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Texture of inner shelf sediments off Penner river, east coast of India

J Seetharamaiah & A S R Swamy
Department of Geology, Andhra University, Visakhapatnam 530 003, India

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Grain size studies of surface sediments off Penner river shelf have been carried out. Though there is wide range in the sediment types, the shelf is predominantly occupied by sands. The inner shelf (< 20 m isobath) is composed of silty sands and clays, which are transported towards north by prevailing waves and currents from the fluvial source. Grain size parameters and C-M pattern suggest that the offshore coarse sediments are deposited from beach and shallow marine origin predominantly by rolling. Further the coarse sands are considered to be relict and represent a beach deposit, which may be the result of Flandrian (Holocene) transgression. The well preserved sands indicate that the existing hydrodynamic conditions on the inner outer shelf are strong enough neither to rework the sediments nor transport river contributed fine sediments to the outer parts.

Information on morphology and textural parameters of the environments of Penner delta has been reported[1,2], but no information is available on the sedimentological distribution. In this communication, sedimentological distribution of inner shelf sediments as related to their source, dispersal and depositional history is reported.

The Penner shelf (0-50 m) extends from Krishnapatnam in the south to Isakapalle in the north covering an area of 760 km^2 with an average width of about 15 km (Fig. 1). The source of the sediments are Archaean igneous and metamorphic rock from the high land areas and Precambrian sedimentary formations of the drainage basin. The climate is arid to subhumid within the drainage basin. Average annual rainfall is about 600 mm and about 70% of the rainfall occurs during the cyclonic period during October-November, and this is the period of peak river discharge[3]. The Penner river carries annually about 6.9×10^6 tonnes of solid material[4]. Some of the these sediments appear to have been transported towards east and north as indicated by the distributional pattern of sediments on the shelf and by the development of spit at the mouth of the estuary.

Materials and Methods

Sediment samples (96) were collected using a Peterson grab off Penner river (Fig. 1) during 21 to 26 February 1987. Representative homogenized samples of approximately 80 g were first treated with H_2O_2 solution (30%) to oxidise carbonaceous organic matter and were washed with distilled water to remove soluble salts. After the dispersion, size analyses were carried out by standard techniques[5]. Graphic measures[6] (mean size, standard deviation, skewness, kurtosis) were computed for each set of txtural data. The first percentile (C) and median (M) of the grain size distri-

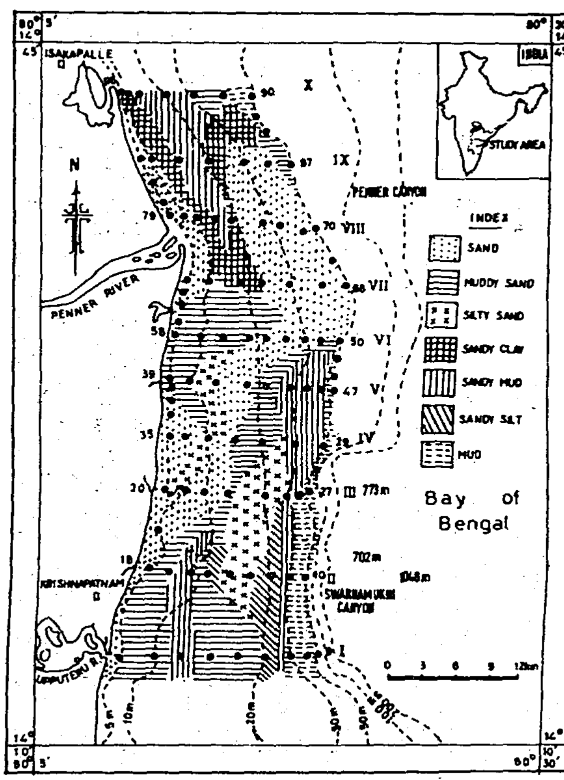

Fig. 1—Sample location and distribution of sediment types in the inner shelf, off Penner river

butions were plotted in C-M diagram to draw influence on the environment of deposition[7].

Results and Discussion

Regional distribution of grain size modes shows that the shelf is covered with a complex mosaic of sediment types rather than a simple seaward fining sheet. The nearshore area (< 5 m) is predominantly covered by sandy sediments (Fig. 1). In southern and northern shelf from 5 m depth contour, clay fraction increases with depth and distance from the coast (Table 1). However, the increase is not uniform and varies from place to place on the inner and outer shelf. Percentage of sand samples from the profiles plotted against the depth (Fig. 2A) indicates that the coarse sand zone starts approximately at 20 m depth, at a distance of 7 km from the present coast line. Sediments having sand percentage as high as 98% are present in this zone.

Penner shelf sediments exhibit a wide range in the phi (ϕ) mean size from 0.04 to 8.36 (Table 1). A progressive increase in ϕ mean size is noticed towards offshore in the southern and northern shelf of the study area. But in the middle shelf, gradual increase of ϕ

Table 1—Textural parameters of the Penner shelf sediments

St no.	Texture	Sand %	Silt %	Clay %	ϕ Mean size	SD	Skew	Kurt	St no.	Texture	Sand %	Silt %	Clay %	ϕ Mean size	SD	Skew	Kurt
1	S	95	3	2	3.40	0.43	0.20	1.19	49	Ss	19	69	20	6.62	2.20	-0.28	0.83
2	mS	69	20	11	4.66	1.80	0.59	2.19	50	S	99	1	-	1.42	0.60	-0.45	1.05
3	Sm	50	19	31	5.40	2.12	0.56	0.68	51	S	99	1	-	1.30	0.78	-0.42	1.09
4	mS	57	22	21	3.43	1.00	0.30	1.83	52	S	99	1	-	2.24	1.27	-0.01	0.77
5	mS	51	17	32	5.97	2.63	0.69	0.57	53	S	99	1	-	2.11	1.40	-0.16	0.79
6	Ss	29	52	19	5.91	2.05	0.59	1.17	54	mS	79	8	13	1.96	2.27	0.57	1.72
7	m	5	44	51	7.68	2.28	-0.19	0.66	55	mS	68	13	19	2.14	2.42	0.24	0.59
8	m	4	46	50	7.68	2.22	-0.06	0.76	56	mS	86	9	5	3.62	0.41	0.11	1.40
9	m	1	39	60	8.36	2.43	-0.06	0.76	57	mS	88	7	5	3.79	0.46	0.06	1.21
10	m	4	42	54	8.24	2.57	-0.02	0.80	58	mS	89	8	3	3.79	0.55	0.17	1.60
11	Sm	12	52	54	6.81	2.38	0.24	0.63	59	mS	77	12	11	3.79	0.48	0.20	1.26
12	Ss	29	49	22	6.61	2.38	0.00	0.90	60	S	91	6	3	2.93	0.46	0.14	1.27
13	Ss	44	43	13	5.06	1.83	0.53	1.53	61	S	96	2	2	3.39	0.54	0.18	1.27
14	sS	56	32	12	5.05	1.74	0.61	2.51	62	S	94	4	2	3.36	0.54	0.21	1.07
15	Ss	42	45	13	5.16	1.67	o.55	2.59	63	S	98	2	-	3.22	0.74	-0.10	1.29
16	mS	86	5	9	3.97	0.68	0.33	1.67	64	Sc	13	25	62	7.07	1.97	-0.55	1.36
17	Sm	17	54	29	6.08	1.62	-0.15	0.82	65	S	96	4	-	0.62	1.14	0.23	0.85
18	mS	89	4	7	3.99	0.57	0.46	1.34	66	S	95	5	-	0.21	0.82	0.10	1.13
19	S	94	4	2	2.24	0.71	0.41	1.44	67	S	90	6	4	0.96	0.77	-0.08	0.86
20	sS	86	9	5	4.17	0.75	0.45	1.14	68	S	96	3	1	1.15	0.76	-0.14	0.83
21	S	98	2	-	1.12	0.65	0.01	0.89	69	S	99	1	-	1.19	0.96	0.04	1.21
22	S	96	3	1	2.11	0.65	0.52	1.40	70	mS	83	7	10	2.02	1.69	0.42	2.02
23	sS	84	13	3	4.06	1.26	0.29	2.70	71	mS	86	9	5	1.14	1.06	-0.17	1.30
24	sS	16	52	32	6.58	2.17	0.02	0.73	72	S	99	1	-	0.09	1.16	-0.44	1.39
25	Sm	58	36	6	5.41	2.36	0.40	1.01	73	S	98	2	-	0.04	0.94	-0.28	0.97
26	m	8	43	49	7.51	2.19	-o.23	0.79	74	S	93	4	3	0.56	0.97	0.01	0.76
27	m	8	42	50	7.62	2.11	-0.27	0.73	75	Sc	43	16	41	4.04	2.19	-0.01	0.97
28	m	8	40	52	7.68	2.52	-0.15	0.84	76	Sm	36	28	36	8.34	2.38	-0.47	1.49
29	Sm	14	36	50	6.05	2.45	0.24	0.69	77	Sc	18	21	61	8.16	2.28	-0.49	1.51
30	Sm	32	27	41	6.41	2.96	-0.05	0.73	78	S	93	6	1	3.27	0.57	0.15	1.18
31	mS	54	27	19	5.18	2.70	0.28	1.10	79	S	94	5	1	3.17	0.46	0.28	0.95
32	mS	79	9	11	4.31	2.43	0.32	2.03	80	S	91	6	3	3.16	0.50	0.45	0.92
33	sS	87	9	4	4.15	0.69	0.35	1.61	81	S	90	6	4	3.17	0.54	0.44	0.88
34	S	97	2	1	2.06	0.59	0.63	2.53	82	Sc	42	14	44	5.05	3.26	0.16	0.75
35	S	94	4	2	3.54	0.46	-0.16	1.60	83	Sm	40	26	34	5.64	2.74	0.45	0.69
36	S	96	2	2	3.59	0.47	0.09	1.75	84	Sc	38	19	43	5.89	3.30	-0.40	0.53
37	S	96	3	1	3.31	0.69	-0.09	1.68	85	S	95	2	3	0.61	0.95	0.06	1.39
38	mS	85	9	6	3.61	0.51	0.26	2.20	86	S	94	3	3	0.70	1.05	0.16	1.23
39	S	91	6	3	3.50	0.45	0.26	1.51	87	mS	80	9	11	1.97	1.59	0.42	1.52
40	sS	90	8	2	3.99	0.63	0.49	1.39	88	mS	75	10	15	2.07	1.59	0.35	1.37
41	S	93	6	1	1.11	0.90	-0.07	0.98	89	m	3	40	57	7.47	2.13	-0.26	0.78
42	S	90	6	4	1.02	0.91	-0.11	1.03	90	m	2	35	63	7.64	2.18	-0.21	0.68
43	mS	85	10	5	1.54	1.09	0.07	1.39	91	Sm	17	40	43	6.64	2.16	0.29	0.64
44	Sm	30	32	38	6.31	3.05	-0.17	0.75	92	Sm	20	39	41	6.59	2.15	0.29	0.64
45	Sm	14	33	53	7.70	2.87	-0.20	0.83	93	Sm	24	35	41	6.54	2.17	0.30	0.66
46	Sm	16	44	40	6.68	2.23	0.21	0.68	94	Sm	30	32	38	6.51	2.24	0.26	0.72
47	m	6	54	40	7.33	2.02	-0.21	0.85	95	Sc	39	17	44	4.70	2.71	0.03	0.77
48	Sm	15	33	52	7.61	2.69	-0.31	0.70	96	S	94	4	2	3.21	0.54	0.48	0.99

S = sand, mS = muddy sand, Sm = sandy mud, sS = silty sand, Ss = sandy silt, Sc = sandy clay, m = mud

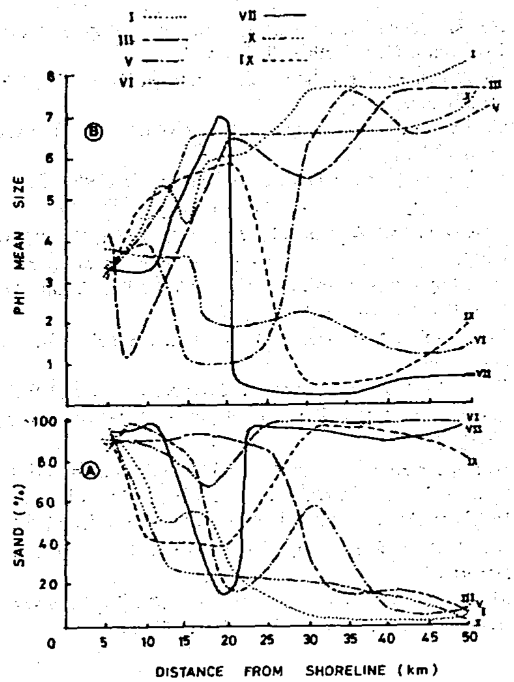

Fig. 2—Sand per cent (A) and phi mean size (B) of shelf sediments from seven profiles plotted against the shoreline

mean size is disrupted and cyclic distribution pattern of the mean size is observed. The ϕ mean size increases up to 20 m isobath and there after up to 50 m isobath it decreases (2 to 0.4 ϕ; Fig. 2B). Sediments near the littoral zone (<5 m) are well sorted and fine sediments occupying the outer parts of the shelf are poorly sorted (Table 1). Shelf sediments have a wide range in the skewness values from strong positive (0.69) to negative (-0.55). However, the coarse sands are nearly symmetrical to negatively skewed (0.02 to -0.55 ϕ) compared to the fine grained shelf sediments, which are more positively skewed (0.25-0.55 ϕ). Kurtosis values vary between 0.59 and 2.7 ϕ (Table 1). The nearshore and offshore sands are platy to mesokurtic (0.59 to 0.97 ϕ) whereas the fine sediments are leptokurtic (1.19-2.7 ϕ).

In the C-M diagram (Fig. 3), paleo beach and nearshore sands are located in the beach zone specified by Passega[7]. This suggests the sandy sediments were deposited under high energy condition probably similar to those existing on the present day shoreface. The inner and outer shelf clayey sediments are scattered slightly away from the C-M line, it shows a difference in the sorting of sediments and lowering energy conditions.

Transgressive sediments on the inner shelf comprise stillstand deposit of coarse sands and shallow marine fine silts and clays. Without radiochemical data an accurate chronology of sedimentation is difficult to establish. However, an understanding of surface sediment formation is possible by the contrasting modern verses ancient origins of sediment patches and of sedimentary deposits. Well to moderately sorted littoral sands extend only a few meters offshore. Occurrence of stillstand deposits in the coastal area shows that the modern hydrodynamic processes are not intense enough to modify the sediments. As indicated by sediment distribution pattern, modern sediment deposition seems to be active only up to 20 m isobath with sandy clay and sandy silt depositing in offshore. C-M pattern also indicates low energy conditions in most parts of the shelf, where fine sediments were deposited. From the characteristic negative skewness, moderate sorting, lack of suspension material and inconsistent occurrence in relatively low energy conditions, the coarse sands in the outer part of the inner shelf are considered to be a stillstand deposition of the Holocene transgression. It appears that during Holocene period there was a rapid rise in the sea level at about 20 m isobath and the shore zone skipped land ward. During the transgression period, sandy sediments were deposited at the shoreline and fine sediments were carried offshore. It is rather difficult to estimate the occurrence of coarse sands in the shallow marine conditions. With the resumption of rapid rise in sea level and assocaited submergence, the shore line migrated landward leaving the coarse sand as a lag deposit. During the study of sediment movement in the littoral waters off Gopalpur Srivastava and Rao[8] questioned the existence of modern sands and viewed the possible presence of relict sands. Other reports[9-12] also state that the paleo shoreline formed during brief lulls in the Holocene transgression can be delineated by the presence of an abnormally high concentration of coarse sediments. The stillstand deposit occurring at 20 m isobath in Nizampatnam bay[13], (east coast of India) ascribed an age of 8200 ± 120 y BP. Mid Holocene standlines were identified on the

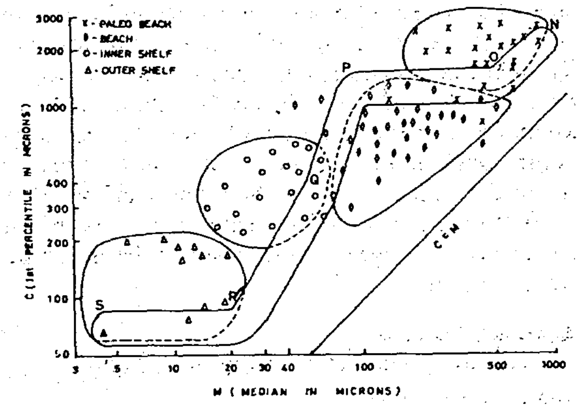

Fig. 3—C-M pattern of the inner shelf sediments

shelf of west coast of India between 20 and 30 m depth based on the occurrence of coarse sediments[14,15]. Though exact locations are lacking, occurrence of coarse sands in the inner shelf of Gopalpur and Visakhapatnam on the east coast of India at about 20 m depth substantiates the above inference[16]. Further detailed investigations on the inner shelf of other parts of the east coast of India are needed to confirm and evaluate the age of this standstill of the Holocene transgression.

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