

Sedimentological and clay mineral studies in Kakinada Bay, east coast of India

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The sediments of Kakinada Bay are predominantly silty clays, with a phi mean range between 2.9 to 7.8. Northern, central and southern parts of the bay consist of finer sediments (5.5 to 7.2 ϕ) while the eastern and western parts of the bay are of sandy sediments (2.9 to 3.05 ϕ). Interrelationships of size statistical parameters and the CM diagram of the bay sediments suggest a mechanism of slow deposition from quiet water. Montmorillonite is the predominant clay mineral followed by kaolinite and illite. Concentration of montmorillonite in the bay sediments is mainly controlled by the energy conditions of depositional environment. Kaolinite enrichment at the drainage channel entrance is due to preferential settling of kaolinite in low saline water.

The total area of Kakinada Bay is approximately 132 km² and is a part of the Godavari estuarine system. There are extensive mud flats and dense mangrove forests on the southern side. Two of the major distributaries of the Godavari, the Coringa and the Gaderu open into the bay in the central region of the southern side. Two other channels the Mattapalem and Chollangi creeks open at the southwestern corner of the bay. An irrigation channel, the Kakinada canal runs through the town and opens into the bay in the central western part. On the eastern side of the bay, there is a long narrow sand bar (Hope Island) separating the bay from the sea. The extreme tip of the sand spit is called the Godavari Point. The sand bar gradually broadens and bends in a northwest direction forming the eastern boundary of the Kakinada Bay. The depth in its southern and western parts is below 1.8 m during spring tides, and large mud flats are exposed during low tide. The depth in the central and northern regions ranges from 1.8 to 9.4 m.

Among the earlier studies in the bay, Mahadevan & Prasada Rao¹ discussed the causes of the growth of the sand spit north of the Godavari Point. Subba Rao² dealt with the environmental changes that took place during the growth of the sand spit and also established three heavy mineral provinces in the Kakinada bay. The present work was carried out to study the depositional environments, sediment distribution pattern and clay mineralogy of the Kakinada Bay.

Materials and Methods

Seventeen sediment samples were collected by VanVeen grab using a mechanised fishing boat

covering mainly central and northern parts of the bay (Fig. 1). Grain size analysis of all samples were performed using standard sieving and sedimentation techniques³. The grain size statistical parameters were calculated following the procedure of Folk &

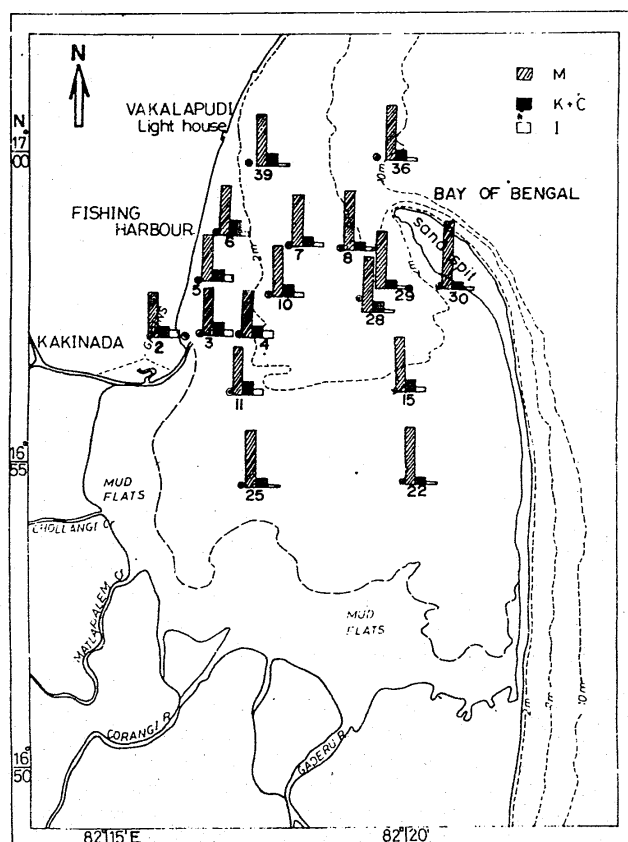


Fig. 1—Location map and clay mineral percentages (M = montmorillonite; K + C = kaolinite + chlorite; I = illite)

Ward⁴. For clay mineral studies, sediments were desalted and treated with hydrogen peroxide and acetic acid to remove organic matter and carbonates respectively. Less than 2 μm fraction was separated using sedimentation technique based on settling velocities. Oriented clay slides were prepared from these clay fractions. A Phillips X-ray diffractometer fitted with Ni filtered Cu K α radiation was used to analyse the samples. Both untreated and glycolated specimens were scanned from 2° to 30° 2 θ at 2° 2 θ per minute. Clay mineral percentages were determined following weighted peak area method⁵.

Results and Discussion

The sediments were texturally classified⁶ by plotting the percentages of sand, silt and clay, in the analysed samples, on the triangular diagram (Fig. 2). Majority of the surface sediments were found to be of silty clay. Three samples come under clayey sand, while one sample each in sand and sand-silt-clay zone. Sandy sediments are present adjacent to the spit in the eastern part of the bay and to the mainland, north of Kakinada drainage channel. Northern, central and southern parts of the bay are of fine sediment texture. Unnikrishnan & Asthana⁷ conducted dye experiments in the Kakinada Bay and reported the influence of tides on the circulation. Influence of currents on the sediment deposition is evident from the distribution of the phi mean size of the sediments. The areas of maximum velocity are restricted and found to have sediments with a phi mean size between 3 and 4, whereas in the remaining parts it is between 6 and 8. Sediments brought into the bay are mostly silty clays that are reworked for providing the finest clay particles to the tidal flats in the protected southern parts of the bay by 1) seaward flow of fresh water due to conserved momentum, 2) currents in and around distributary mouths due to density differences (mixing between masses of fresh water and salt water) and also due to hydraulic head, 3) tidal currents and wind waves and longshore currents².

The statistical parameters of textural characteristics are given in Table 1. The mean grain size of the bay sediments ranges from 2.9 to 7.8 ϕ . The mean size of the coarse sediments adjacent to the sand spit and main land ranges from 2.9 to 3.05 ϕ . In the central and northern parts of the bay the sediments are very fine and the mean size vary from 5.5 to 7.2 ϕ . Coarse sediments are relatively better sorted than the fines and the values range from 0.67 to 2.21. Majority of the samples are negatively skewed and the skewness ranges between -0.69 to 1.71. Among diagrams showing the interrelationships between size

statistical parameters, median against standard deviation is the most reliable for identifying mechanisms of deposition^{8,9}. In Fig. 3 (MD vs sorting) the sediments are scattered throughout the suspension field. From the view point of depositional mechanisms, two samples are of polygenetic nature. In the CM diagram (Fig. 4) most of the samples are located in quiet water deposit zone, specified by Passega¹⁰.

Montmorillonite is the most abundant mineral followed by kaolinite and illite (Table 1). Montmorillonite percentage ranges from 67% to 87%. It is high (80%) towards southern and western areas (Fig. 1). The sediment supply to the Kakinada bay is mainly from the river Godavari, through its distributaries Gaderu and Corangi, that joins at the southern end. High concentration of montmorillonite is due to the catchment areas of the river basin i.e. Deccan traps of the Western Ghats that are

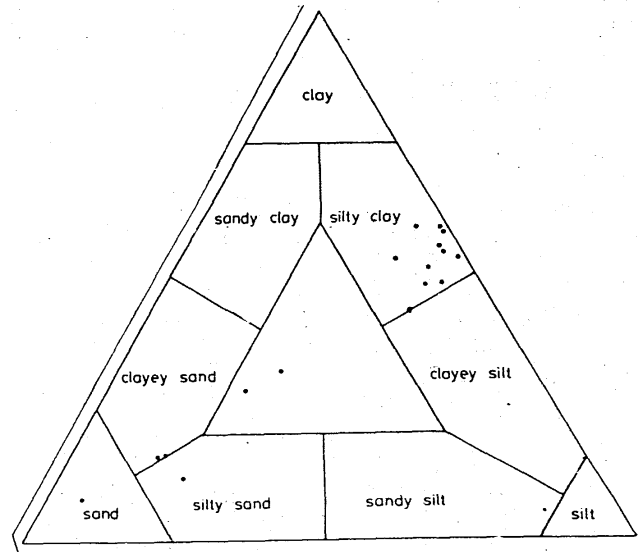


Fig. 2—Shepard's triangular diagram

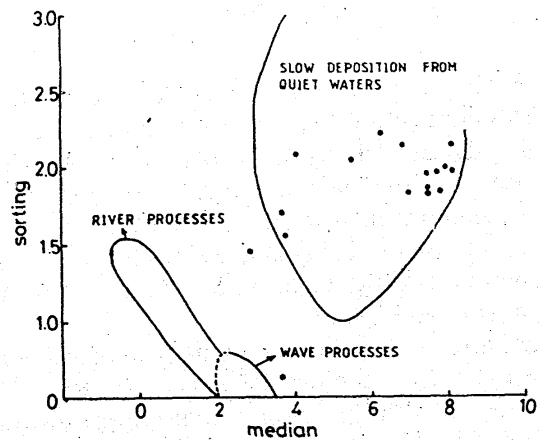


Fig. 3—Scatter plot of median vs sorting (after Stewart, 1958)

Table 1—Textural characteristics

St. no.	Size parameters			Texture (%)			Clay mineral (%)		
	Mean	Sorting	Skewness	Sand	Silt	Clay	M	K+C	I
2	6.90	1.96	-0.30	2.6	42.6	54.8	67.3	20.7	12.0
3	4.45	1.52	0.75	67.5	20.3	12.2	71.1	20.4	8.5
4	6.61	2.13	-0.14	7.4	42.1	50.5	67.4	19.0	13.6
5	3.71	0.67	0.33	68.2	16.3	15.5	68.7	19.4	11.9
6	7.01	2.01	-0.59	1.2	45.5	53.3	72.6	21.6	5.8
7	6.81	1.91	-0.56	2.8	43.5	53.7	78.6	14.8	6.6
8	7.20	2.15	-0.54	11.3	36.0	52.7	86.6	12.2	1.2
10	6.92	1.83	-0.39	0.9	40.4	58.7	75.3	18.4	6.3
11	6.80	1.92	-0.62	49.3	23.4	27.3	70.3	20.0	9.7
15	6.91	1.78	-0.34	6.5	45.6	47.9	79.8	15.6	4.6
22	4.12	1.72	0.48	69.3	14.9	15.8	86.2	11.5	2.3
25	7.06	1.98	-0.69	5.0	35.8	59.2	82.9	13.9	3.2
28	6.02	2.05	0.26	13.8	43.0	43.2	81.5	14.7	3.9
29	5.36	2.08	1.71	40.4	27.4	32.2	84.7	14.1	1.2
30	3.18	1.45	1.12	85.6	6.0	8.4	86.2	11.5	2.3
36	6.26	2.21	-0.10	9.7	43.0	47.3	81.6	15.9	2.5
39	6.92	1.85	-0.37	0.4	41.5	58.7	77.5	18.7	3.8

M = montmorillonite; K+C = kaolinite+chlorite; I = illite

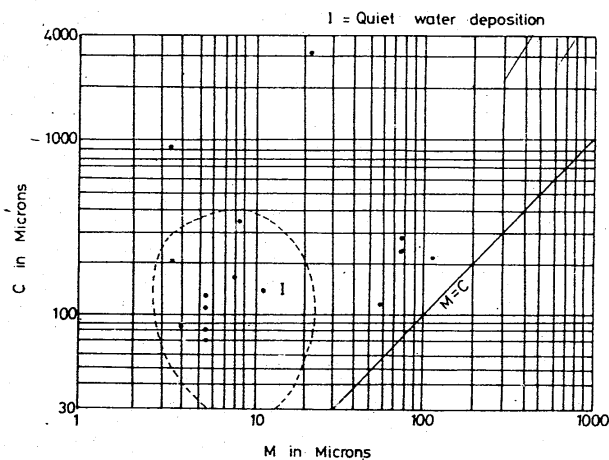


Fig. 4—C-M diagram

covered by montmorillonite rich black cotton soils. High montmorillonite concentration coincide with the abundance of clayey sediments. Montmorillonite, because of its fine grain size, form aggregates and is deposited more in low energy environment while illite and kaolinite being coarser do not show such preferential settling, and hence gets deposited even in high energy conditions.

Kaolinite is the next abundant mineral with concentrations ranging between 10 to 20%. Godavari river in the lower reaches drain through Precambrian formations thereby increasing in kaolinite content. Areal distribution of kaolinite

indicates two specific zones. One, with more than 18% at the entrance of the Kakinada drainage channel. The other occupies the remaining part of the bay. Whitehouse & McCarter¹¹ observed preferential settling of kaolinite in low salinity water, where clay floccule formation often occurs by surficial adsorption of cations. This drainage channel which carries agricultural waste water along with the drainage water of the Kakinada town maintain a low salinity zone in this area. Irrespective of grain size this zone had lowest montmorillonite (< 70%) compared to the bay on the whole.

Illite is the least abundant with values between 1 to 13%. Lowest values of less than 5%, illite presence, is noticed in the eastern part adjoining to the spit and in the south where enrichment of montmorillonite is noticed.

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