CHAPTER

VIII

COASTAL DEPOSITS

TIDAL MUDFLAT DEPOSITS
BEACH DEPOSITS

CHAPTER VIII

COASTAL DEPOSITS

TIDAL MUDFLAT DEPOSITS

Tidal mudflats which constitute, by far the most extensive deposits of the Gulf appear to be the products of strong tidal currents operating within the Gulf. These important Gulf sediments have remained practically uninvestigated. The present author has endeavoured to collect some details pertaining to the nature of these sediments, which by their sheer abundance, dominate the Gulf environment. They are so conspicuous to observe, but a lot remains to be known about them. There are many questions which need to be answered. One must know the precise source of these sediments. Where do they come from?

Secondly, how do they get reworked and redistributed constantly on account of tidal agitation? No doubt, the various rivers from the Mainland are the principal sources of the Gulf of Khambhat sediments, little information is available on the nature of the detritus brought by them. In this chapter, the author has endeavoured to provide a 'bird-eye-view' of the nature of sediment load deposited by the tidal waters of the Gulf. With a view to obtain maximum data pertaining to the nature of these tidalflat sediments the present author analysed samples from representative locations. His studies comprised :

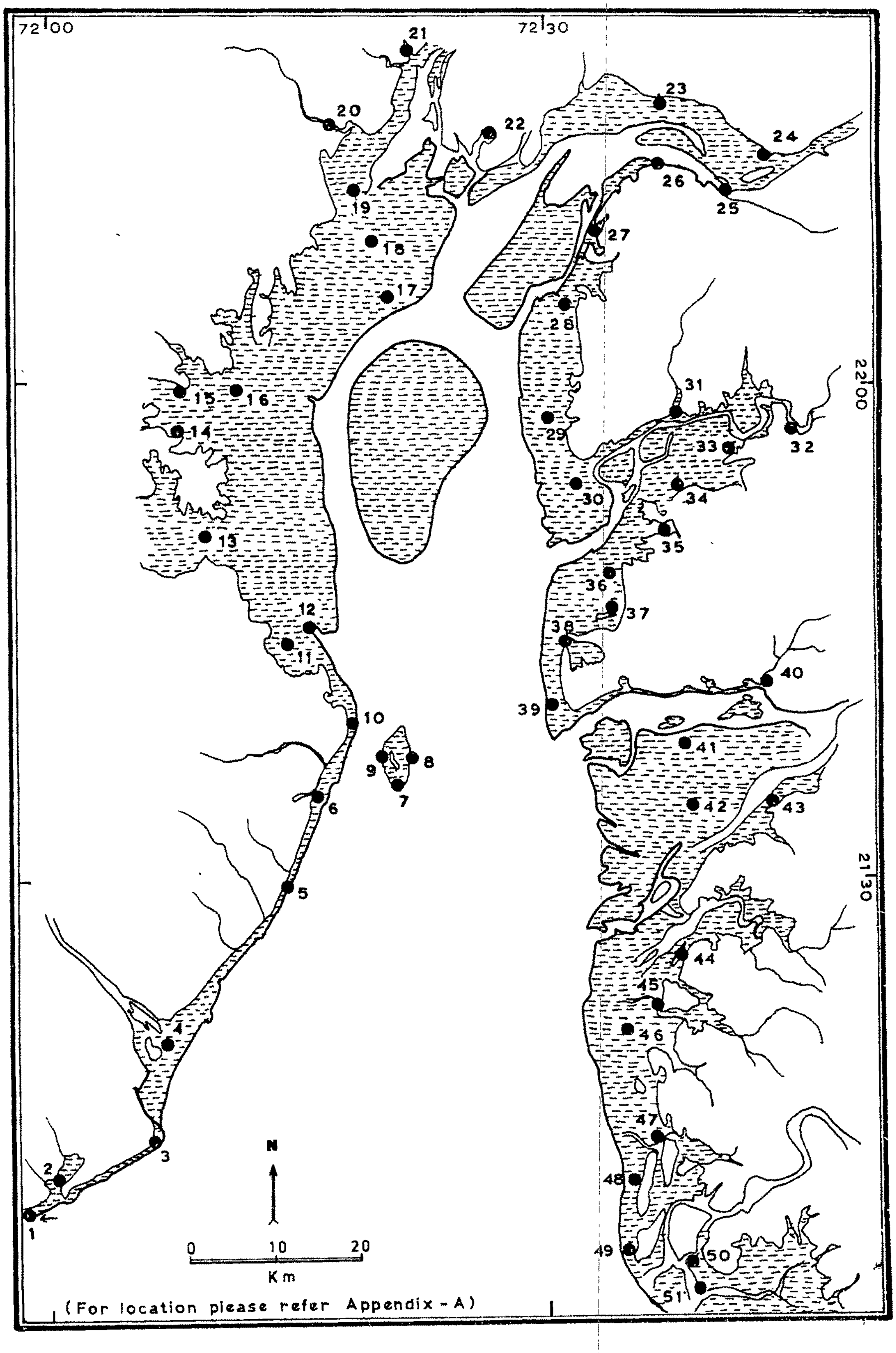
i) Grain size analysis
ii) X-Ray analysis (bulk mineralogy)
iii) Bulk chemistry
iv) Clay mineralogy

For the above studies 78 samples were collected from 51 stations (Fig.VIII.1).

GRAIN-SIZE ANALYSIS

The muds from 50 locations were analysed. Samples were properly washed to remove the dissolved salts. The washing procedure involved disaggregation of the mud in distilled water and allowing to settle for a few days followed by decantation. This procedure was repeated several times until free from dissolved salts. The washed samples were then kept

FIG. VIII.1



LOCATION MAP OF TIDAL MUD SAMPLES

at 40°C in oven till they were completely dry.

Previously weighed (approx. 20 gm) sample was then taken and soaked in distilled water. For the separation of coarser (sand) and finer (silt + clay) fractions it was then allowed to pass through ASTM 230 mesh sieve. The coarser fraction (sand $> 62\mu$) was retained in the sieve, while the finer fractions (silt + clay $< 62\mu$) passed through it. The two fractions were collected separately, ~~and~~ dried and weighed.

The finer fraction was further analysed for the estimation of silt and clay fractions with the help of a computerised Centrifugal Particle Size Analyser (Shimadzu, Model SA-CP2). For this analysis approximately 1 gm sample was taken and soaked overnight in distilled water along with 5 % sodium hexametaphosphate (dispersing agent). Next day it was stirred in a magnetic stirrer and fed to the instrument as per the procedure recommended for the instrument. The samples were run in a 'combined' mode (i.e. gravity method + centrifugal method) which gives the automatic printout of the weight percentages of different size fractions. Prior to this analysis the average particle density of the samples were measured by a density measuring bottle. During operation the following instructions were fed to the instrument:

Particle density - 2.6 gm/cc (varies from sample to sample)

Liquid density - 0.9 gm/cc (subject to change with room temperature)

Viscosity - 1.1 centipoise (Subject to change with room temperature)

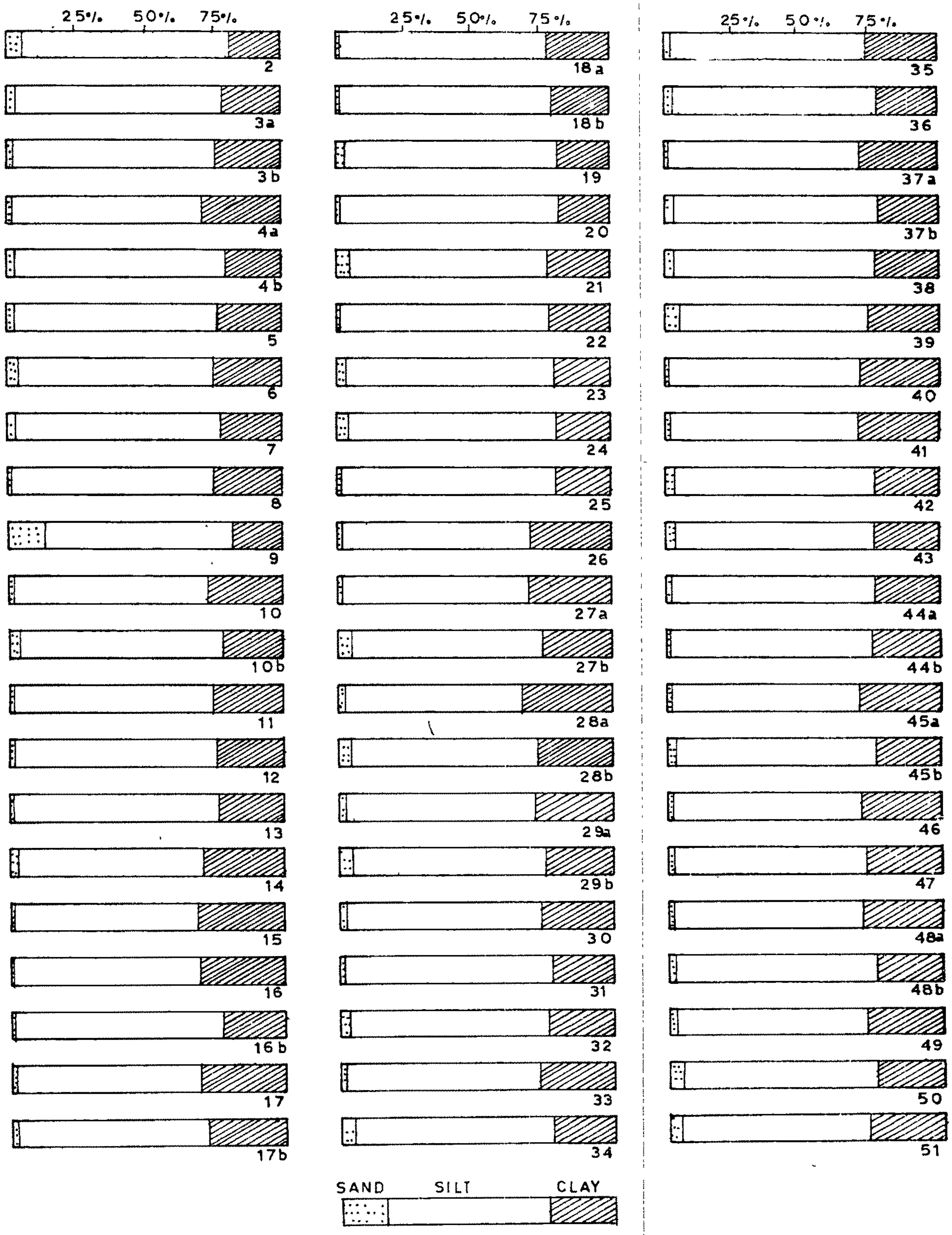
Depth of the cell - 1

Rotation - 500 RPM

The percentages of sand, silt and clay fractions were then calculated (Fig.VIII.2) and plotted on Shepard's triangular diagrams (Fig.VIII.3). It is seen that the major bulk of tidal mud in all segments is made up of silt sized particles, their proportion varying from 60% to 75 %. The sand fractions are always less than 6 %, while clay fraction varies from 15 % to 30 %. The triangular diagrams show that for all the segments the overall sizes of the tidal mud fall within the 'clayey silt' to 'silt' field.

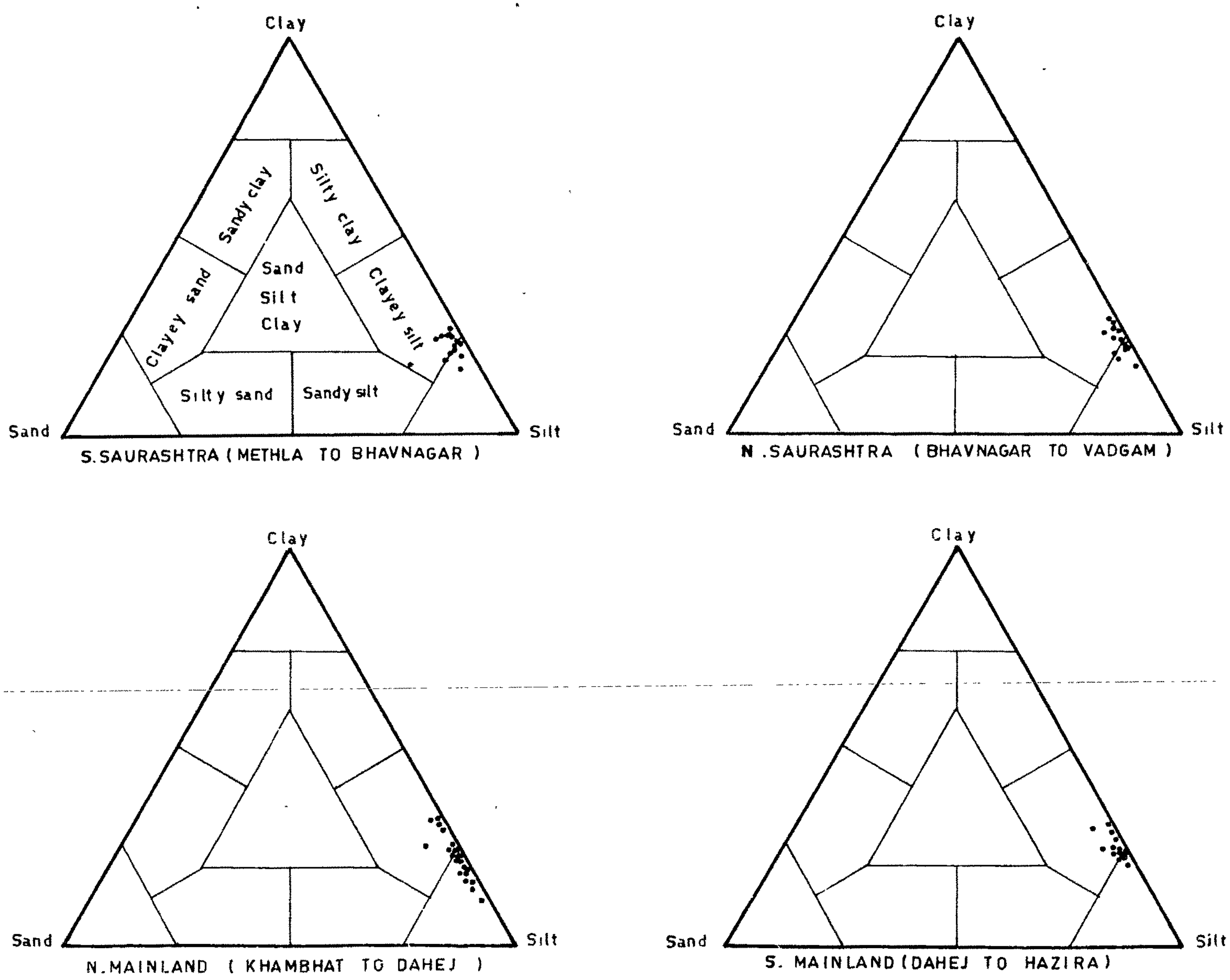
An interesting phenomenon recorded is the relative richness in clay fraction nearer to the low water line as compared to that at the high water line. The present author collected two samples each from the representative locations and determined their sand, silt and clay percentages. The results are shown in Fig. VIII.4. Obviously this indicates that during flood tide the sediments are carried towards high water line and then the larger particles (sand + silt) are dropped and the finer particles are carried back during ebb tide.

FIG VIII. 2



GRAIN SIZE DISTRIBUTION OF TIDAL MUD IN PERCENTAGE

FIG. VIII. 3



TRIANGULAR GRAIN SIZE VARIATION DIAGRAM OF TIDALMUD

FIG. VIII.4

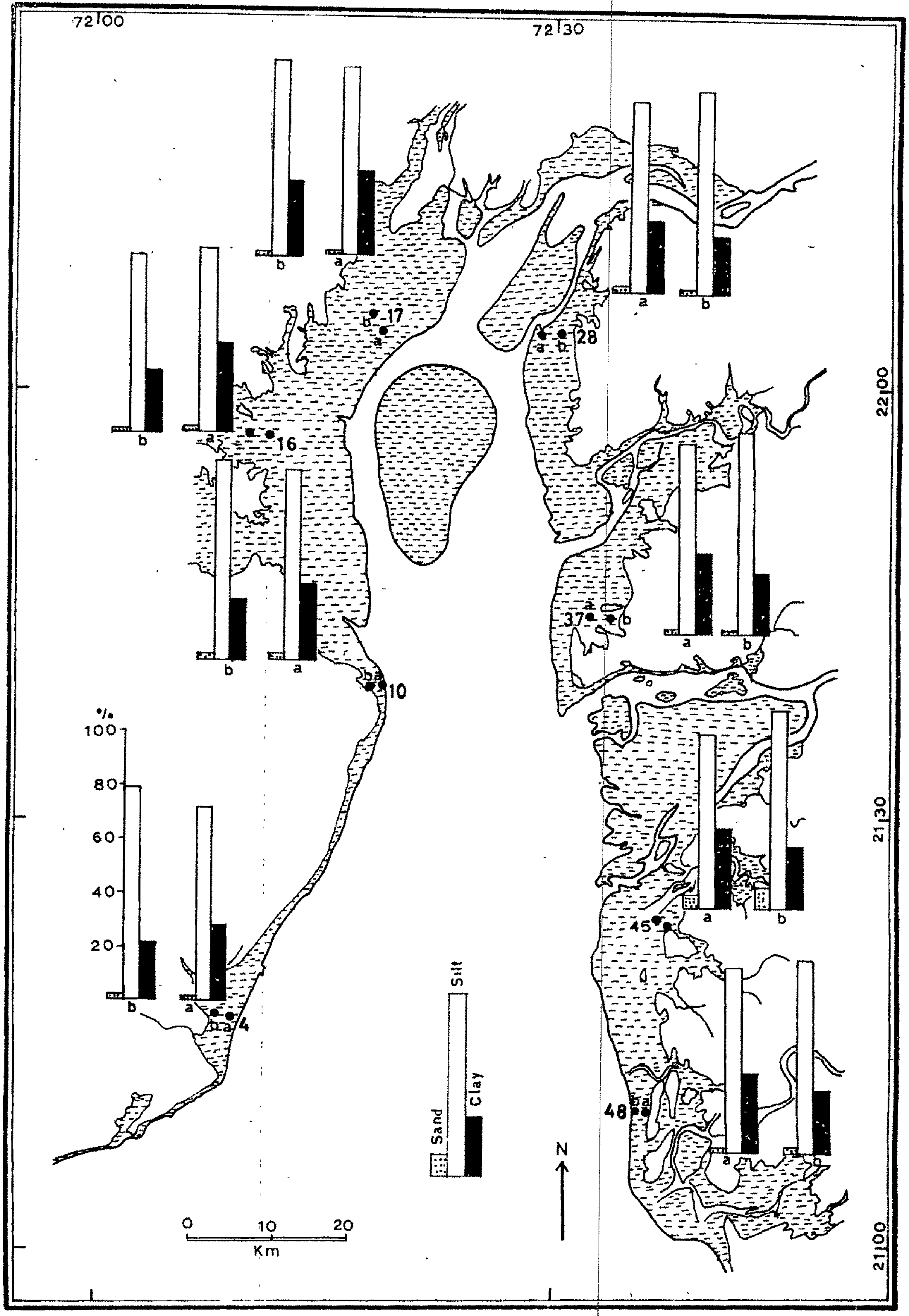


DIAGRAM SHOWING RELATIVE RICHNESS OF CLAY FRACTION NEARER TO THE LOW WATER LINE

X-RAY ANALYSIS (BULK MINERALOGY)

To know the mineral constituents of the mud samples, a few selected samples were studied by X-Ray Diffraction method. The total bulk samples of the mud were analysed. Each sample was first oven dried at 40°C for an hour and finely powdered with the help of an agate mortar. The dry powder was then mounted over slides, fed to the X-Ray machine and diffractograms obtained. Analyses were carried out on the Philips PW-1720 X-Ray generator with Philips PM 1840 diffractometer with Silicon detectors using Ni filtered Cu$k\alpha$ radiation. In order to get sharp peaks slow scanning speed was chosen. The diffractograms were obtained by scanning the samples from 2°2θ to 70°2θ with High tension: 35 kv, Filament current: 25 mA, Goniometer speed: 0.02°2θ/s, Chart speed: 10 mm/°2θ, Range: 5×10^3 C/s. Time constant: 1 second and Slit: 0.3 mm.

For the interpretation of the diffractograms the 'd' spacing and intensities were calculated and compared with the ASTM Card Data File for different minerals. The results obtained are given in Tables 8.1 to 8.4.

The bulk mineralogy of the mudflats as revealed by the X-ray studies points to an overall uniformity. No significant variation trends are observed and this has to be expected because the material analysed typically represents the product of continuous mixing and repeated cycling of

TABLE 8.1 X-RAY ANALYSES OF MUD SAMPLES
SOUTH SAURASHTRA (METHLA TO BHAVNAGAR)

	MINERALS	SAMPLE NOS.											
		1	2	3	4	5	6	7	8	9	10	11	12
CLAY MINERALS	Mo	O	O	O	O	O	O	O	O	O	O	O	O
	Ka	O	O	O	O	O	O	O	O	O	–	–	O
	Ha	–	O	O	O	O	–	–	O	O	O	O	–
	Na	–	–	O	–	O	–	O	O	O	–	–	O
	Di	–	–	–	–	–	–	–	–	O	–	–	O
	I	O	O	O	O	O	O	O	O	O	O	O	O
	Bi	–	–	–	–	–	–	O	–	O	–	–	–
	Mu	O	O	O	O	O	O	O	O	O	O	O	O
	Zi	–	–	–	–	–	–	O	–	–	–	–	–
	Gla	–	–	–	–	–	–	–	–	O	–	–	–
	Ch	O	O	O	O	O	O	O	O	O	O	O	O
	Pe	–	–	–	–	–	–	–	–	–	–	–	–
	Se	–	O	–	O	–	O	O	O	–	–	O	–
NON-CLAY MINERALS	Q	O	O	O	O	O	O	O	O	O	O	O	O
	Ca	O	O	O	O	O	O	–	–	O	O	O	–
	Ar	–	–	–	–	–	O	–	–	–	–	–	–
	Ze	–	–	O	–	–	–	O	O	O	O	–	–
	Ab	–	O	O	–	O	–	–	O	–	–	O	–
	Mgh	–	–	–	–	–	–	–	–	–	–	–	–
	Goe	–	–	–	–	–	–	–	–	–	–	–	–
	Gib	O	O	O	O	–	O	O	O	–	O	O	O
	Ba	–	–	–	O	O	–	–	–	–	–	–	–

'O' Present, '–' Absent / Under detectable limit
(For location please refer Fig VIII I)

TABLE 8 2 X-RAY ANALYSES MUD SAMPLES
NORTH SAURASHTRA (BHAVNAGAR TO VADGAM)

	MINERALS	SAMPLES NOS								
		13	14	15	16	17	18	19	20	21
CLAY MINERALS	Mo	O	O	O	O	O	O	O	O	O
	Ka	O	O	O	O	O	—	O	O	—
	Ha	O	—	—	O	—	O	—	O	O
	Na	—	O	—	O	O	—	O	O	—
	Di	—	O	—	—	—	—	—	—	—
	I	O	O	O	O	O	O	O	O	O
	Bi	—	—	O	—	—	—	O	—	—
	Mu	O	O	O	O	O	O	—	O	O
	Zi	—	—	—	—	—	—	—	—	—
	Gla	—	—	—	—	—	—	—	—	—
	Ch	O	O	O	O	O	O	O	O	O
	Pa	—	—	—	—	—	—	—	—	—
	Se	—	O	O	O	O	—	O	O	O
NONCLAY MINERALS	Q	O	O	O	O	O	O	O	O	O
	Ca	O	O	O	O	O	O	O	O	—
	Ar	—	—	O	—	—	O	—	—	—
	Ze	—	—	—	O	O	—	O	—	—
	Ab	—	—	—	—	—	—	O	O	—
	Mgh	—	—	—	—	O	—	O	—	—
	Goe	—	—	—	—	—	—	—	—	—
	Gib	O	—	—	O	—	—	—	O	—
	Ba	—	—	O	—	—	—	—	—	—

O Present '—' Absent / Under detectable limit
(For locations please refer Fig VIII I)

TABLE 8.3 X-RAY ANALYSES OF MUD SAMPLES
NORTH MAINLAND (KHAMBHAT TO DAHEJ)

	MINERALS	SAMPLE NOS.																		
		22	23	24	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
CLAY MENERALS	Mo	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	
	Ka	O	O	O	O	—	—	O	O	—	O	—	O	—	O	O	O	O	O	
	Ha	O	O	—	O	—	O	O	O	O	—	—	—	O	O	—	—	O	—	
	Na	—	—	O	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	
	Di	—	O	—	—	O	—	—	—	—	—	—	—	—	—	—	O	O	—	
	I	O	O	—	O	O	—	O	O	O	O	O	O	—	O	O	O	O	O	
	Bi	—	—	—	O	—	—	—	—	O	—	—	—	O	O	—	—	—	O	
	Mu	O	O	O	O	—	O	O	O	O	O	O	O	O	O	O	O	O	O	
	Zi	—	—	—	—	—	O	—	—	—	—	—	O	—	O	—	—	O	—	
	Gla	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Ch	O	O	O	O	O	—	O	O	O	O	O	O	O	O	O	O	O	O	
	Pa	—	O	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—	—	
	Se	O	O	O	O	O	—	—	O	O	—	—	—	—	—	—	O	O	—	
NONCLAY MINERALS	Q	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	
	Ca	O	O	O	O	O	O	—	O	O	—	—	O	O	—	O	—	O	O	
	Ar	—	—	—	—	—	—	—	—	—	O	O	O	—	—	O	—	—	—	
	Ze	—	O	—	—	—	O	—	—	O	—	O	O	O	O	O	—	—	—	
	Ab	—	O	O	—	—	—	—	O	—	—	—	—	—	—	—	—	O	O	
	Mgh	—	—	—	—	—	—	—	—	—	—	—	O	O	—	—	—	—	—	
	Goe	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Gib	O	O	—	O	O	O	—	O	O	—	O	O	O	O	O	—	O	O	
	Ba	—	—	—	—	—	—	—	—	O	O	O	O	O	—	—	—	—	—	

O Present, '—' Absent / Under detectable limit.

(For location plese refer Fig. VIII.I)

TABLE NO. 8 4 X - RAY ANALYSES OF MUD SAMPLES
SOUTH MAINLAND (DAHEJ TO HAZIRA)

	MINERALS	SAMPLE NOS.										
		41	42	43	44	45	46	47	48	49	50	51
CLAY MINERALS	Mo	O	O	O	O	O	O	O	O	O	O	O
	Ka	—	O	O	O	—	—	O	O	—	O	—
	Ha	O	O	O	O	—	—	—	O	—	O	—
	Na	—	—	O	—	—	—	O	—	—	—	—
	Di	—	—	—	—	—	—	O	O	—	—	—
	I	O	O	O	O	O	O	O	O	O	O	O
	Bi	O	O	O	—	—	—	O	—	—	O	—
	Mu	O	O	O	O	O	O	O	—	O	O	O
	Zi	—	—	—	—	—	—	O	—	—	O	—
	Gla	—	—	—	—	—	—	—	—	—	—	—
	Ch	O	O	O	O	O	O	O	O	O	O	O
	Pa	—	—	—	—	—	—	—	—	—	—	—
	Se	O	—	O	O	—	O	O	—	O	—	—
NON-CLAY MINERALS	Q	O	O	O	O	O	O	O	O	O	O	O
	Ca	O	O	O	O	O	O	—	O		O	O
	Ar	—	—	—	—	—	—	O	—	—	—	—
	Ze	O	—	—	O	—	—	—	O	—	—	—
	Ab	—	—	—	—	—	—	—	—	—	—	—
	Mgh	—	—	—	—	—	—	—	—	—	—	—
	Goe	—	—	—	—	—	—	—	—	—	—	—
	Gib	O	O	—	O	O	O	—	O	O	O	—
	Ba	—	—	O	O	—	—	—	O	O	—	—

'O' Present, '—' Absent / Under detectable limit
(For locations please refer Fig.VIII I)

Gulf sediments and fluvial material by tidal processes. However the data gives a good insight towards understanding the precise mineralogy of the sediments and the likely sources.

BULK CHEMISTRY

Chemical characters of tidal sediments are difficult to explain, but the data on chemistry to a certain extent provide useful information towards understanding the fine sediments in totality, which are otherwise difficult to study because of their fineness. No doubt, the chemistry does not give all or many answers, but it certainly throws some light on the nature of sediments, when considered along with other analytical data and field characters. In the present case also, the author has endeavoured to obtain some information on the chemistry of tidal muds, but this attempt has to be viewed in the light of the difficulty of proper sampling, lack of information about the precise mineralogy and complexity of offshore processes that have been constantly mixing and redistributing the sediments. The chemical aspects of the tidal mud samples, as obtained by the author have been given here more with a view to acquaint the reader with the chemistry of the tidal muds without arriving at definite conclusions because this was not possible at this stage of the study. The data presented by the author has to be viewed in this light only. The purpose of presenting the chemical data, therefore, aims at providing useful factual information relevant to the present study.

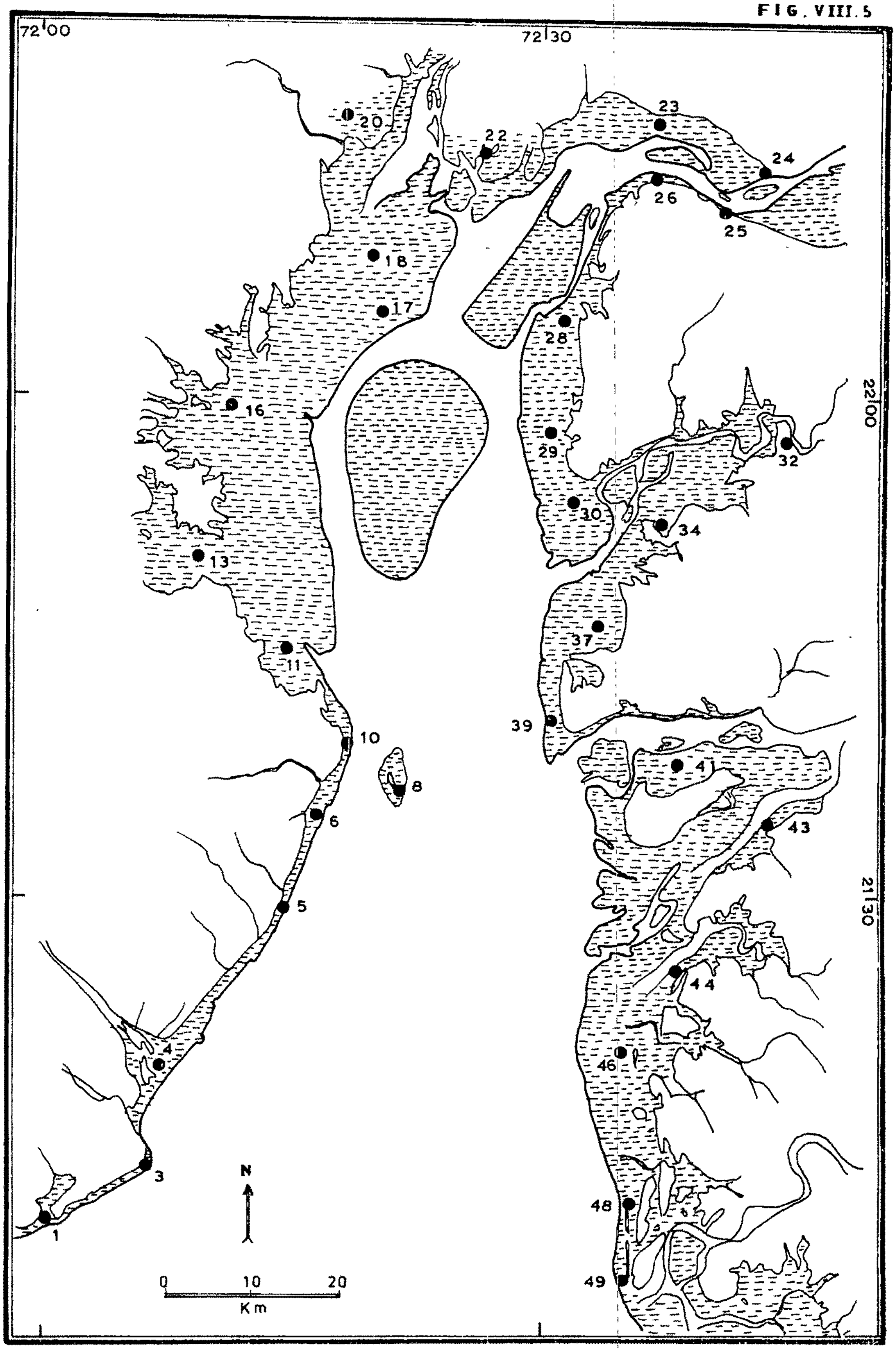
The present author analysed 31 mud samples from different locations (Fig.VIII. 5) and determined all the major oxides, following the standard procedure adopted by Shapiro & Brannock (1962) and Vogel (1975). The chemical data obtained is presented in Table 8.5 & 8.6.

The chemistry of the sediments indirectly reflects the mineralogical make up of the tidal muds in the different parts of the coast. Of course, no clear-cut conclusions can be drawn from the data, because the material analysed represents fine sediments that have been constantly reworked by tidal action. By knowing the approximate chemistry of the tidal mud, some broad conclusions on the nature of fine constituents can be drawn.

By and large, the chemistry of the mud does not point to any marked and conspicuous trend or variation. Perhaps, this is expected in an environment where the tides are constantly churning up the suspended particles. However, following generalisations, can be made:

(1) SiO_2 values tend to increase from south to north. Samples from Saurashtra and Mainland show this

FIG. VIII.5



TIDALMUD SAMPLE LOCATIONS FOR CHEMICAL ANALYSIS

TABLE 8.5 CHEMICAL ANALYSES OF TIDAL MUDS (SAURASHTRA COAST)

Oxides / Sample No	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	SO_3	L.O.I
1	43.00	16.21	10.97	0.94	5.89	3.21	2.84	2.21	0.81	12.98
3	48.5	16.53	10.01	1.61	5.71	2.17	2.06	1.72	0.72	10.57
4	50.25	17.01	10.18	1.05	6.15	2.32	2.53	1.31	0.89	9.01
5	50.5	16.51	10.38	1.61	6.17	2.27	2.91	1.01	0.52	8.43
6	50.05	16.96	12.02	1.07	5.39	1.92	1.77	1.44	0.27	9.05
8	49.35	15.63	9.58	1.85	7.15	2.55	3.72	1.35	0.39	8.44
10	50.35	17.07	10.57	0.89	4.91	2.17	2.19	1.26	0.45	10.07
11	49.85	15.82	10.08	1.43	4.82	2.81	2.89	1.76	0.72	9.31
13	50.2	16.01	9.58	1.29	6.59	2.22	1.98	1.46	0.92	9.08
16	51.03	16.40	10.58	1.07	3.66	2.89	2.73	1.76	0.17	10.26
17	52.65	14.45	9.78	1.35	4.23	2.29	2.83	1.55	0.93	9.65
18	51.37	13.01	10.42	1.81	7.04	2.40	2.98	1.11	0.18	9.66
20	51.6	16.11	10.13	1.79	5.41	2.73	2.72	1.27	0.42	7.99
22	50.71	13.29	9.57	0.63	7.13	1.85	2.59	2.14	0.21	11.75

TABLE 8.6 CHEMICAL ANALYSIS OF TIDAL MUDS (MAINLAND COAST)

Oxides / Sample No	SiO_2	Al_2O_3	Fe_2O_3	F_eO	CaO	MgO	Na_2O	F_2O	SO_3	L.O.I
23	54.8	11.07	9.38	2.09	7.29	3.05	2.98	1.75	0.16	7.35
24	57.27	10.62	9.79	2.81	6.36	1.74	2.61	1.37	0.11	7.22
25	56.43	12.76	9.08	1.03	7.31	2.36	2.08	1.23	0.20	6.62
26	56.85	11.75	8.58	0.63	7.13	2.41	1.65	1.21	0.17	9.59
28	54.00	12.86	10.57	1.25	4.99	2.44	2.17	2.01	0.36	9.26
29	54.69	12.17	11.57	0.93	4.07	2.09	2.21	1.72	1.02	8.68
30	53.21	11.23	10.88	1.08	6.45	3.01	2.38	1.35	0.63	9.69
32	52.36	12.20	11.36	1.27	5.31	2.89	2.85	1.53	0.21	10.18
34	54.4	10.92	11.58	2.17	6.03	2.32	1.91	1.01	0.31	9.13
37	52.01	11.36	10.59	1.63	7.89	3.53	2.25	1.27	0.17	9.17
39	52.27	12.84	10.78	1.07	5.13	1.92	2.49	1.30	0.25	11.9
41	52.3	13.12	10.97	1.03	5.75	2.73	2.86	2.13	0.32	8.58
43	48.17	14.79	12.98	1.16	5.73	3.33	1.67	1.19	0.21	10.65
44	52.5	12.10	12.07	2.03	6.03	1.71	2.57	1.26	0.66	8.92
46	48.55	13.29	11.77	1.72	5.26	3.14	2.32	1.08	0.89	11.67
48	46.99	14.75	12.68	1.71	6.16	2.80	2.31	1.21	1.63	9.70
49	48.25	15.07	11.08	2.61	5.19	2.72	2.68	1.76	1.27	8.50

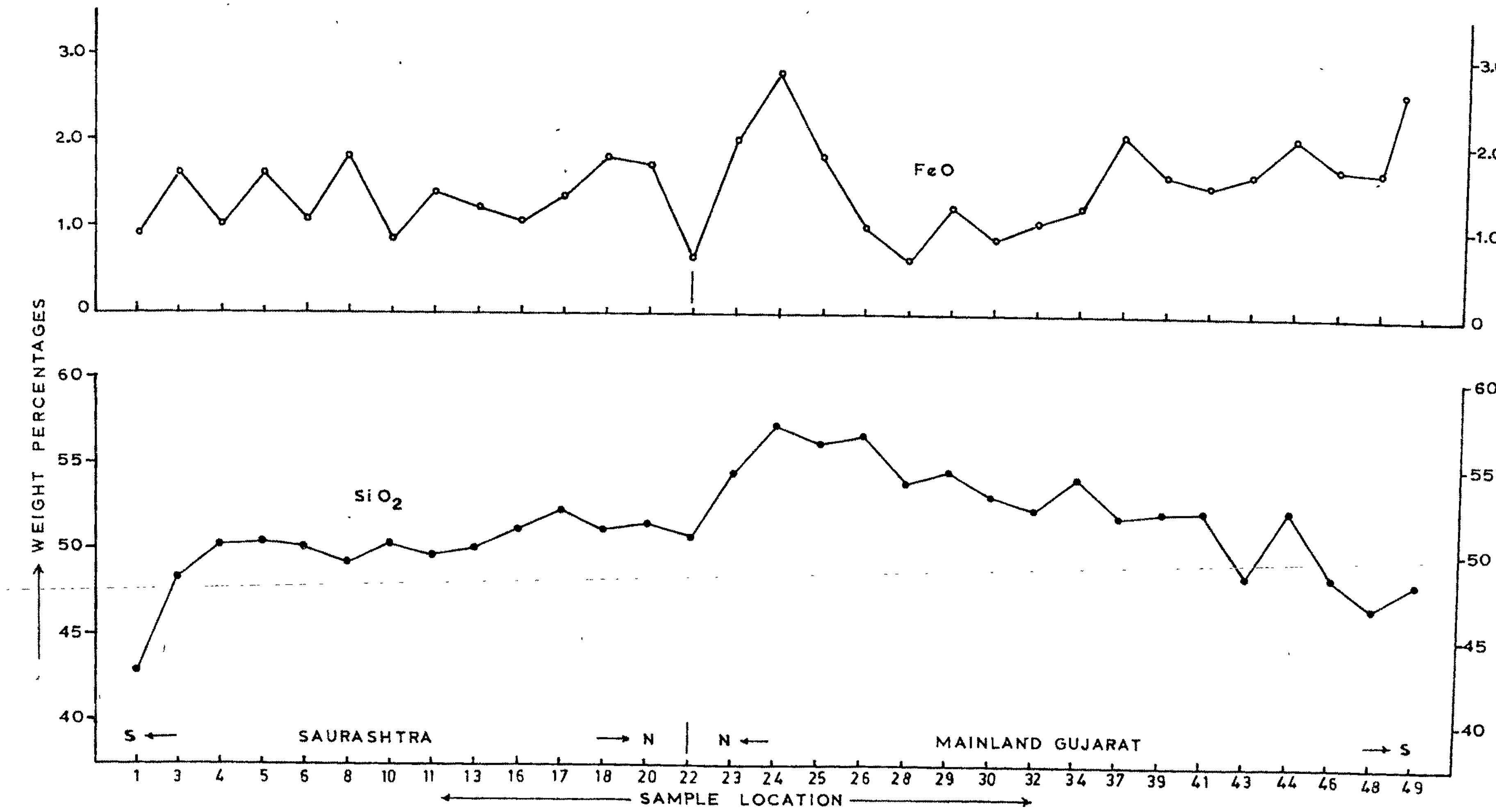
variation. On Saurashtra side, the value 43 % at Methla rises to 57 % near Dhuvaran. Similar trend is revealed on the Mainland coast; the percentage value being 47 % at Suvali (near Hazira) rising northward (Fig. VIII.6).

(2) Al_2O_3 exhibits a reverse trend. Values tend to decrease from south to north on both the coasts. At Saltanpur on Saurashtra side, it is 17 %, and this value remains more or less constant upto Bhavnagar and a little beyond, and then goes down as low as 10.62 % at Dhuvaran. Along the Mainland coast, to the southward of Dhuvaran, the Al_2O_3 content shows a tendency to increase, and at Hazira it is as high as 15.07 % (Fig VIII.7).

(3) Fe_2O_3; FeO, these two oxides of iron, point to interesting variations. Fe_2O_3 shows a slight increase from south to north, on both the coastal flanks. On the other hand, FeO values show an overall increasing trend from Saurashtra to Mainland (Fig VIII.6 & 7).

(4) So far as other oxides i.e. CaO, MgO, Na_2O and K_2O are concerned, they do not show any trend.

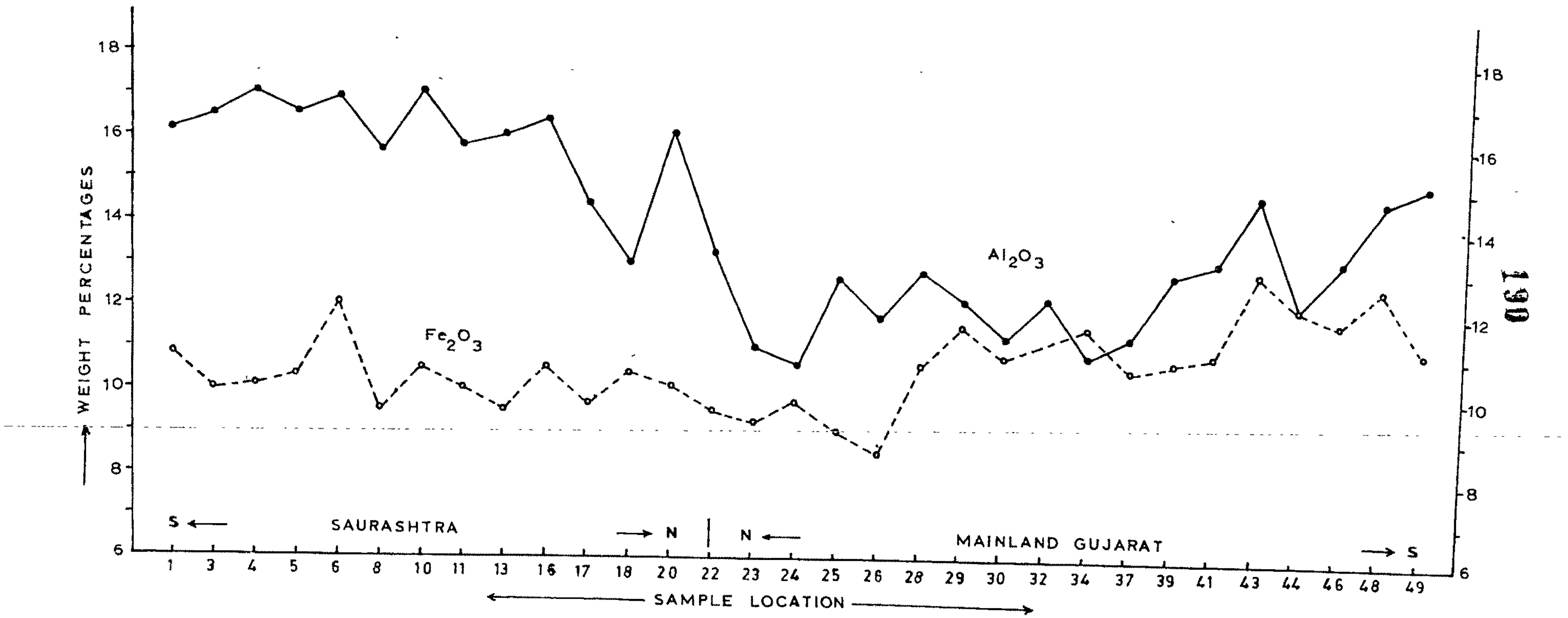
It can be deduced that provenances and source rocks, have been responsible for the chemical variations observed.



VARIATION DIAGRAM OF SiO_2 AND FeO IN THE TIDAL MUD

FIG. VIII.6

FIG. VIII. 7

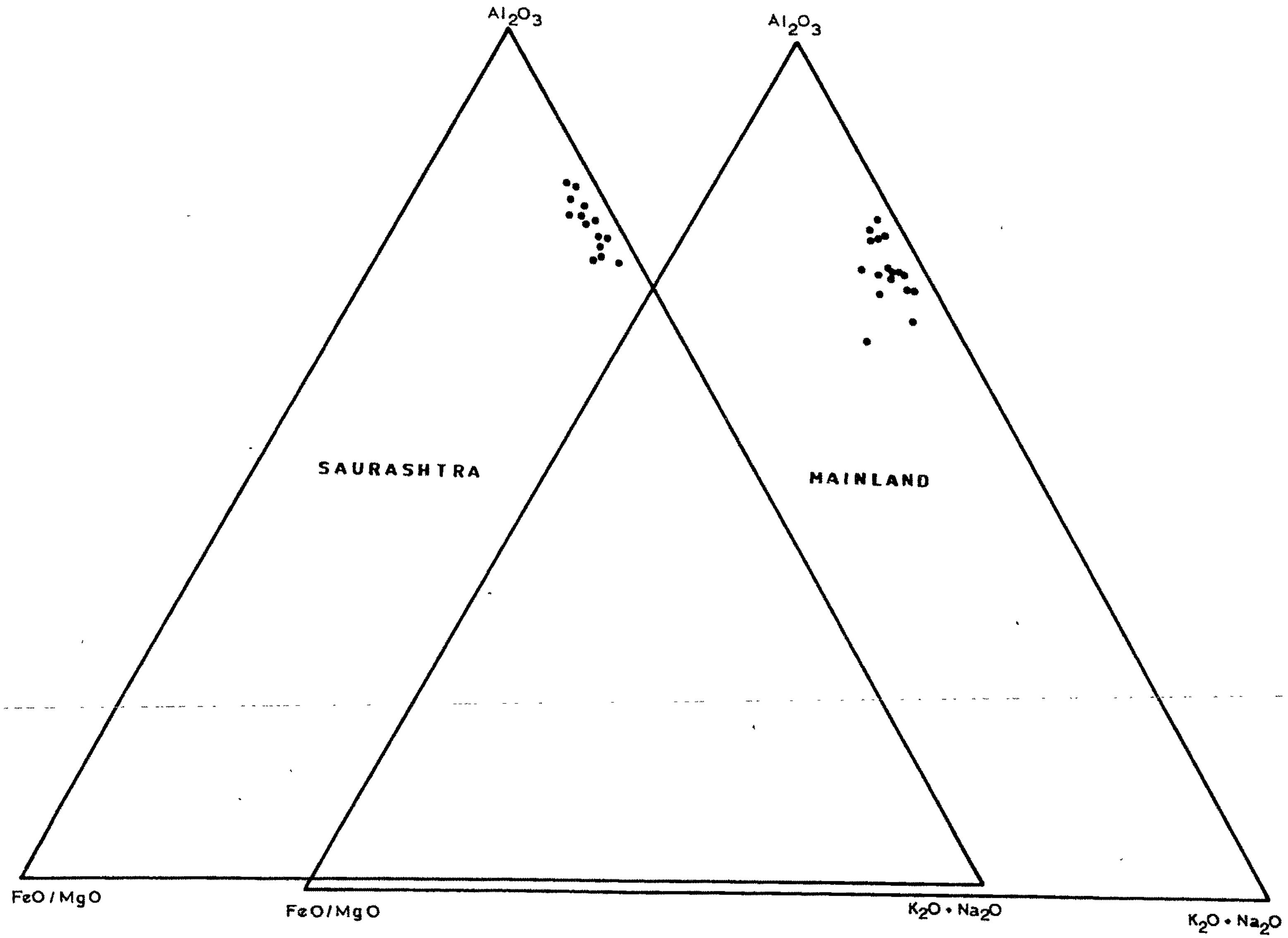


VARIATION DIAGRAM OF Al_2O_3 AND Fe_2O_3 IN THE TIDAL MUD

The tendency of relative increase in SiO_2 and decrease in Al_2O_3 contents from south to north, can best be explained by taking into account the fluvial detritus brought by the various rivers upto the Gulf. Mahi and Sabarmati bring a lot of sediments from the granitic and metamorphic areas of North and Central Gujarat, whereas the rivers on Saurashtra side as well as those of South Gujarat coast predominently drain basaltic terrains. This is reflected in the decreasing tendency for SiO_2 from north to south. The increase of Al_2O_3 is also similarly explained, the source of alumina being the lateritic (= bauxite) rocks of Saurashtra and Mainland.

The author has plotted triangular diagrams for Al_2O_3 - FeO/MgO-(K_2O+Na_2O) which show some subtle differences in the nature of the mud accumulations from Saurashtra and Gujarat Mainland (Fig.VIII.8). The range of variation of FeO/MgO ratios is more in the Mainland samples, whereas it is not so in the samples from Saurashtra side. Similarly, the variation ranges for Al_2O_3 for Mainland and Saurashtra samples are different, of course with some amount of overlapping. On the other hand, there is no significant difference in the K_2O+Na_2O contents on the two coastal flanks. These variation perhaps reflect the nature of the parent rocks that supplied these elements.

FIG. VIII.8



TRIANGULAR VARIATION DIAGRAM OF FeO / MgO-(K_2O + Na_2O)- Al_2O_3 IN THE COASTAL MUDFLAT SEDIMENTS

CLAY MINERALOGY

The author has analysed 23 representative samples to know the clay mineralogical variation in the coastal mud deposits.

Sample Preparation

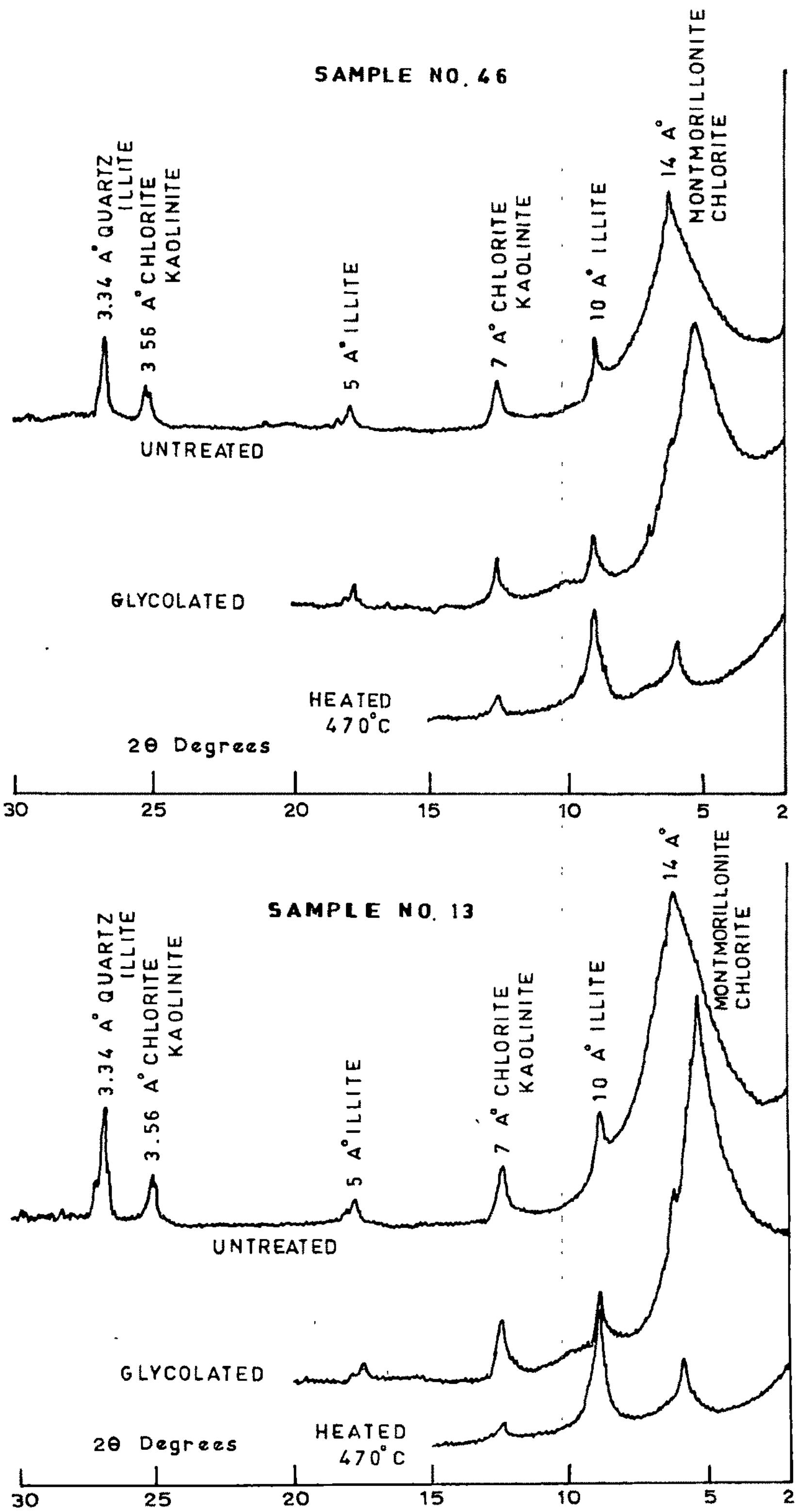
For making the slides of clay minerals the bulk sample was soaked in excess quantity of distilled water. After proper soaking the sample was treated with 5 % acetic acid and hydrogen peroxide (H_2O_2) to remove calcium carbonate and organic matter from the sample respectively. H_2O_2 acts as a dispersive agent also for the separation of individual clay minerals. After proper washing it was kept in 1000 cc cylinder, stirred properly and allowed to settle according to the Stockes' Law, used for pipette analysis. Clay fraction ($< 2\mu$) was separated by decanting the appropriate column of water from the cylinder. The clay fraction thus separated was then allowed to settle and after decantation, the concentrated suspension was obtained. Air dried oriented samples were then prepared by pipetting the sample in suspension on glass slides.

X-Ray diffraction

Clay mineral analyses were carried out by X-ray diffraction techniques by using the X-Ray Diffractometer referred to earlier. Each sample was scanned from $2°2\theta$ to $30°2\theta$ and then after glycolation by ethelene glycol, again from $2°2\theta$ to $20°2\theta$. Finally, the samples were heated for one hour at 470°C and again scanned from $2°2\theta$ to $15°2\theta$. All the samples were scanned under the following instrument setting: High tension : 35 kv, Filament current : 25 mA, Goniometer speed : 0.02 2θ/s, Chart speed : 10 mm/min, Range: $2X10^3$ C/S. Time constant : 1s, Slit : 0.2 mm.

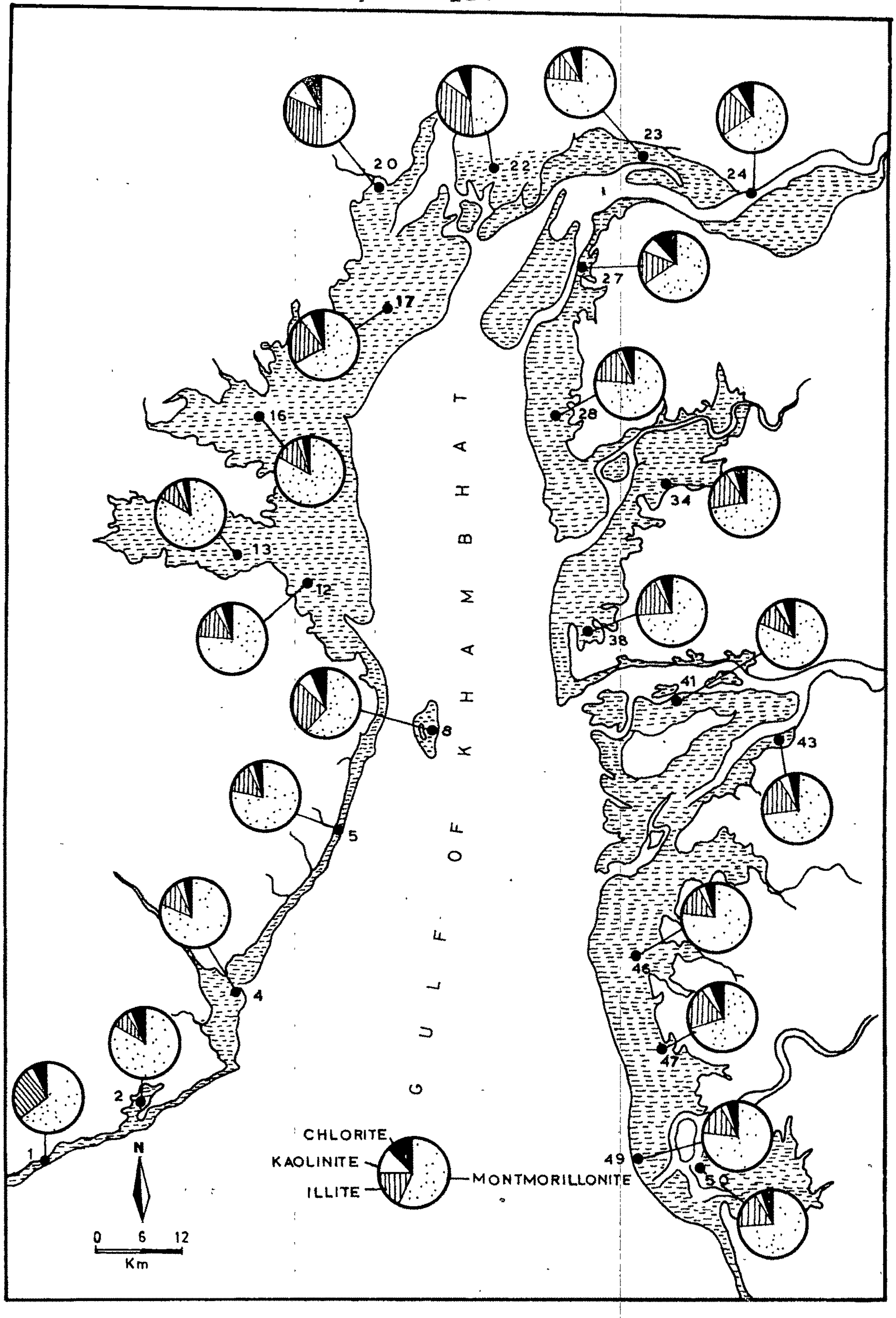
To determine the abundances of the clay minerals the author has followed the method of Biscaye (1965). The area under 17Å montmorillonite (Smectite), 10 Å illite and 7 Å chlorite plus kaolinite (Fig VIII.9) were measured using a planimeter. The relative abundances of these major clay minerals was then calculated as per below: The area of the 17 Å glycolated peak for montmorillonite; four times (4 x) the 10 Å peak area (glycolated trace) for illite; and twice (2 x) the 7 Å peak area, for kaolinite plus chlorite. For the separation of kaolinite and chlorite the 7 Å peak was divided according to the peak height ratio of 3.5 Å doublet (Biscaye, 1964). The four peak areas were summed and then normalized to 100%.

In Table 8.7 and Fig.VIII.10 are given the percentages of clay minerals present and pattern of clay mineral distribution respectively. Plates VIII.1,2,3 & 4 shows the SEM photographs of clay fractions from different locations.



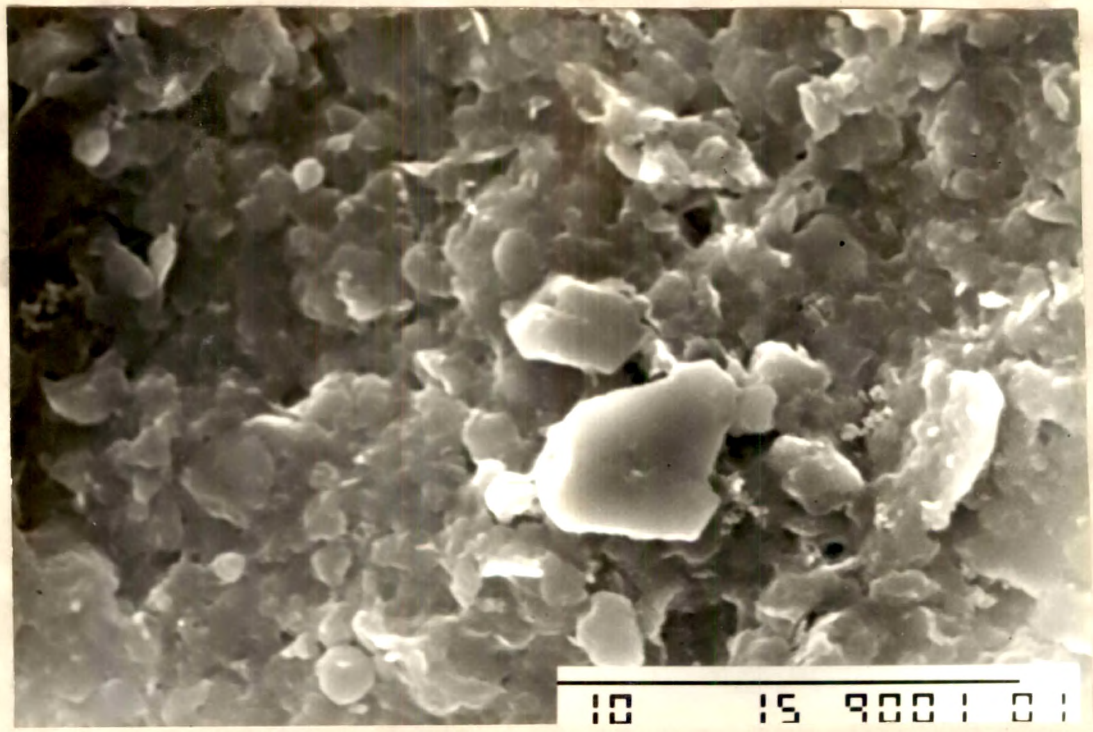
X-RAY DIFFRACTOGRAMS OF ORIENTED CLAY FRACTIONS OF SELECTED SAMPLES UNDER VARIOUS TREATMENTS

FIG. VIII.10



DISTRIBUTION OF CLAY MINERALS IN THE MUDFLATS OF THE GULF OF KHAMBHAT

(Based on peak area percentage)



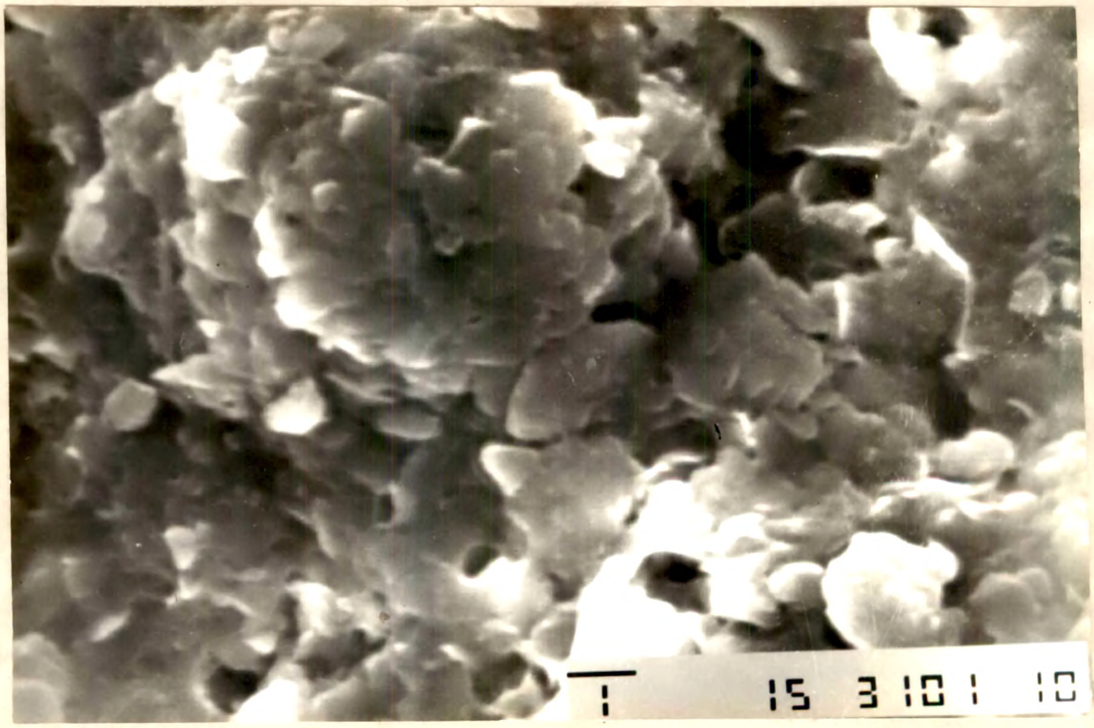
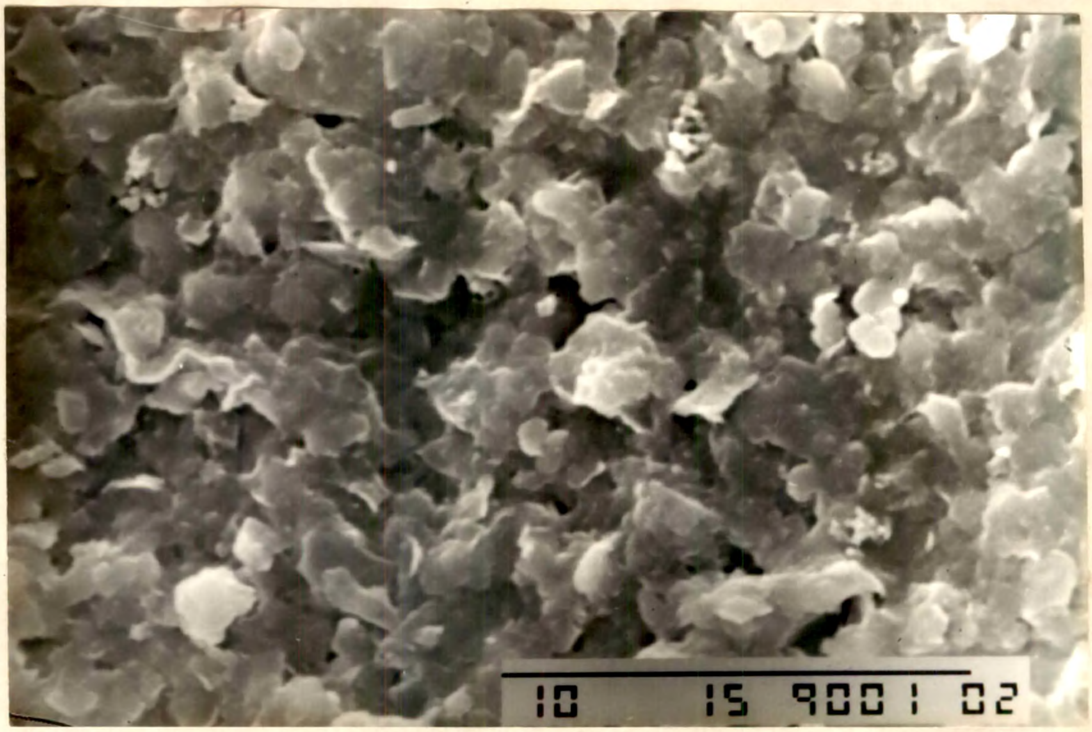
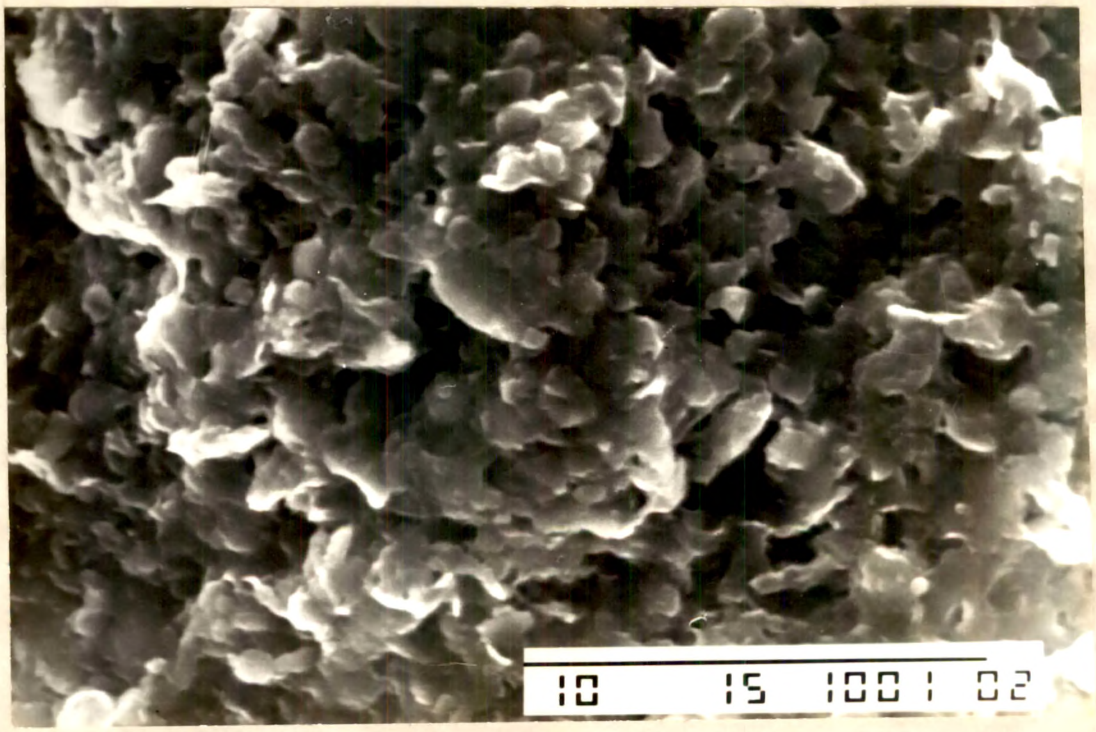


Plate VIII.1 & 2. SEM Photographs of clay fractions
1. Methla (x 6500)
2. Piram East (x 9500).





<u>Plate VIII. 3 & 4.</u> SEM Photographs of clay fractions

3. Dahej (x 6400)

4. Hazira (x 6400).

TABLE- 8.7. CLAY MINERAL PERCENTAGES IN TIDAL MUD

Sample No.	Montmorillonite %	Illite %	Kaolinite %	Chlorite %
1	63.88	25	4.01	7.10
2	82.59	9.21	3.17	5.03
4	81.14	11.43	3.73	3.70
5.	78.94	14.71	3.15	3.20
8	62.45	23.76	6.37	7.42
12	75.75	15.50	13.95	4.80
13	82.51	12.02	2.71	2.76
16	88.45	10.55	2.84	3.16
17	68.29	20.60	5.17	5.94
20	49.28	31.88	9.89	8.95
22	49.57	35.24	8.01	7.18
23	76.57	14.23	4.1	5.1
24	65.21	23.20	4.76	6.83
27	63.02	18.12	8.69	10.17
28	75.93	16.66	2.89	4.52
34	72.88	18.08	3.90	5.14
38	73.49	17.68	3.16	5.67
41	81.02	10.76	4.03	4.19
43	73.45	18.75	3.79	4.01
46	77.16	15.44	3.45	3.95
47	70.44	19.71	4.20	5.65
49	76.03	15.74	3.30	4.93
50	74.68	15.86	4.05	5.41

From the data obtained, it is observed that four major clay minerals, viz montmorillonite, illite, chlorite and kaolinite are almost universally present, the first one however is most predominant almost 70 to 80%. In all areas, of the Gulf coast, except in the northernmost part, the proportions of various clay minerals are more or less constant. The present author's findings are identical to those of Nair et al., (1982) who have shown the entire northern part of shelf area of the Arabian sea to comprise a montmorillonite zone. These authors have also attributed the major bulk of clay minerals from the land-derived detritus brought by rivers. Obviously, the abundance of montmorillonite is correlatable with the preponderance of Deccan Trap along the Gulf coast. However, in the mud samples in the northern part of the Gulf, near the mouths of Sabarmati and Mahi, an appreciable increase in illite content is recorded. The presence of illite is attributable to its derivation from the granitic and other crystalline rocks drained by the two rivers. The same argument can be put forth for a marginal increase in the kaolinite and chlorite content.

BEACH DEPOSITS

Compared to the extensive development of tidal mudflats, that of sandy beaches is very much subordinate. On Saurashtra side, beach sands are encountered only to the south of Ghogha and on the Piram Island. Beach development on the Mainland coast is restricted to Dahej and its south. Beaches on the two coastal flanks, are quite different from north to south. In Chapter V, the author has described the geomorphic aspects of the beaches. Here he has given the salient features of the constituent sands that make up the beaches. In addition to the routine information pertaining to mineralogy the author has also made some studies on the statistical measures for the beach material. He has used moment measure formulas given by Friedman (1979) as under:

Statistical measure	Symbol	Formula
Mean	$\bar{X}$	$1/100 \sum fm$
Standard deviation	σ	$(\sum f(m_\varphi - x_\varphi)^2/100)^{\frac{1}{2}}$
Skewness (Third moment)	α_3	$1/100^{-3} \sum f(m_\varphi - x_\varphi)^3$
Mean-cubed deviation	$\alpha_3 \sigma^3$	$1/100 \sum f(m_\varphi - x_\varphi)^3$
Simple sorting measure	So_s	$1/2(\varphi_{95} - \varphi_5)$
Simple skewness measure	α_s	$(\varphi_{95} + \varphi_5) - 2(\varphi_{50})$

SAURASHTRA COAST

Sands first appear near Ghogha and southward upto Shetrunji river mouth, these form a very narrow beach. Beyond this river they increase in bulk and dimensions. The nature of beach material is distinct from each other on two sides of the Shetrunji river. To the north of Shetrunji the beach material consists of coarse to fine sands essentially quartzose and lithic. At the upper limit the beach material becomes of shingle size and is seen made up of rounded to sub-angular fragments. The minerals of the sands are quartz, chalcedony, agate, illmenite, beryl, garnet, hornblende, muscovite, gypsum and a few opaque minerals, the quartz predomating. Rock fragments of basalt and Gaj rocks are also common. Shells and shell fragments of Foraminifera, Ostracoda, Gastropoda, Pelecypoda are present in small proportions and the percentage of calcareous material ranges from 14 to 22%.

To the south of Shetrunji river the beaches are better developed. Sand accumulations occur almost continuously from Gopnath to Methla village and further southwest. Essentially coarse to very fine in size, the sands here are very rich in carbonate content because of the richness in bioclastic grains (mainly foraminiferal tests). The carbonate content is observed to increase from Gopnath to Methla side, being 30-37% at Gopnath and as high as 60% at Methla. Quartz, bioclastics, peloids, illmenite, garnet, beryl, muscovite, hornblende etc. make up the beach sands. Quartz is the dominant non-carbonate constituent. The percentage of heavy mineral is low and varies from 18 to 23% in Gopnath and 13 to 18% in Methla.

In Piram Island, beach sands are restricted to the southern and eastern parts and essentially consist of dominantly quartz, with chalcedony, illmenite, beryl, garnet, tourmaline, calcareous sands and a few opaque minerals. The carbonate content is low and ranges from 17 to 22%. Heavy mineral percentages vary from 40 to 48.

The sands on the Saurashtra side show the following statistical parameters.

Sample Location	Mean	Standard deviation	Skewness (third moment)	Mean cube deviation	Simple sorting measure	Simple skewness measure
Methla	2.84	0.58	-0.81	-0.16	0.97	-0.55
Gopnath	2.96	0.42	0.41	0.03	0.53	-1.45
Alang	2.59	0.85	-0.01	-0.23	1.2	0.1
Kuda	2.73	0.444	-0.07	-0.007	0.73	-0.05
Hathab	2.34	0.62	.009	0.11	0.59	-0.01
Piram Island	2.63	0.35	-0.77	-0.03	0.6	-0.4

MAINLAND COAST

Beach sands first appear at Dahej and then southward show increasing development. To the north of Narmada, the beach is not so well defined and around Dahej-Luhara, it is better seen as a wide intertidal zone consisting of very fine to coarse sand, flanked landward by unconsolidated coastal dunes. Further south, the sandy beach is again encountered at Hazira, where it is forming a wide zone with unconsolidated dunal accumulations above the berm line.

The beach sand at Luhara consists of Quartz, illmenite, magnetite, beryl, garnet, gibbsite, tourmaline, hornblende with other opaque minerals, the quartz and illmenite being the dominant constituents. The carbonate content in this beach varies from 10-15% and the heavy concentration is 38 to 45%. The heavy mineral concentration increases as one advances towards Hazira beach. The heavy mineral concentration varies from 75 to 80% at Hazira beach whereas the carbonate content is 5 to 10%. The heavies are illmenite, magnetite, gibbsite, zircon, garnet, beryl and some other unidentifiable opaque minerals. At Hazira, illmenite predominates over all other minerals.

The Mainland beach material has been analysed to show following textural characteristics:

Sample Location	Mean	Standard deviation	Skewness (Third moment)	Mean cube deviation	Simple sorting measure	Simple skewness measure
Luhara	2.43	0.55	0.63	0.1	0.9	0.01
Mora	2.65	0.60	-0,03	-0.006	1.00	-0.3
Dandi	2.78	0.56	-0.001	-0.03	0.95	-0.1
Hazira	2.66	0.56	-0.003	-0.05	0.97	-0.15

The present author is of opinion that the Saurashtra beach has a different mode of origin from that of Mainland coast. On Saurashtra side, the carbonate sands of Gopnath-Methla beach comprise calcarenite transported by longshore drift generated by wave action and tidal currents. In contrast, the beach to the north of Shetrunji which is made up of very coarse sands, and shingles, reveal the phenomenon of accumulation of land derived particles, the finer sediments having been washed away to the deeper parts.

On the other hand, the beach deposits of the Mainland reveal the accumulation of sands in those areas which are affected by waves generated by southwesterly winds. The author has however observed that a sizable proportion of the present day beach sand is derived from the erosion and re-working of the ancient dunal material. This is better observed at Dahej but further south, it appears that in addition, a lot of fluvial sand added by Narmada and Tapi have been washed back by waves to augment to the beach sands.