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A review on geology, geomorphology, origin and textural analysis of red sediments of east coast Visakhapatnam

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ABSTRACT

Red sediments are of a unique feature that exists in the east coast near Visakhapatnam. The Origin has been debated for over the years, most accepted is formed by the denudational remnants of a great sandbank of Pliocene times or isolated banks formed around sunken hills. Red sediments are formed by the cumulative work of wind and running water, where the red colour pigment is being preserved by the digenetic breakdown of iron-bearing minerals. Iron oxides derived from the red soils in the sources area (Khondalite terrain). Favorable environmental conditions for the preservation of the pigment in the depositional basin. The colour of the red sediments is mostly moderate reddish brown and moderate red. Moderate yellowish brown and dark reddish brown sediments are occurring in certain parts of Visakhapatnam region. The upland soils are pale reddish brown to moderate reddish brown. Many geomorphic features are observed like gullies, buried channels, Lineaments, beach ridges, sand dunes, wave-cut terrace, knick points and waterfalls, yellow sand unit, reddish-brown concretion bearing sand unit, brick-red sand unit, light yellow sand unit, duricrust, and pebble beds. Textural analysis has been made in these areas; results show that these are originated from under fluvial environment.

Keywords— *Red sediments, Red pigment, Khondalite, Iron oxides, Geomorphic features, Textural analysis*

1. INTRODUCTION

The areas under investigation are of two regions both are adjacent to river Gosthani near Bhimunipatnam town surrounding. The first area is nearby INS kalinga and the second one near Annavaram village. The red looking sand occurring along the Visakhapatnam surroundings attracted field investigators that revealed red looking sand includes various kinds of sediments such as red sediments, yellow and brown sands which were formed under different depositional conditions. The red sediments were first described in a published report by King (1886) and were considered to be a denudational remnant of a great sandbank of post-pliocene time or isolated banks formed around sunken hills. Later, many papers were written on these, but Rao, et.al (1993), studied on coastal sediments along Visakhapatnam region where the red sediment dunes are formed from different depositional environments from the Khondalitic origin. C^{14} dating suggested that the age of red sediments set around 6000-3000 B.P.

2. GEOLOGY

The Precambrian formations that constitute the hill ranges in the area in the order of decreasing abundance are Garent- Sillimanite gneisses, Garnetiferous granite, Granite, Charnokite series, Garnet-biotie- Sillimanite Gneisses, Pegamatite and Quartz Veins (Rao and Deva varma, 1992).

The sandy sediments confined to an arrow zone along the coast overlie the Precambrian gneisses. The sediments are reported by the previous investigation as a single sedimentary unit. The detailed field relations observed in the whole sedimentary prism reveals broadly the following units:

Modern beach and dunes
Reddish brown layered dune sands
Red sediments with pebble zones
Concretion –bearing brownish red dune sands
Brown sands
Reddish brown layered dune sands yellow sands
…… Pebbly zone……..
Sandstone (Gondawana)
……Angular unconformity……

Basement (khondalite) the different sedimentary units deposited on the khondalitic basement are considered as coastal sediments. The type of coastal sedimentary sequence is widely exposed in a channel cutting near Bhimunipatanam. The khondalitic basement exhibits a perfect wave-cut platform that is 7m above mean sea level .the assorted pebbly zone present above the basement is made up of khonadlite and quartzite boulders and pebbles. A gritty zone with ferruginous concretions overlies the pebbly zones .yellow sand is overlain by reddish brown dune sand and the very upper part of the brown sand is red in color this sandy zone is further overlain by dunes, characterized by common calcareous concretions above the concretion-bearing sand are observed the red sediments with pebbly horizons .the red sediments are marked by badland topography.

2.1 Locations of the areas

Fig. 1: Area near INS kalinga (Google earth pic)

Fig. 2: Area near Annavaram (Google earth pic)

3. GEOMORPHOLOGY

The red sediments of Visakhapatnam exhibit a remarkable similar badland topography described by

3.1 Gullies

There are about 16 major gullies streams and a host of their tributaries cutting across the sand mound with 14 of them traversing its eastern flank toward the shoreline, while the remaining two are along the western margin of the mound, joining the chittigedda stream, which is a tributary of Peddagedda River.

3.2 Buried channels

Quite a number of buried channels are identified along the northern and southern sides of the sand mound along the Gostani and pedda gedda river courses. While the buried channels exist on both sides of the present gostani course, the abandoned channels of peddda gedda, however, are confined only to the north of its present course. This phenomenon appears to suggest that pedda geddda might have shifted its course progressively southward away from the rising sand mound.

3.3 Beach Ridges

There are at least three parallel and closely spaced beach ridges in several locations along the Visakhapatnam – Bhimunipatnam coast over a width of about 400m immediately behind the backshore zone. The elevations of these ridges range between 3and 6m above the sea level. The ridges are separated by narrow inter-ridge swales. The Holocene beach-dune ridges are lying juxtaposed with the red sediments of the study area apparently with an erosional contact in between.

3.4 Sand dunes

The sand dunes along the coastal region of Visakhapatnam are of two types, namely active dunes and relict dunes. The active dunes north of the pedda gedda river mouth are of migrating type with their heights ranging from 2to 9m along the present shoreline. Besides these active dunes, there are quite a number of relict parabolic dunes in the area located on the un-dissected part of the eastern flank of the mound between 10m and 60m elevations from about 400m to 2 km inland from the shoreline. These dunes are partially covered by vegetation. The existence of dunes at such higher elevations and up to considerable landward distances indicates strong Aeolian activity in the region through time.

3.5 Lineaments

Lineaments are linear features that are the surface expression of fractures or fault zones, which may be identified on aerial photographs and satellite imagery based on tonal variations or alignment of stream courses, escarpments, etc. Even in areas where unconsolidated sediment covers the surface, it is likely that these bedrock features appear as lineation's on the aerial photographs and satellite imagery, some of which could be the result of neo-tectonic activity.

3.6 Wave-cut terrace

A Khondalite platform is exposed along the course of Gully 1, at about 968m inland at an elevation of about +12m at its shoreward margin. This platform is exposed by gully erosion and subsequent removal of the overlying 25m thick sediment over an extent of about 270m^2 while the rest of its unknown lateral extent is beneath the sediment. Its eastern end is marked by a 2m gorge and 1.5 vertical cliff-like break-in slopes. Prudhvi Raju and Vaidyanadhan (1978), Rao et al. (1993a), although considered its elevations as +7m, presumed that this could be a wave-cut platform.

3.7 Knick points and Waterfalls

The thalwegs of several gullies reveal the presence of a number of knick points at various elevations. In Gully 1, for instance, there are at least three knick points, created due to the presence of bedrock, duricrust and pebble beds, respectively at various elevations along its length. Waterfalls are formed at an elevation of 10.5m at about 850m inland from the shoreline as the gully stream descends the ledge of the khondalite bedrock. In fact, a 2m deep and less than a meter wide gorge is cut by the stream in

the bedrock from where it falls down by 1.5m creating this waterfall. Another 4m waterfall is formed due to the presence of a 25cm thick duricrust layer, at about 1.3km inland along Gully 1 where the ground elevation is about 25m.

3.8 Yellow sand unit
The yellow sand unit overlies the Precambrian khondalite bedrock, except along the lower reaches of gully 1 where it rests on sandstone. At a few other locations, however, this yellow sand unit is underlain by a well-defined boulder-pebbly –gravel layer, which rests on the khondalite or sandstone basement. The maximum thickness of this unit is 10m. The most striking aspect of this yellow sand unit is the distinct stratification of its sediments.

3.9 Reddish – brown concretion bearing sand unit
This sand is predominantly reddish brown in color with considerable light grey patches. The relative position of this unit is variable in different parts of the area. In eastern side, it lies between the underlying yellow sand and the overlying brick-red sand, while in the western parts of the area, it rests above the khondalite basement and duricrust layer is in between this unit and the upper brick-red sand. In some locations, however, this layer is on the surface probably due to the removal of the overlying brick-red sand.

3.10 Brick-red Sand Unit
In the study area, the brick-red sand unit overlies the reddish brown concretion bearing sand. Its maximum thickness of 15m is seen in Gully 1 along an approximately 30m high steep gully section, which is facing north at about 850 m inland from the shoreline. This layer gradually thins out to about 10 m toward the west, North West, and north.

3.11 Light Yellow Sand Unit
Overlying the brick red sand unit is a thin light yellow loose sand layer, which in fact caps the eastern slopes of the mound. This unit is about 0.5 to 1.0 m thick, which can be seen on the top of the dissected gully walls. In most of the sections in the badland part of the mound, however, this unit is absent perhaps as this loose sand was removed by intense gully erosion and rain washing. The relatively unconsolidated and unweathered nature of the sands beside its uppermost position in the sedimentary column in the area indicates a comparatively recent origin to this light yellow sand unit.

3.12 Duricrust
A significant feature in the area is the presence of duricrust layers in variable thickness at various levels within different sediment units. In the eastern part of the sand mound, the duricrust is embedded in the bottom yellow sand unit as a continuous 15 to 50 cm thick layer, in the middle reaches of the eastern slope; however, the duricrust occurs at an elevation of 36-38 m embedded within the brick red sand unit.

3.13 Pebble Beds
Besides the duricrust, the presence of pebble beds is another significant feature of the area. These are exposed at a number of locations in the area. The position of the pebble beds with respect to the other sediment layers is variable at different points. For instance, in the middle reaches of the eastern slope of the mound, pebble beds are exposed at about 4 locations within the brick red sand unit over the varying thickness of 25 to 60 cm. Similarly, along with the downward slopes also pebble beds are embedded in the brick red sand unit but thinner (10-25cm). Further downstream toward the coast, however, these beds are much thinner (about 10 cm) and are embedded in the lower yellow sand unit. Much further downstream along Gully 1 at about 834 m inland, a 10 cm thick pebble bed is lying below the yellow sand and above the sandstone, while at another location around 500 m from the shoreline, it is directly resting on the khondalite bedrock below the yellow sand unit.

3.14 Origin
Red sediments around Bhimunipatnm area are formed by the denudational remnants of the great sand bank of Pliocene times or isolated banks formed around sunken hills. Red sediments Bhimunipatnm are formed by the cumulative work of wind and running water (Mahadevan and Sathapathi1949). They were considered to dune environment (Vishunuvardhana rao and Duraga prasada rao 1968).

In general, the three following processes are seen to account independently cumulatively for the pigment in the red sediments:

(i) The digenetic breakdown of iron-bearing minerals.
(ii) Iron oxides derived from the red soils in the sources area.
(iii) Favorable environmental conditions for the preservation of the pigment in the depositional basin. The color of the red sediments is mostly moderate reddish brown and moderate red. Moderate yellowish brown and dark reddish brown sediments are occurring in certain parts of Visakhapatnam region. The up land soils are pale reddish brown to moderate reddish brown.

4. TEXTURAL ANALYSIS
Grain size analysis is frequently used by sedimentologists to characterize the depositional environments of clastic deposits. The study of grain size distribution reveals the physical effects of the environments and deposition and the hydrodynamic conditions existing at the time of the deposition.

Samples were analyzed in our type areas, the four statistical parameters on which the textural analysis is based are graphic mean, graphic standard deviation, graphic skewness, and graphic kurtosis.

The grain size parameter values are given in the table.

Table 1: Showing textural analysis of samples collected

Sample No.	M_Z	σ_1	SK_1	K_G	Remarks
RED SEDIMENTS					
S_1 top	3	0.268	0.67	0.953	FG, VWS, PS, MK
S_1 bottom	3	0.232	0.69	0.953	FG, VWS, PS, MK
S_2 middle	3.133	0.008	0.747	1.61	VFG, VWS, PS, VLK
S_2 bottom	1.866	0.825	0.847	2.076	MG, MS, PS, VLK
S_3 top	1.933	1.17	0.693	1.971	MG, PSO, PS, VLK
S_3 middle	2.033	1.157	0.575	2.276	FG, PSO, PS, VLK
S_3 bottom	1.933	0.936	0.475	2.025	MG, MS, PS, VLK
S_4 bottom	1.933	0.881	0.3704	1.821	MG, MS, PS, VLK
S_5 middle	3.26	2.234	0.741	1.902	VFG, VPSO, PS, VLK
S_6 bottom	2.3	1.126	0.597	0.909	FG, PSO, PS, MK
S_7 middle	3.3	1.922	0.649	0.72	VFG, PSO, PS, PK
S_7 bottom	2.9	1.792	0.867	1.434	FG, PSO, PS, LK
S_8 top	2.066	1.121	0.609	1.713	FG, PSO, PS, VLK
S_8 middle	1.8	0.876	0.337	2.16	MG, MS, PS, VLK
S_8 bottom	1.883	0.881	0.68	1.928	MG, MS, PS, VLK
S_9 top	1.883	0.946	0.589	2.097	MG, MS, PS, VLK
S_9 middle	1.85	0.565	0.253	0.896	MG, MWS, PS, PK
S_9 bottom	1.993	0.542	0.057	0.845	MG, MWS, PS, PK
S_{10} bottom	1.82	0.603	0.336	0.802	MG, MWS, PS, PK
S_{11} top	1.933	1.031	0.298	1.692	MG, PSO, PS, VLK
S_{12} top	1.63	0.059	0.644	2.092	MG, VWS, PS VLK
S_{12} bottom	1.466	1.157	0.63	2.561	MG, PSO, PS, VLK
S_{13} top	1.85	1.071	0.536	1.885	MG, PSO, PS, VLK
S_{13} bottom	1.933	0.887	0.161	1.454	MG, MS, PS, LK

FG = Fine Grained, MG= Medium Grained, VFG= Very Fine Grained
WS= Well Sorted, VWS= Very Well Sorted, MS= Moderately Sorted, MWS= Moderately Well Sorted, PSO= Poorly Sorted, VPSO= Very Poorly Sorted
PS= Positively Skewed
VPK=Very Lepto Kurtic, PK= Platy Kurtic, MK= Meso Kurtic,
LK= Lepto Kurtic, VLK= Very Lepto Kurtic

In this investigation, the grain size parameters report that red sediments have a positive skewness and these the red sediments are formed from the fluvial environment.

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