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Textural Studies on Red Sediments of Bhimunipatnam, Andhra Pradesh, East Coast of India

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ABSTRACT

The study presents the textural characteristics of late Quaternary red sediments of Bhimunipatnam to understand the process of formation of these sediments. The red sediments are classified into (a) yellow sediments (b) reddish brown sediments (c) brick red sediments and (d) light yellow sediments sequence in the vertical litho section. The yellow sediments, rests on the khondalite basement, comprises of medium grained, moderate to poorly sorted and positively skewed. The rounded pebble beds with trough cross bedding indicate high energy turbulent conditions of deposition. The fining upward sequences indicate sediments were deposited under decreasing energy conditions under fluvial regime. The iron bearing minerals like garnets and pyriboles have undergone chemical weathering under high oxidizing environment resulting in addition of silt and clay to the reddish brown and brick red sediments and concretions were formed by carbonate precipitation. These processes caused changes in the mean grain size and sorting nature of these sediments which are originally aeolian in origin. The light yellow sediments were medium to fine grained, well sorted and similar to modern dune sands in terms of textural parameters. These sediments were deposited under low oxidation environmental conditions and acquired yellow colour due to Fe hydroxides.

INTRODUCTION

Coastal palaeo red sediments are reported to occur in south Asia viz. (a) southern Sri Lanka (b) Teri sands of south east coast of Tamil Nadu and (c) red sediments along Visakhapatnam to Bhimunipatnam coast in Andhra Pradesh. These sediments are distributed along the dissected coastal topography.

Red sediments of Visakhapatnam – Bhimunipatnam are denudational remnants of the great sand bank of the late pliocene or isolated banks formed around the sunken hills (King, 1886). Earlier publications on red sediments infers different depositional environments. Sediments are the result of wind and fluvial (Mahadevan and Sathapathi, 1949), wind (Vishnuvardhana Rao and Durga Prasada Rao, 1968; Srihari, 1980) fluvial (Prudhvi Raju and Viadyanadhan, 1978; Rao, 1978; Raman and Rao, 1980) marine, wind and fluvial (Prudhvi Raju et al., 1985); fluvial and aeolian (Rao et al., 1993; Madabhushi, 2003) processes. Hence the present study try to establish the depositional environment of red sediment types based on textural studies.

STUDY AREA

The red sediments of Bhimunipatnam is located (17°51' and 17°53' N and 83°23' to 83°25' E) about 20 km north of Visakhapatnam in Andhra Pradesh (Fig. 1). It has an average elevation of 51 m above MSL. A predominantly red-looking sediment deposit covering an area of 10 km^2, extending 1.5 to 2.5 km inland from the beach road and length of 5 km along the coast.

Bhimunipatnam is bounded by Eastern Ghat Granulite Belt (EGGB) consisting of khondalites (garnet-sillimanite gneisses) and leptynites (garnet-biotite gneisses) (Rao et al., 1993). These rocks belong to Precambrian and are characterized by the occurrence of metasediments and intrusive metaigneous bodies besides the occurrence of red sediments with calcium carbonate calcretes, dune and beach sediments with black sands.

METHODOLOGY

Fifteen geological sections (Fig. 2) at different gullies were studied. The type lithological sections (Nos: 3, 6, 9 and 10) are presented in Table 1.

Lithological section No. 3. The total thickness of the brick red sediments (N 17°52'42.2" and E 83°25'39.3") in this section is 69'. Yellow sediments (30') at the bottom of the section followed by the brownish red colour sediments (31') and brick red sediments (8'). Devoid of concretions, cross bedding and laminations (Fig.3A).

Lithological section No. 6. The total thickness of the sediments (N 17°52'12.9" and E 83°25'33.1") is 34'. Basement khondalite (3') overlained by weathered khondalite (9'), pebble bed (3'), and yellow sediments (18'). Concretions are not present (Fig.3B).

Lithological section No. 9. The total thickness of the yellow sediments (N 17°52'24.9" and E 83°25'28.9") is 66'. The bottom part (9') is overlained by trough cross bedded sediments of 12' and planar cross bedded sedimentary unit of 6'. This is overlain by horizontal laminated sediments (18').The upper part is structureless sediments (18'). Fining upward sequences are present (Fig.3C).

Lithological section No. 10. The total thickness of the yellow sediments (N 17°52'26.1" and E 83°25'29.1") is 20'. The bottom part yellow sediments (4'), followed by yellow sediment with cross bedding and planar lamination (10') (Fig.3D).

The yellow sediments is the bottom sequence resting on the khondalite basement and its thickness varies from 20' to 66' in different studied sections. The yellow sediments is overlained by concretion bearing reddish brown sediments with variable thickness from 25' to 50'. It is overlained by brick red sediments with variable thickness of 8' to108', followed by the top light yellow sediments (thickness varies from 21' to 81').

Sampling Method

Total 68 sediment samples (14 in yellow sediments, 12 in reddish brown sediments, 22 in brick red sediments 10 in light yellow sediments and 10 in modern dune sediments) were collected by penetrating plastic tube (3" diameter) to a depth of 15-20 cm from the surface. All the sediment samples were air dried for laboratory studies. The representative portion of 100 gm is soaked in distilled water to dissolve salts, 15% hydrogen peroxide is added to remove organic matter and treated with 10% dilute HCl to remove the shell material. These samples

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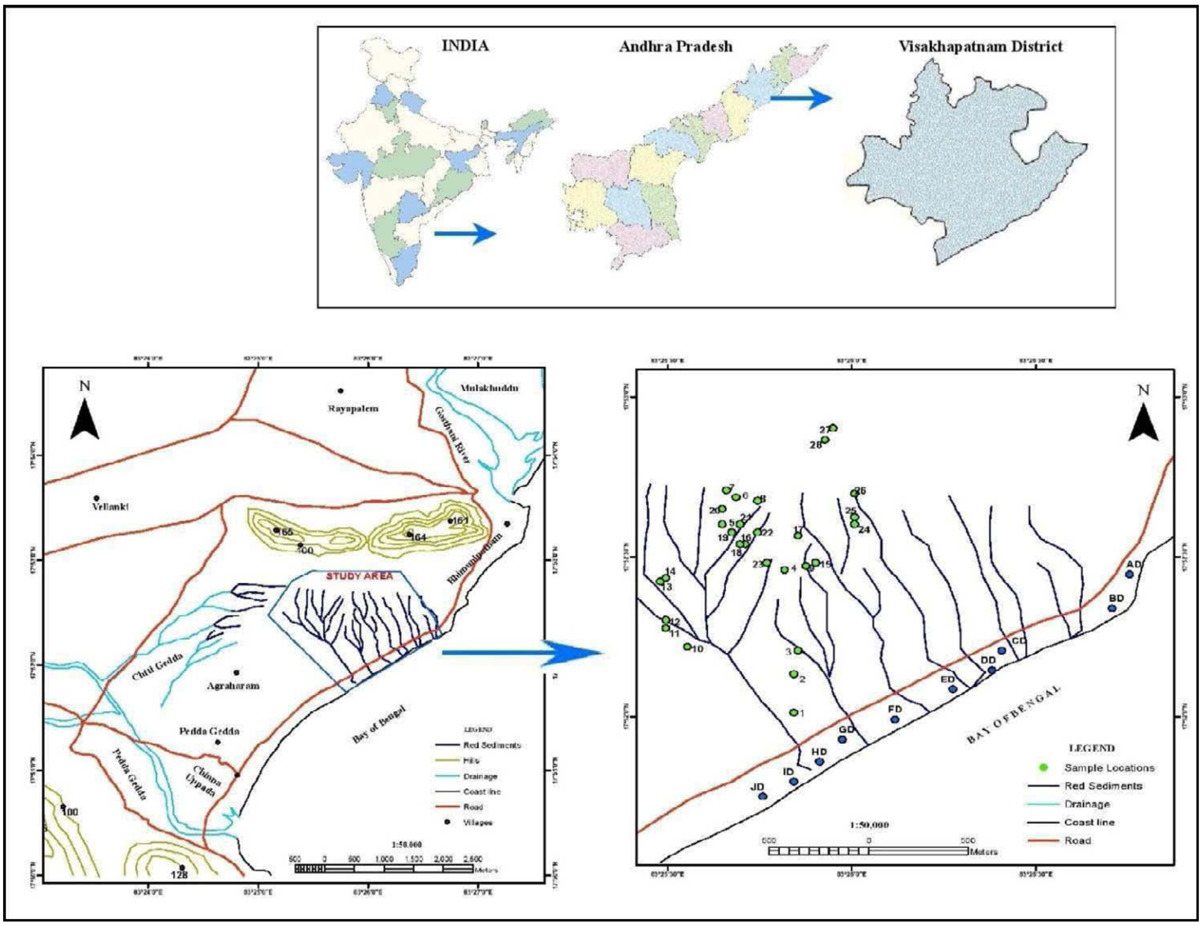

Fig.1. Sample location map of the study area.

Table 1. Location and lithology of geological sections in red sediments of Bhimunipatnam

Section No.	Location	North Latitude	East Longitude	Total Thickness of section	Lithology
1	3	17° 52' 08"	83° 25' 50.2"	39'	Brick Red Sediments
2	4	17° 52' 27.5"	83° 25' 48.8"	66'	Brick Red Sediments
3	7	17° 52' 42.2"	83° 25' 39.3"	69'	Brick Red Sediments Reddish brown Sediments Yellow Sediments
4	8	17° 52' 40.0"	83° 25' 44.7"	108'	Reddish brown Sediments
5	9	17° 52' 27.9"	83° 25' 52.8"	72'	Brick Red Sediments
6	10	17° 52' 12.9"	83° 25' 33.1"	34'	Yellow Sediments Pebble bed Weathered khondalite Basement khondalite
7	11	17° 52' 16.7"	83° 25' 29.5"	21'	Light Yellow Sediments
8	12	17° 52' 17.9"	83° 25' 29.4"	87'	Light Yellow Sediments
9	13	17° 52' 24.9"	83° 25' 28.9"	66'	Yellow Sediments Planar lamination Planar cross bedding Yellow Sediments Trough cross bedding Yellow Sediments
10	14	17° 52' 26.1"	83° 25' 29.1"	20'	Planar cross bedding Cross bedding Yellow Sediments
11	24	17° 52' 35.7"	83° 26' 0.52"	50'	Reddish brown Sediments
12	25	17° 52' 37.7"	83° 26' 0.35"	25'	Reddish brown Sediments
13	26	17° 52' 41.4"	83° 26' 0.10"	41'	Reddish brown Sediments
14	27	17° 52' 54.2"	83° 25' 57.1"	60'	Light yellow Sediments
15	28	17° 52' 52.1"	83° 25' 55.1"	60'	Light yellow Sediments

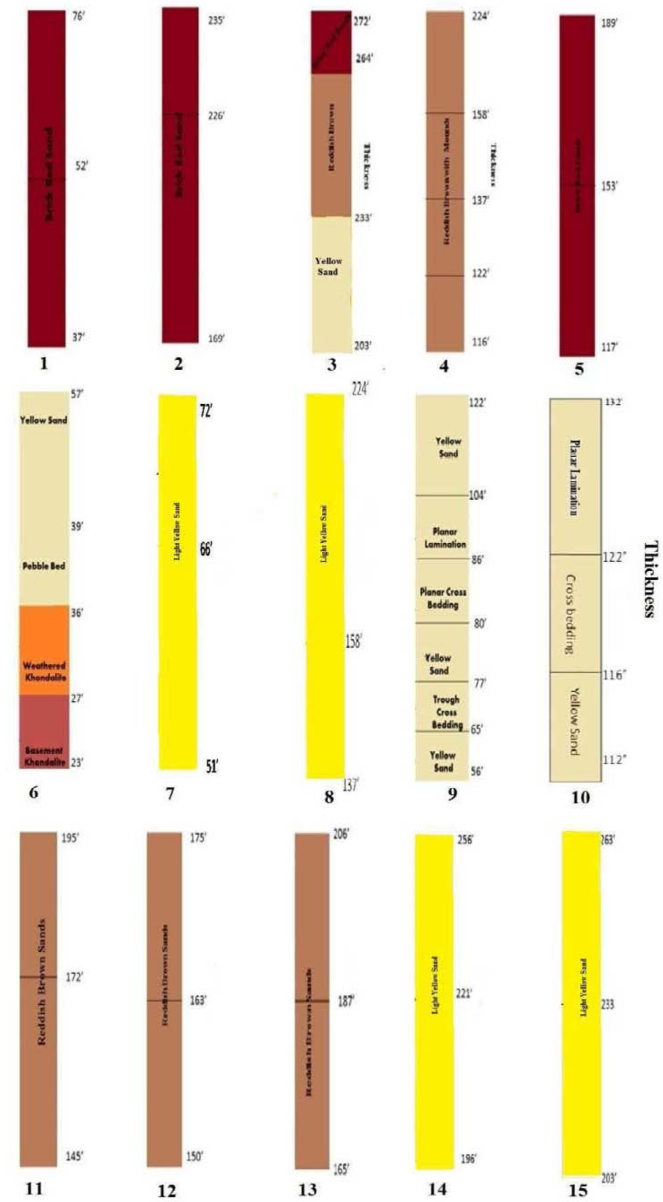

Fig.2. Geological cross-sections.

were wet sieved by 230 ASTM mesh. The +230 mesh materials were subjected to dry sieving into +60, -60 to +120 and -120 to +230 ASTM mesh size fractions. Pipette analysis of clay samples is carried out following the procedure of Krumbein and Pettijohn (1938) and Folk (1968). The G-Stat program (Dinesh, 2009) was used to determine sand, silt and clay proportion and the grain size parameters (Table 2).

RESULTS AND DISCUSSION

Sand, Silt and Clay Relative Abundance

Relative abundances of sand, silt and clay in red and dune sediments are recorded (Table 2). In yellow, reddish brown, brick red and light yellow sediments, sand is 90.15% (average) and silt + clay content is less (av. 9.85 %). In yellow sediments silt + clay is <12%, while in 11B in which silt + clay is upto 19%. In reddish brown sediments, silt + clay is <10%, except in sample nos. 12T, 24T, 24M and 24B in which it is up to 43%. In brick red sediments, silt + clay content is <10% but in sample nos. 1T, 9T, 3M, 4M, 7M and 3B is up to 24 %. The variation of silt + clay is not systematic from top to bottom. In the light yellow sediments, silt + clay content is <11%. In the modern dune sands silt + clay <1% (Table 2).

TEXTURAL PARAMETERS

Mean Grain Size (M_z): Mean grain size values of yellow, reddish brown, brick red and light yellow sediments ranges from 1.44 to 3.11 ϕ and these are medium grained sands except a few fine grained samples(>2 ϕ, Table 2). Modern dune sediments have average mean grain sizes 2.25 ϕ (ranges 2.01 to 2.62 ϕ) and these are fine grained sands (Table 2).

Standard Deviation (σ_I): The standard deviation values of yellow, reddish brown, brick red and light yellow sediments ranges from 0.39 to 2.20 ϕ (Table 2) which indicates that the sediments are poor to moderately sorted. The average standard deviation value of the dune sands is 0.48 ϕ (ranges from 0.40 to 0.62 ϕ) and these are moderately sorted to well sorted in nature (Table 2).

Skewness (S_k): The skewness values of yellow, reddish brown, brick red and light yellow sediments ranges from -0.01 to 0.69 ϕ and these sediments are near symmetrical to very positively skewed. The average skewness values of dune sediments is 0.13 ϕ (range from -0.22 to 0.44 ϕ) and these sediments are negatively skewed to very positively skewed. All sediment samples of red sediments are either positively skewed or very positively skewed except three samples in light yellow sediments which are near symmetrical (Table 2).

Kurtosis (K_g): The kurtosis values of yellow, reddish brown, brick red and light yellow sediments ranges from 0.63 to 3.05 ϕ and these sediments are very platykurtic to extremely leptokurtic (Table 2). The dune sediments average 0.99 ϕ (ranges from 0.86 to 1.51 ϕ) and these sediments are platykurtic to leptokurtic in nature.

BIVARIATE PLOTS

Scatter plots describe the role of addition and removal of fine and/ or coarse fraction during the transit of sediment along beaches, riverbeds and dunes in controlling the variation in textural/statistical parameters among the sediments. An attempt is made here to understand the inter relationship of different grain size parameters through scatter plots.

Mean size vs Standard Deviation: The scatter plot between mean size and standard deviation (Fig.4A) show significant positive correlation in yellow, reddish brown, brick red, light yellow and dune sediments. The scatter plot indicates that finer the grain size of the sediments, poorer the sorting in red sediments. While in dune sediments finer the grain sizes better the sorting. More than 70% of samples from yellow sediments are medium sands and poorly sorted in nature. Reddish brown, brick red and light yellow sediments are fine to very fine sands with poor sorting. In dune sediments with decreasing grain size, sorting increases.

Standard Deviation vs Skewness: The scatter plot between standard deviation vs skewness (Fig.4B) show significant positive relation for light yellow, reddish brown and brick red sediments which indicates that positively skewed sediments are poorly sorted and yellow sediments show negative correlation in skewness and standard deviation. The light yellow, reddish brown and brick red sediments are positively skewed and moderately sorted to very poorly sorted in nature. The scatter plot indicates that as the sediments become more positively skewed, sorting becomes poorer except in yellow sediments. There is insignificant relation between standard deviation and skewness in dune sediments of the study area.

DISCUSSION

The fifteen geological cross sections in the gullies of the Bhimunipatnam red sediments area reveals that sedimentary sequence i.e. (a) yellow (b) reddish brown (c) brick red and (d) light yellow sediments from basement to top (Rao et al., 1993) is neither present in all the places nor same units exposed in all sequences in vertical sections. Except 3, 6, 9 and 10, in the remaining studied sections only one sedimentary unit is present.

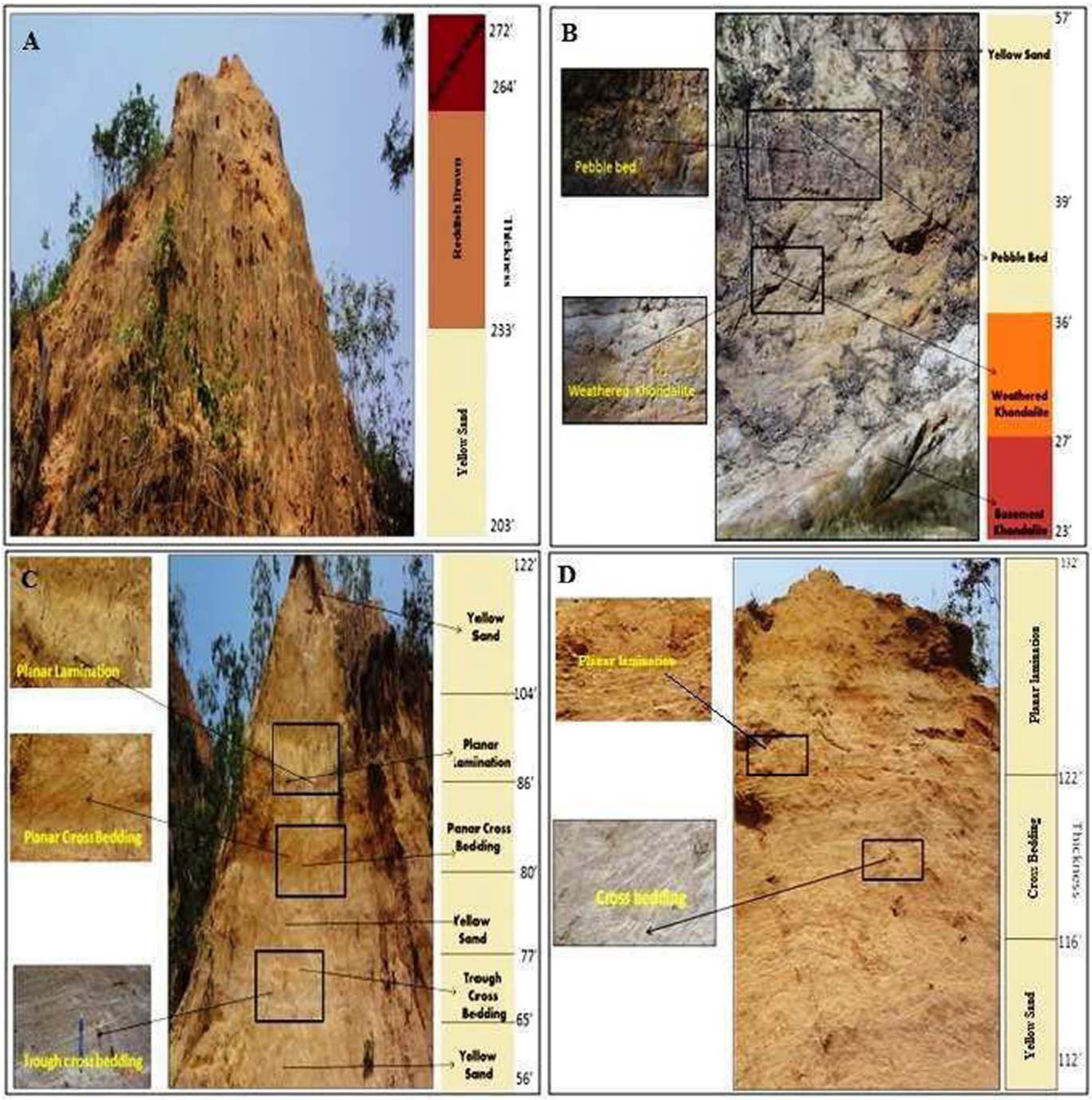

Fig.3. Type lithological section (A) section no.3 (B) section no.6 (C) section no.9 and (D) section no.10

Field observations and interpretations revealed that the thicknesses of the sand units are not same throughout the study area. The bed rock configuration in the depositional basin is variable (Nageswara Rao et al., 2008) which causes variation of thickness of overlained sand unit but other sand units also shows variable thickness because of different dunal morphology.

The bottom yellow unit comprises of medium grain sands which are moderate to poorly sorted and positively skewed. This sand unit showing fining upward sequence with pebble beds at the bottom overlained by coarse to medium sand with trough cross bedding overlain by medium to fine sands with cross lamination and overlain by fine sands with planar lamination.

The fining upward sequence and the rounded pebble beds with trough cross bedding indicate high energy turbulent conditions of deposition by fluvial regime. Cross bedding and its thickness indicates flow conditions, intensity of energy and direction of flow while planar lamination indicates calm environment of deposition. The structures in yellow sediments indicate that these sediments were deposited in fluvial environment under different energy conditions.

The reddish brown and brick red sediments are medium to very fine grain sands and are poorly sorted. The variation of sorting reflects continuous addition of fine or coarse material to the respective sedimentary units in various proportions (Ramanathan et al., 2009). These two sedimentary units contain micritic calcretes which were formed by evaporate process and rapid precipitation of carbonates (Duraga Prasad Rao and Srihari, 1980).

The heavy mineral assemblage in the present study area are in decreasing abundance with ilmenite, magnetite, sillimanite, garnet, zircon, rutile, kyanite and monazite (Murali Krishna et al., 2016) and garnets and pyriboles are not present. It indicates that these iron bearing minerals might have undergone chemical weathering under high oxidizing environment, produce Fe_2O_3 and $SiO_2^- + Al_2O_3$. The Fe oxide solutions circulation gives red colour to the sediment and $SiO_2^- + Al_2O_3$ aided in the formation of silt and clay. In the present study area brick red and reddish brown sedimentary units contain more silt + clay (av.11.8%) and concretions. These processes might have changed the mean grain size and sorting nature of these sediments.

The light yellow sediments are medium to fine grained and well sorted and similar to modern dune sediments in terms of textural parameters and light yellow sediments were deposited under low

Table 2. Sand, Silt and Clay percentages and textural parameters of red sediments and modern dune sediments of Bhimunipatnam

Loc. No.	Sample No.	Sand	Silt	clay	Textural	Mean Size (Ø)	SD (Ø)	Skewness (Ø)	Kurtosis (Ø)	Remarks
Light Yellow Sediments										
8	8T	95.55	4.39	0.06	Sand	1.62	0.63	0.21	1.51	MS, MSd, PSk, VLK
8	8M	93.34	6.39	0.28	Sand	1.76	0.84	0.35	2.06	MS, MSd, VPSk,VLK
8	8B	89.31	10.56	0.14	Sand	2.04	1.18	0.48	2.41	FS, PS, VPSk, VLK
8	8B1	95.08	4.73	0.19	Sand	1.71	0.71	0.29	1.81	MS, MSd,PSk, VLK
27	27T	96.00	3.00	1.00	Sand	1.61	0.53	0.11	1.05	MS, MSd, PSk, MS
27	27M	96.50	2.50	1.00	Sand	1.73	0.39	-0.01	1.03	MS, WS, NSy, MK
27	27B	95.50	3.00	1.50	Sand	1.73	0.49	0.11	1.10	MS, WS, PSk, MK
28	28T	96.25	2.75	1.00	Sand	1.44	0.45	0.04	1.01	MS, WS, NSy, MK
28	28M	97.00	2.00	1.00	Sand	1.70	0.49	0.09	1.09	MS, WS, NSy, MK
28	28B	96.55	2.45	1.00	Sand	1.59	0.61	0.12	1.03	MS, MSd, PSk, MSk
Min		89.31	2.00	0.06		1.44	0.39	-0.01	1.01	
Max		97.00	10.56	1.50		2.04	1.18	0.48	2.41	
Av		95.11	4.18	0.72		1.69	0.63	0.18	1.41	
Brick Red Sediments										
1	1T	81.30	17.45	1.25	Sand	2.57	1.74	0.66	1.86	FS, PS, VPSk, VLK
2	2T	89.98	9.23	0.79	Sand	1.93	1.07	0.38	1.97	MS, PS, VPSk, VLK
4	4T	93.55	6.07	0.38	Sand	1.75	1.10	0.55	1.79	MS, PS, VPSk, VLK
5	5T	95.09	4.13	0.78	Sand	1.79	0.79	0.26	1.47	MS, MSd, PSk, LK
6	6T	96.22	3.36	0.42	Sand	1.77	0.68	0.18	1.27	MS, MSd, PSk, LK
7	7T	89.79	9.93	0.28	Sand	1.97	0.98	0.50	2.26	MS, MSd, VPSk, VLK
9	9T	88.36	11.38	0.27	Sand	1.98	1.22	0.46	2.35	MS, PS, VPSk, VLK
15	15T	91.43	7.75	0.82	Sand	1.94	0.99	0.37	1.89	MS, MSd, VPSk, VLK
17	17T	91.06	7.88	1.06	Sand	1.88	1.04	0.37	2.02	MS, PS, VPSk, VLK
18	18T	92.58	6.81	0.62	Sand	1.82	0.99	0.27	1.83	MS, MSd, PSk, VLK
19	19T	92.09	7.05	0.86	Sand	1.82	0.99	0.28	1.90	MS, MSd, PSk, VLK
20	20T	92.29	6.92	0.79	Sand	1.78	1.01	0.28	1.85	MS, PS, PSk, VLK
22	22T	93.23	6.49	0.28	Sand	1.77	0.95	0.17	1.79	MS, MSd, PSk, VLK
3	3M	76.13	23.38	0.49	Sand	2.77	1.83	0.69	1.22	FS, PS, VPSk, LK
4	4M	84.43	15.29	0.28	Sand	2.18	1.51	0.59	2.37	FS, PS, VPSk, VLK
7	7M	82.49	16.31	1.20	Sand	2.69	1.92	0.69	2.20	FS, PS, VPSk, VLK
9	9M	94.00	5.74	0.26	Sand	1.93	0.86	0.34	1.82	MS, MSd, VPSk, VLK
3	3B	84.53	14.99	0.48	Sand	2.17	1.43	0.59	2.18	FS, PS, VPSk, VLK
4	4B	92.40	7.52	0.08	Sand	1.49	1.27	0.47	2.84	MS, PS, VPSk, VLK
7	7B	92.73	5.97	1.30	Sand	1.85	1.12	0.40	2.41	MS, PS, VPSK, VLK
9	9B	90.64	8.71	0.66	Sand	1.93	0.96	0.37	1.83	MS, MSd, VPSk, VLK
13	13B1	93.42	5.15	1.43	Sand	1.57	1.41	0.28	1.56	MS, PS, PSk, VLK
Min		76.13	3.36	0.08		1.49	0.68	0.17	1.22	
Max		96.22	23.38	1.43		2.77	1.92	0.69	2.84	
Av		89.90	9.43	0.67		1.97	1.17	0.42	1.94	
Reddish Brown Sediments										
3	3T	94.72	5.27	0.01	Sand	2.09	0.76	0.33	1.49	FS, MSd, VPSk, LK
12	12T	88.59	10.75	0.66	Sand	1.78	1.20	0.40	1.90	MS,PS, VPSk, VLK
21	21T	91.44	7.94	0.62	Sand	1.82	1.07	0.35	1.68	MS,PS, VPSk, VLK
24	24T	57.02	40.23	2.75	Silty Sand	3.11	2.00	0.52	0.69	VFS, PS, VPSk,PK
24	24M	66.63	32.04	1.33	Silty Sand	2.86	1.91	0.59	0.63	VFS, PS, VPSk, VPK
24	24B	75.60	23.23	1.18	Sand	2.76	1.74	0.58	0.89	FS, PS, VPSk, PK
25	25T	91.29	6.87	1.84	Sand	1.77	0.99	0.38	1.92	MS, MSd, VPSk, VLK
25	25M	93.57	5.70	0.73	Sand	1.68	0.97	0.32	1.87	MS, MSd, VPSk, VLK
25	25B	88.47	8.70	2.83	Sand	1.83	1.18	0.43	2.12	MS, PS, VPSk, VLK
26	26T	89.73	9.80	0.47	Sand	1.84	0.97	0.32	1.60	MS, MSd, VPSk, VLK
26	26M	93.05	6.21	0.74	Sand	1.73	0.89	0.35	1.85	MS, MSd, VPSk, VLK
26	26B	89.89	9.79	0.32	Sand	1.85	0.96	0.39	1.66	MS, MSd, VPSk, VLK
Min		57.02	5.27	0.01		1.68	0.76	0.32	0.63	
Max		94.72	40.23	2.83		3.11	2.00	0.59	2.12	
Av		85.00	13.88	1.12		2.09	1.22	0.41	1.52	
Yellow Sediments										
10	10T	95.39	4.40	0.21	Sand	1.95	0.70	0.25	1.57	MS, MSd, PSk, VLK
11	11T	94.78	4.53	0.69	Sand	1.57	1.22	0.10	1.09	MS, PS, PSk, MK
13	13T	92.30	6.03	1.67	Sand	1.59	1.53	0.31	1.71	MS, PS, VPSk, VLK
14	14T	91.74	7.58	0.68	Sand	1.77	1.01	0.60	1.65	MS, PS, VPSl, VLK
16	16T	91.42	8.38	0.20	Sand	1.78	0.97	0.53	1.54	MS, MSd, VPSk, VLK
23	23T	94.46	5.08	0.46	Sand	1.74	0.90	0.53	1.53	MS, MSd, VPSk, VLK
11	11M	93.86	4.70	1.45	Sand	1.58	1.28	0.10	1.21	MS, PS, PSk, LK
12	12M	89.55	10.28	0.17	Sand	1.84	1.69	0.15	1.23	MS, PS, PSk, LK
13	13M	87.56	10.58	1.87	Sand	1.64	1.69	0.22	1.51	MS, PS, PSk, VLK
7	7B1	94.38	4.08	1.54	Sand	1.64	0.93	0.37	2.18	MS, MSd, VPSk, VLK
7	7B2	94.12	5.82	0.06	Sand	1.56	1.11	0.42	3.05	MS, PS, VPSk, VLK
11	11B	81.46	17.28	1.26	Sand	2.48	2.20	0.41	1.43	FS, VPS, VPSk, LK
12	12B	86.24	9.86	3.91	Sand	2.32	1.65	0.31	2.04	FS, PS, VPSk, VLK
13	13B	92.47	6.94	0.59	Sand	1.76	1.01	0.59	1.69	MS, PS, VPSk, VLK

Min		81.46	4.08	0.06		1.56	0.70	0.10	1.09	
Max		95.39	17.28	3.91		2.48	2.20	0.60	3.05	
Av		91.41	7.54	1.05		1.80	1.28	0.35	1.67	
Modern Dune Sediments										
29	AD	99.81	0.19	0.00	Sand	2.05	0.53	0.23	0.94	FS, MSd, PSk, MK
30	BD	99.45	0.55	0.00	Sand	2.62	0.42	-0.22	1.51	FS, WS, NSk, VLK
31	CD	99.95	0.05	0.00	Sand	2.52	0.42	-0.06	1.08	FS, WS, NSk, MK
32	DD	99.97	0.03	0.00	Sand	2.24	0.40	0.10	0.86	FS, WS, PSk, PK
33	ED	99.93	0.07	0.00	Sand	2.11	0.44	0.23	0.90	FS, WS, PSk, MK
34	FD	99.97	0.03	0.00	Sand	2.25	0.62	-0.20	0.95	FS, MSd, NSk, MK
35	GD	99.87	0.13	0.00	Sand	2.35	0.47	0.15	0.85	FS, WS, PSk, PK
36	HD	99.92	0.08	0.00	Sand	2.01	0.48	0.35	1.00	FS, WS, VPSk, MK
37	ID	99.87	0.13	0.00	Sand	2.15	0.47	0.44	0.87	FS, WS, VPSk, PK
38	JD	99.83	0.17	0.00	Sand	2.21	0.51	0.31	0.91	FS, MSd, VPSk, MK
Min		99.45	0.03	0.00		2.01	0.40	-0.22	0.86	
Max		99.97	0.55	0.00		2.62	0.62	0.44	1.51	
Av		99.86	0.14	0.00		2.25	0.48	0.13	0.99	

MS: Medium Sand, FS: Fine Sand, VFS: Very Fine Sand, MSd: Moderately Sorted, WS: Well Sorted, PS: Poorly Sorted, PSk: Positively Skewed, VPSk: Very Positively Skewed, NSy: Near Symmetrical, NSk: Negatively Skewed, VLK: Very Leptokurtic, LK: Leptokurtic, MK: Mesokurtic, PK: Platykurtic

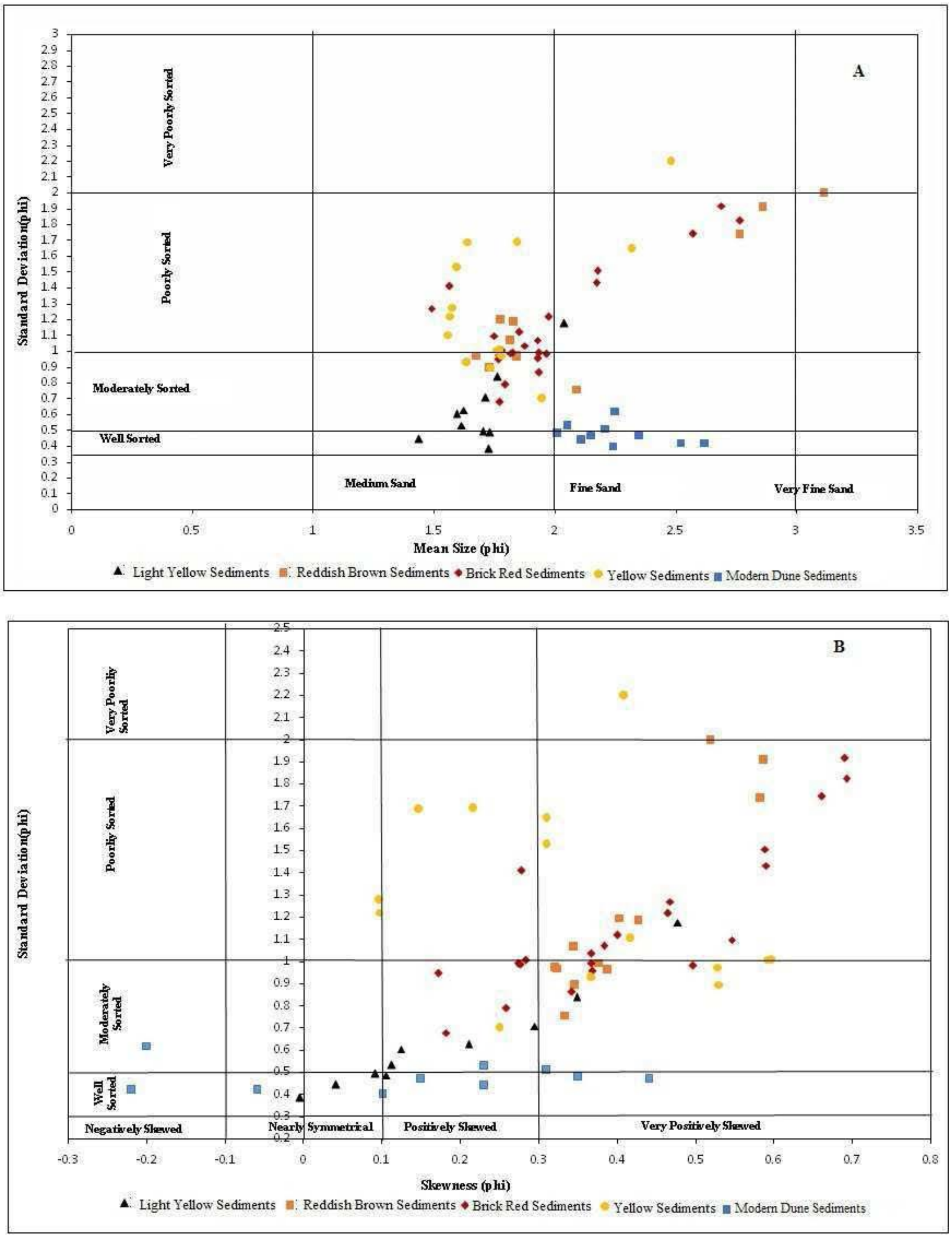

Fig.4. Comparison between **(a)** Mean vs Standard deviation **(b)** Skewness vs Standard deviation

oxidation environmental conditions and yellow colour is added due to Fe hydroxides.

All sediments are positively skewed indicating the deposition of sediments is by winnowing action. The positive skewness indicates deposition by either wind or river (Martin, 2003).

The range of kurtosis values (0.63 to 2.84 Ø) of light yellow, reddish brown and brick red sediments in the red sediments, suggested that these sediments achieved their sorting elsewhere in high energy environment (Friedman, 1962). The variation in the kurtosis values is a reflection of the flow characteristics of depositional medium (Baruah et al., 1997; Ray et al., 2006) and dominance of finer size and platykurtic nature of sediments reflects the maturity of sand.

CONCLUSIONS

1. The scatter plots of a) mean grain size vs standard deviation indicates that finer the grain size, poorer the sorting and b) standard deviation vs skweness shows that when the sediments become more positively skewed, sorting become poor except yellow sands. The fining upward sequence and the rounded pebble beds with trough cross bedding indicate high energy turbulent conditions of deposition by fluvial action.
2. The light yellow and modern dune sediments grain size parameters are similar which supports the aeolian origin for the light yellow sedimentary unit of the red sediments.
3. The textural characteristics of the reddish brown and brick red sediments are similar and silt + clay content in these sediments is relatively higher than the yellow, light yellow and modern dune sediments. This is due to geochemical alteration of the ferruginous minerals (garnets+ pyriboles) in reddish brown and brick red sediments giving rise to more silt and clay and also adding colour to the sediments.
4. The study brought out the difference in depositional history of the bottom most yellow unit which is fluvial while overlained other three units are aeolian in origin.

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