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Textural and physico-chemical studies of innershelf sediments off Gangolli, west coast of India

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Textural and physico-chemical studies such as grain size, organic carbon, Ca and magnetic susceptibility of sediments of the innershelf off Gangolli have been carried out. The sediments are clayeysilt and siltyclay in texture. They are well-sorted, negatively skewed and leptokurtic. Multigroup descrimination analysis suggests that these sediments are derived from shallow marine origin by saltation and suspension. The amount of organic carbon and Ca ihcreases with the depth. Organic carbon has positive correlation with Ca. The magnetic susceptibility(Xm) shows high values and has the positive correlation with mean size (Mz).

Study of sediment characters like texture, magnetic susceptibility, organic carbon and Ca content gives an important information on depositional environments. Some of these sediment characteristics do also play an important role in the diagenesis of sediments. Textural, physico-chemical and geochemical aspects of the shelf sediments along the west coast have been studied[1-6]. The sediments in the (nearshore) area adjacent to the Gangolli estuary (the confluence of Haladi, Chakra and Kolluru rivers at Gangolli village is called as the Gangolli river/estuary) are studied to know their depositional environs and the behaviour of physico-chemical conditions in this shallow marine domain.

Materials and Methods

Twenty seven surface sediment samples were collected in March 1989 (premonsoon period) at depths of 10, 20 and 30 m along the coast off Gangolli (Coondapur) using a peterson grab. The samples were also collected in November 1989 (postmonsoon period) to know the textural variations. The interval between each sample station along a particular depth profile is 5 km (Fig. 1). Samples were washed free of salts with distilled water and oven-dried at 60°-70°C for over-night. Size analysis[7] of samples was carried out and graphic measures of sand fractions[8] were calculated. Multigroup discriminant analysis[9] is used to know the depositional conditions. The organic carbon was determined[10], and organic matter was computed by multiplying with a factor[11] of 1.724. $CaCO_3$ content was determined by treating 0.1 g of well powdered sample (after removing the shells) with 1*N* HCl. After filtering the residue, the filtrate was made up to volume. Following Vogel[12], Mg was precipitated with 8 *M* KOH and the interfering

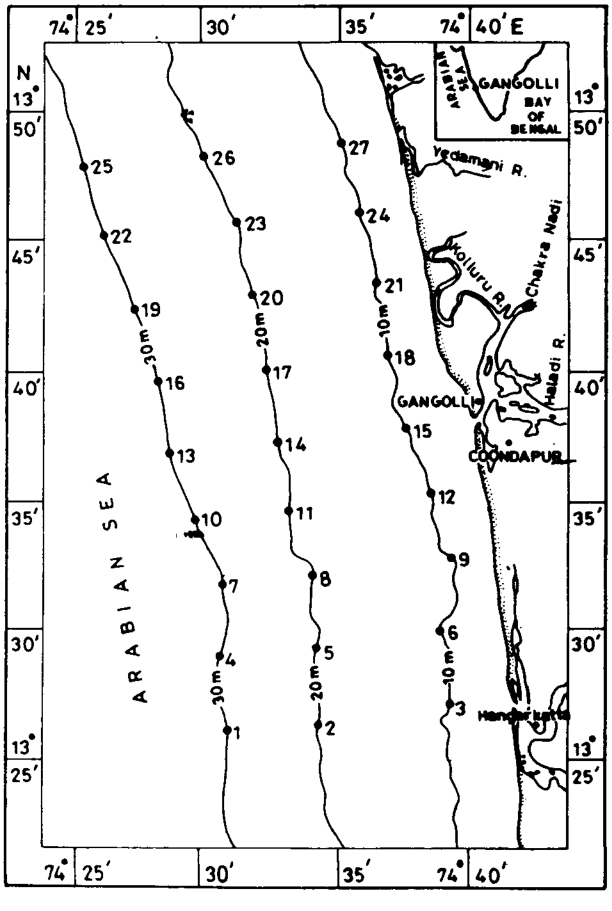

Fig. 1—Sample locations and bathymetry of the study area

elements were masked with triethenolamine and hydroxylamine hydrochloride, so that they could no longer react with Patton and Reeders indicator or with EDTA salt used for titration. Ca was computed by multiplying $CaCO_3$ with a factor[12] 0.4. Magnetic susceptibility was estimated[13] using a susceptibility and hysteresis apparatus (Model RMSH-III).

Results and Discussion

Textural parameters—Average sand, silt and clay ratios of the sediments are 14.71, 49.76 and 35.53 respectively. Most of the samples exhibit clayey-silt texture (Table 1, Fig. 2). Most of the sand fraction that the samples contain is distributed in 3-4 φ size grades. The deposition of sand (26-70% sand content) as a strip is in SW direction from the Gangolli river mouth (Fig. 2A). The direction of currents is SW during this period (March)[14,15] and these currents might have influenced the development of the sand patch. It may be understood that the input of coarser material in to the nearshore area by the Gangolli river is transported in SW direction by the bottom currents and these coarse particles form as a sand strip away from the river mouth as the currents are weakened. During the same season, another sand patch is noticed at the NW of river mouth in the shallow marine region. But the sand percentage in this patch is less, and amounts only to 12-20%.

Postmonsoon textural data reveal the presence of the sand patch in SW direction of the river mouth in this season (November) also but comparatively with less sand percentage (20-43%). However, the sand patch of the northern part has higher sand percentage during postmonsoon period (26 to 40%) as compared to premonsoon season (Fig. 2B). This might be due to the effect of the currents in this season[14,15]. The

Table 1—Textural parameters and eigen vectors (V_1, V_2) of inner shelf sediments off Gangolli

St.No. (depth m)	March 1989 Sand (%)	Silt	Clay	Nov. 1989 Sand (%)	Silt	Clay	Grain-size parameters (φ) M_z	M_d	σ_I	SK_I	K_G	Eigen Vectors V_1	V_2
1 (30)	3.37	54.76	41.87	8.40	38.50	53.10	3.59	3.62	0.61	−0.64	0.96	2.1263	1.4147
2 (20)	17.50	56.10	26.40	13.60	40.00	46.40	3.53	3.56	0.45	−0.32	1.41	2.3202	1.9058
3 (10)	22.12	61.78	16.10	10.10	50.20	39.70	3.48	3.55	0.52	−0.31	1.22	2.2587	1.7045
4 (30)	16.91	48.30	34.70	20.00	54.70	25.30	3.71	3.70	0.17	−0.17	1.55	2.4202	2.1708
5 (20)	40.86	42.27	16.87	28.62	40.20	31.18	3.71	3.70	0.13	0.06	1.32	2.4038	2.0194
6 (10)	6.45	60.50	33.05	16.62	41.20	42.18	—	—	—	—	—	—	—
7 (30)	9.21	44.78	46.00	10.62	55.00	34.36	3.58	3.62	0.27	−0.41	2.15	2.5545	2.5845
8 (20)	70.18	16.69	13.12	42.60	32.00	25.40	3.48	3.57	0.31	−0.49	1.22	2.0754	1.7562
9 (10)	45.89	35.71	18.40	40.40	31.00	28.60	3.50	3.57	0.28	−0.42	1.46	2.2091	1.9817
10 (30)	4.21	44.06	51.73	10.50	58.30	31.20	—	—	—	—	—	—	—
11 (20)	10.74	49.39	39.89	20.62	45.00	34.38	3.64	3.65	0.23	−0.35	2.92	2.9371	3.2641
12 (10)	26.11	46.30	27.59	28.60	46.40	25.00	3.43	3.57	0.38	−0.58	1.20	2.0366	1.6909
13 (30)	3.56	50.79	45.65	6.60	56.00	37.40	—	—	—	—	—	—	—
14 (20)	9.17	53.59	37.24	7.42	52.80	39.78	3.58	3.62	0.27	−0.41	2.15	2.5545	2.5845
15 (10)	2.84	58.94	38.22	4.32	59.60	36.08	—	—	—	—	—	—	—
16 (30)	1.24	48.72	50.04	8.42	59.00	32.58	—	—	—	—	—	—	—
17 (20)	19.62	44.74	35.64	26.42	42.10	31.48	3.52	3.60	0.57	−0.63	1.41	2.2667	1.7985
18 (10)	13.47	52.49	34.04	39.60	42.00	18.40	3.70	3.70	0.14	−0.10	1.64	2.4779	2.2591
19 (30)	5.40	58.65	35.95	4.46	68.00	27.54	—	—	—	—	—	—	—
20 (20)	18.31	45.64	36.05	26.62	54.23	19.15	3.71	3.71	0.18	−0.14	1.82	2.5545	2.4005
21 (10)	15.95	50.43	33.62	30.12	42.30	27.58	3.64	3.65	0.20	−0.32	2.32	2.6746	2.7712
22 (30)	17.29	40.69	42.02	11.62	64.23	24.15	3.51	3.67	0.66	−0.76	1.48	2.3100	1.7835
23 (20)	12.04	48.08	39.88	4.62	52.30	43.08	3.64	3.65	0.28	−0.37	3.77	3.3226	3.9627
24 (10)	1.04	62.67	36.29	16.60	45.26	38.14	—	—	—	—	—	—	—
25 (30)	0.36	52.48	47.16	11.42	68.00	20.58	—	—	—	—	—	—	—
26 (20)	1.31	55.92	42.77	9.92	54.20	35.88	—	—	—	—	—	—	—
27 (10)	1.96	59.15	38.89	6.60	65.00	28.40	—	—	—	—	—	—	—
Mean	14.71	49.76	35.53	17.24	50.28	32.48	3.59	3.63	0.33	−0.37	1.76	—	—

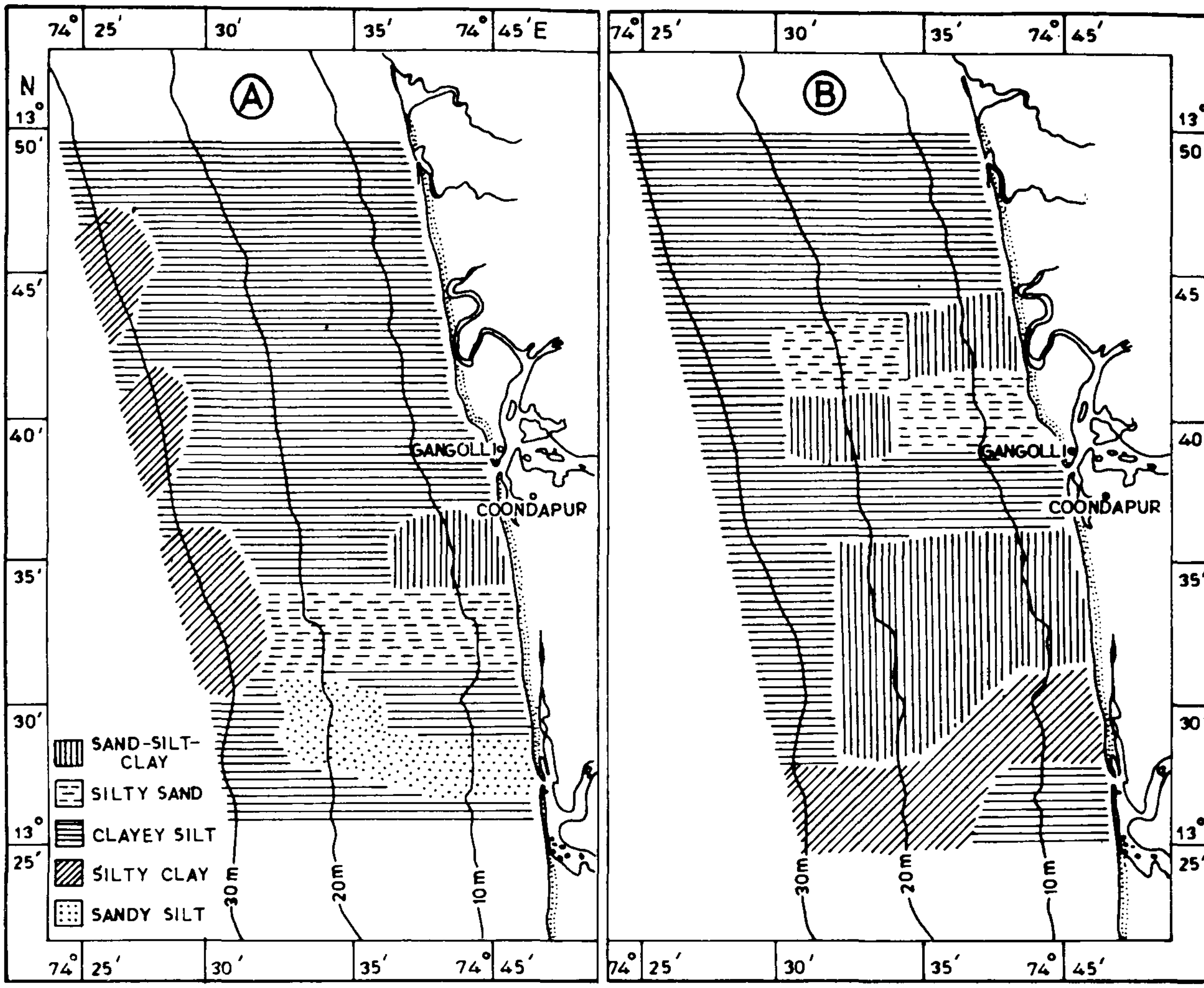

Fig. 2—Sediment distribution in the study area—(A) March 1989 and (B) November 1989

direction of currents is N-NNE in this season and the sediment input of the Gangolli river is carried out by currents in this direction and developed into a sand strip. Though these sand strips are present in both the seasons, their sand percentages vary seasonally, may be because of the effect of transportation by currents. The clayeysilt and siltyclay nature of the most of the nearshore sediments also indicates the limited input of the coarser material by Gangolli river to the adjacent marine environment and whatever the coarser material that is carried by rivers is largely trapped in the estuary. The function of estuaries as filters has been widely recognised. During the filtering process, the estuaries trap coarse-size particles and allow only fine particles to escape into the innershelf area. The deposition of fine particles on the innershelf of SW coast of India has been attributed to the filtering efficiency of the west coast estuaries[16].

Most of the sands are moderately well-sorted to well-sorted. Skewness values vary between -0.76 and 0.06 ϕ. All the sediments are negatively skewed (coarse to moderate) except one sample. Kurtosis values vary between 3.77 and 0.96 ϕ and are of leptokurtic. The multigroup discriminant analysis (Fig. 3) reveals that the samples were deposited in shallow marine environment by saltation and suspension processes.

Physico-chemical characters—Ca content varies from 3.2 to 6.52% (Table 2). The shells, varying in concentration from 0.1 to 6.1% (by weight), may also be contributing to the Ca content of sediments. Ca content increases as depth of sediment increases and this may be due to the decrease in rate of sedimentation at higher depths[5]. Ca might have been derived into sediments from a biogenous source. Ca shows positive correlation with organic carbon of sediments. Organic matter varies from 3.45-8.45 %. This is much higher than the reported[17] world average of 2-4% and also much higher than the average values of 1.33 % and 2.55 % for marine

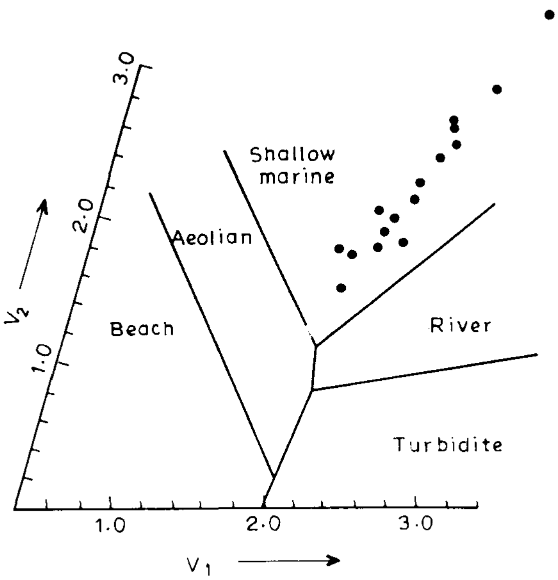

Fig. 3—Multigroup discrimination of depositional environments

sediments off east[18] and west coasts[4] of India respectively. The organic carbon content also increases with increase in depth in the Gangolli area. The high organic carbon content in the study area indicates the high biological activity and low oxygenated water that are incapable of decomposing the organic matter[19].

Organic carbon shows positive correlation (0.31) with ϕ mean size of the sediment which suggests the enrichment of organic carbon in fine grained sediments. Several investigators have noted that the fine grained sediments generally contain higher amount of organic carbon than the coarser ones[4,5,20]. This enrichment of organic carbon in fine grained sediments is due to the similarity in sinking and behaviour of finer particles and organic matter[21,22]. The positive correlation (0.27) exhibited by Ca and organic carbon suggests the production of organic carbon from the calcareous plankton and benthos[20] Correns[23] has obtained a linear relationship between organic matter and $CaCO_3$ and concluded that the calcareous material contained about 0.2% organic matter.

Magnetic susceptibility (*Xm*)—Xm of the sediment varies from 35.623 to 74.916×10^{-6} emu.g^{-1}. These values are higher than the reported Xm values for surficial sediments off the west coast of India[24,25]. Karbassi[25] has reported an average of 10×10^{-6} emu.g^{-1} for the marine sediments off Mulki, west coast of India. Xm shows a positive correlation (0.35) with mean size (Mz) of the sediments suggesting the concentration of magnetic minerals in finer sizes.

Table 2—Physico-chemical parameters of sediments off Gangolli

St No.	Shells (wt%)	$CaCO_3$ (%) (values in paranthesis are of Ca %)	Organic carbon (%) (values in paranthesis are of organic matter %)	Magnetic susceptibility (Xm) ($\times 10^{-6}$ emu.g^{-1})
1	1.20	15.38 (6.15)	3.05 (5.26)	52.9770
2	0.96	14.55 (5.82)	2.80 (4.83)	36.1200
3	0.85	13.10 (5.24)	2.10 (3.62)	55.1630
4	0.72	15.15 (6.06)	3.69 (6.36)	55.0924
5	0.85	13.00 (5.20)	2.20 (3.79)	56.9663
6	0.89	9.55 (3.82)	3.02 (5.21)	57.2160
7	0.87	16.00 (6.40)	4.90 (8.45)	51.7579
8	0.69	15.00 (6.00)	2.0 (3.45)	47.0526
9	0.65	13.10 (5.24)	2.26 (3.90)	42.5714
10	0.12	12.75 (5.10)	4.28 (7.38)	41.2327
11	1.25	13.50 (5.40)	3.20 (5.52)	45.6268
12	5.93	10.25 (4.10)	2.10 (3.62)	50.0880
13	0.35	12.95 (5.18)	3.06 (5.28)	51.2688
14	0.58	12.25 (4.90)	2.90 (5.00)	58.7362
15	0.12	8.00 (3.20)	2.62 (4.52)	74.9162
16	0.12	16.00 (6.40)	3.80 (6.55)	59.2599
17	9.95	13.65 (5.46)	2.69 (4.64)	53.0398
18	0.65	14.38 (5.75)	2.46 (4.24)	61.4632
19	0.10	16.00 (6.40)	3.00 (5.17)	57.4458
20	0.57	16.55 (6.62)	2.70 (4.65)	50.8894
21	2.02	14.00 (5.60)	2.98 (5.14)	51.5900
22	6.12	14.38 (5.75)	2.68 (4.62)	48.9863
23	3.13	16.15 (6.46)	2.52 (4.34)	35.6230
24	0.11	12.80 (5.12)	2.64 (4.55)	36.5547
25	0.10	15.75 (6.30)	3.10 (5.34)	49.2110
26	0.10	11.00 (4.4)	2.68 (4.62)	45.9725
27	0.12	14.50 (5.80)	2.48 (4.28)	36.9931
Mean	1.45	13.70 (5.48)	2.89 (4.98)	50.5100

The sand patches in the study area, developed in SW and NW directions of Gangolli river mouth, are due to transportation of river sediments by monsoonal currents. The study reveals high content of organic carbon, Ca and Xm. The concentration of organic carbon and Ca also increases as depth does, and this can be attributed to benthic biological productivity.

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References

1 Hashimi N H, Kidwai R M & Nair R R, *Indian J Mar Sci*, 7 (1978) 231.
2 Nair R R, Hashimi N H, Kidwai R M, Gupta M V S, Paropakari A L, Ambre N V, Muralinath A S, Mascarenhas A & D'Costa G P, *Indian J Mar Sci*, 7 (1978) 224.
3 Veerayya M & Varadachari V V R, *Sed Geol*, 14 (1975) 63.
4 Murty P S N, Reddy C V G & Varadachari V V R, *Proc Natn Inst Sci India*, 35 (1969) 377.
5 Paropakari A L, *Indian J Mar Sci*, 8 (1979) 127.
6 Shankar R, Subba Rao K V & Kolla V, *Mar Geol*, 76 (1987) 253.
7 Carver, *Procedures in sedimentary petrology*, (Wiley-Inter-Science, New York) 1971, pp. 653.
8 Folk R L & Ward W C, *J Sed Petrol*, 27 (1957) 3.
9 Sahu B K, *Indian J Earth Sci*, 10 (1983) 20.
10 El-Wakeel S K & Riley J P, *J Cons Perm Int Explor Mer*, (1957) 22.
11 Wiseman J D H & Bennette H E, *John Murray Expedition*, 3 (1940) 193.
12 Vogel A I, *A text book of quantitative inorganic analysis*, (Longman Inc, New York) 1978, pp. 925.
13 Radhakrishnamurthy C, *Operating instructions for susceptibility and hysteresis apparatus*, Model RMSH-III. (Tata Institute of Fundamental Research, Bombay) 1979.
14 Maddikery G V, *Hydrographical features in relation to fisheries in the Arabian Sea off Gangolli region, Dakshina Kannada*, M.F.Sc, thesis, Fisheries College, Mangalore, India, 1981.
15 Venkatesh Prabhu (unpublished data).
16 Nair R R & Hashimi N H *J Coast Res*, 2 (1986) 199.
17 Huc A Y, in *Kerogene*, edited by Durand B, (Teihnip, Paris) 1980, pp.444.
18 Subba Rao M, *Bull Am Ass Petrol Geol*, 44 (1960) 1713.
19 Kolla V, Kostecki J A, Robinson R, Bicaye P E & Ray P K, *J Sed Petrol*, 49 (1981) 563.
20 Ramamurthy M, Venkatesh K V & Nrasimham C V L, *Indian J Mar Sci*, 8 (1979) 176.
21 Trask P D, *Recent marine sediments*, (Donner Publications Inc, New York) 1968, pp. 428.
22 Sverdrup H V, Johsnon M W & Fleming R F, *The oceans*, (Prentice Hall, New York) 1942, pp. 1087.
23 Correns C W, Ergebn dt atlantlant Exped, *Meteor* (1937) 3.
24 Shankar R, *Geochemistry and magnetic susceptibility of sediments from the Arabian Sea*, Ph. D. thesis, Indian Institute of Technology, Bombay, 1982.
25 Karbassi A R, *Geochemical and magnetic studies of marine, estuarine and riverine sediments near Mulki (Karnataka), India*, Ph. D. thesis, Mangalore University, India, 1989.