4, 15 & 5, 15 & 6, 15 & 7, 15 & 8, 15 & 8, 15 & 9, 15 & 10, 15 & 11, 15 & 12, 15 & 13, 15 & 14, 15 & 15, 15 & 16, 15 & 17, 15 & 18,
17	17 & 11, 17 & 13,
19	19 & 1, 19 & 2, 19 & 3, 19 & 4, 19 & 6, 19 & 7, 19 & 8, 19 & 9, 19 & 11, 19 & 12, 19 & 13, 19 & 14, 19 & 16, 19 & 17, 19 & 18, 19 & 20,
20	20 & 2, 20 & 6, 20 & 7, 20 & 8, 20 & 9, 20 & 11, 20 & 12, 20 & 13, 20 & 16, 20 & 17, and 20 & 18.

TABLE VII.11

Table showing various pairs of selective deposition (Case 2)

No. of Profile	Pairs showing case 2 (selective deposition)
1	1 & 3,
2	2 & 1 2 & 3, 2 & 4, 2 & 6, 2 & 14,
4	4 & 1, 4 & 3,
7	7 & 6,
8	8 & 1, 8 & 3, 8 & 6, 8 & 14,
11	11 & 3, 11 & 6, 11 & 13, 11 & 14,
12	12 & 1, 12 & 2, 12 & 3, 12 & 4, 12 & 6, 12 & 7, 12 & 8, 12 & 14, 12 & 16, 12 & 17 12 & 18,
13	13 & 6, 13 & 14,
16	16 & 1, 16 & 3, 16 & 6, 16 & 14,
17	17 & 1 17 & 3, 17 & 6, 17 & 14,
18	18 & 1, 18 & 3,
20	20 & 1, 20 & 3 & 20 &4.

TABLE VII.12

Table showing various pairs of selective depositions (Case 3)

No. of Profile	Pairs showing case 3 (selective deposition)
6	6 & 1, 6 & 3,
7	7 & 1, 7 & 2, 7 & 3, 7 & 4, 7 & 16,
10	10 & 1, 10 & 3, 10 & 4, 10 & 5, 10 & 19,
11	11 & 1, 11 & 8, 11 & 16, 11 & 18,
13	13 & 1, 13 & 3, 13 & 16, 13 & 18,
14	14 & 1, 14 & 3,
17	17 & 2.

An examination of grains-size trends among 20 grab samples from the lower beach face suggests the following.

1. Of 380 possible pairs contained in the complete suite of samples a possible 190 (N) "north trending" pairs and conversely, 190 "south trending" pairs of the possible cases are case B (FB-) in the north direction is the only significant trend (Table VII.13).

2. The S to N transport is dominant over N to S.

3. The S-N transport is controlled mainly by SW and westerly winds whreas N-S transport is related to the ebb tide effect of Gulf of Cambay.

4. The main bulk of the sediments comes from deeper parts of the shelf, various river e.g Indus, Narmada, Mahi, Sabarmati etc., intertidal rocky platform and Mass wasting action.

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Table. VII.13 summary of numbers of pairs of West Coast (Dahanu-Kora) producing transport trends.

		North Trend	South Trend
Case - B	F	N = 190	N = 190
	B	X = 46	X = 15
	-	Z = 4.88	Z = -1.92
Case - C	C	N = 190	N = 190
	B	X = 16	X = 6
	+	Z = 1.7	Z = 3.89