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The Variation of Texture and Chemical Composition of Sediment: A Case Study from Bhimunipatnam Badland to Bhimlli Beach, Visakhapatnam, Andhra Pradesh, India

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ABSTRACT

Badland is a kind of dry land and rugged landscape with absence of vegetation. Badlands may comprise zones of coalesced hill slope gullies within which little of the pre-gullying terrain remains. Badland formation of this region depends on geological setting of Eastern Ghats Belts (EGB). Geological setting and lithounits of the EGB are subjected to polyphase deformation and meta-morphism. Sediment gradient is not maintained in this area. Sediment texture is poorly shorted in this part and practically, there is no relation between decreasing slope and grain size. Wind and water are in operation to develop this rugged topography. Khondalite and migmatite are two rocks in the badland area of Bhimunipatnam.Charnokite and sedimentary rocks are found towards north western and western part of this rugged topography. Due to surface runoff, loose Charnokite and sedimentary layer eroded and deposited on khondalite basement. During rainy season erosion rate is higher than other month. Badland of Bhimunipatnamis characterized by different types of mineral namely apatite, calcite, laterite, quartz, vermiculite, and white-clay. Various minerals leached off in this region due to percolation and surface run off deposited the sediments in Bhimlli beach that is why there is a similarity in its mineral concentration.Inthe badland and beach, there is a huge difference in sediment grain size and amount of mineral.

Keywords: *Badland, Gully, Erosion, Sediment, Laterite*

INTRODUCTION

Badlands are considered as a dry and rugged landscape with absence of vegetation. It may be comprised zone of coalesced hill slope gullies. Generally formation and evolution of badlands morphology are dominated by single process, but many badlands are formed by interactions between several processes (Schumn,1956). In case of Bhimunipatnam's Red sand areas, multiple factors are in operation which havegiven rise to the development of suchlandscape. Badlands are generally found in lateriticterrain. Overland flow and soil pipingare the main causes of land degradation. Nutrient loss, chemical weathering, soil leaching, poor water holding capacities are very common in badlands.Ravines affected area in Indiais about 2.678 million hector(GOI, 1996).On the Bay of Bengal coast, to the south of the Bhimunipatnam ridge, is an area comprising deeply gullied red sand dunes of around 4km length and 2km width. It is bounded by stream "Chittigadda" in the north –west and

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"peddagadda" in the south-west. This area is referred to as "ErraMattiDibbalu". This area is unique because of the gullied red dunes formations. Scientists believe that the red sand dunes formed during the quaternary era (18 million years ago); during which sea level oscillation and subsequent rapid climatic and geomorphological change were involvedin multiple cycle of deposition and erosion.

LOCATION OF THE STUDY AREA

Red sediments are prominent features near Bhimunipatnam, about 20 km north of Visakhapatnam. These sediments are homogeneous in nature, unfossiliferous and exhibit characteristic reddish color, which give the name 'Red Sediments'. Red Sand deposit occurs extending over a 10.55 square km area up to 2.5 km inland from the beach road that runs along the backshore zone.The Study area is located between 17° 51' N to 17°53' N and 83° 23'E to 83° 26' E. Red sands occur in a palaeobaywhich is south of the east-west Bhimunipatnam ridge,4km long and 2 km wide sand dune and bounded by the streams chittigadda in the northwest and Peddagadda in the southwest.

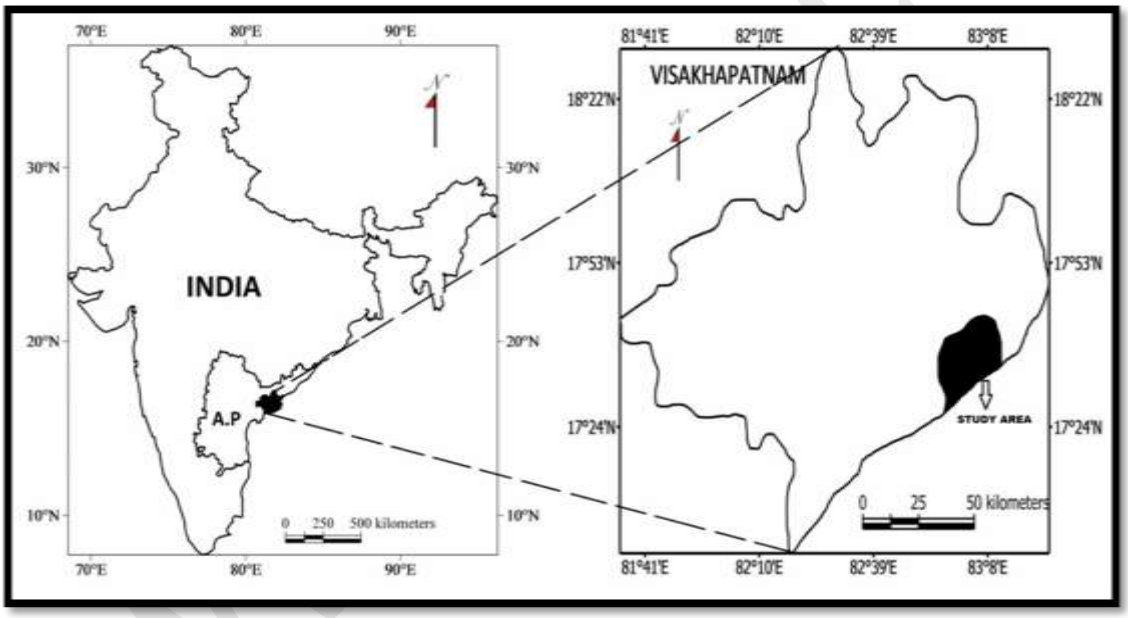

Figure -1 Location of the study area

OBJECTIVES

i. To study the texture, grain size, heavy mineral distribution pattern frombadland to Bhimllibeach areas near Bhimunipatnam.
ii. To study the variation of chemical composition of sediment from Bhimunipatnam badland to Bhimlli beach

MATERIALS AND METHODS

The work has been carried out with the help of survey of India topographical sheet (scale 1:25000) having the number 65O/5/SW, 65O/5/SE and 65O/6/NW and Abney's Level, hand held GPS (Germin, eTrex H-20), tape, Clinometer and Burnton Compass were used in the

field to generate data set and mapping. Satellite images (Bhuvan, Google Earth, 2013-2014) are also used for extraction of different geological and micro-geomorphological features of the study area.The analysis of the basin shape parameter was calculated from the satellite images and SRTM DEM (2006). The lateritic eroded mounds and beach slope were measured by the Abney's Level and GPS. Rills and gullies were mapped directly from the field. The different research articles were reviewed and consulted for understanding of the research on lateritic terrain of the tropical areas.

FORMATION OF MINERALS AND SEDIMENT

Tectonic Evolution of Eastern Ghat Belt (EGB)

Formation of EGB is characterized by multiphase deformation and metamorphism thus the geological settings of EGB is very complex. Different types of models explain the formation of Eastern Ghat Belt. Latest model is proposed by Dasgupta et al. There is no accuracy of the age of fold and not established on a regional scale. This area is dominated by several magmatic rocks including the gabbronorite–pyroxenite–anorthosite, layered complex and later enderbite to charnoenderbiteintrusives. Ramakrishnan et al. (1998) presented a detail geological map of the EGB in which they identified four longitudinal litho tectonic domains, named as Western and Eastern Khondalite Zones, Central Migmatite Zone, and Western Charnockite Zone.

Khondalite Zone

The Khondalite Group is composed of Garnetiferousbiotite-sillimanite gneiss, with occasional bands of cale-granulite and quartzite. Irregular patches of Khondalite are seen in north and north-western part of the badland area. The resistivity of Khondalite is high and erosional rate is very low. By origin, it represents some politic rocks with high alumina content that were later metamorphosed under granulite facies. Khondalite is a typical metamorphosed rock which mainly an amalgamation of Fe, Mg, Na and K. The minerals like garnet manganese, rhodonite, sillimante are of common origin from khondalite zone which are the main composition of red sediment area of Bhimunipatnam.

Charnokite Zone

Charnockite zones are found to be in eastern part of Baster Craton.Laterites are mostly developed on Khondalite and rarely on charnockites. Charnockite group of rock are older than other two groups. Charnockite are varying from highly acidic to intermediate.

Migmatite Zone

Migmatitezone is the newest edition in EGB. Mainly this zone hasbeen found in the central part of EGB. The age of this zone lies in between 0.7-.75 Ga. The minerals like monzonite, tonalite are also available from migmatite zone.

VARIATION OF SEDIMENT TEXTURE AND MINERAL COMPOSITION

Kaolinite with subordinate illite is the general clay mineral assemblage in both the red sediments and the upland soils. Clayey particles are highly concentrated in red sand area but heavy minerals are comparatively less concentrated in this area. The similar clay mineral

composition indicates that the upland soils are the source for the clay material in the red sediments.During rainy season, runoff rate is very high and in this time loosen sediments and mineral are washed out. In the process of shorting out of sediment, grain size both fluvial and aeolian processes are in operation. Winnowing process of wind is very strong in back dune and berm areas. Rifting force left behind the heavy minerals in the back dune areas. Due to distance decay effect caring capacity became lower towards beach,thus concentration of heavy mineral is higher in upland areas of red sediment. In some pocket area of Bhimllibeach, very fine heavy mineral layers are found because of depositional works of winds. Traction and saltation occur in case of coarse grains, which make them rounded, rubbed and smooth, and suspension in case of finer particles. While the mid-stream reaches, some of the heavy minerals are deposited according to the velocity of water and durable light minerals such as quartz are transported further towards the sea with the remaining heavy mineral. Thus, the mid region of the channel will have the higher heavy mineral concentration than the source and bar regions. The concentration of heavy minerals depends on the hydrodynamic conditions like sediment flux from the hinterland. In this process wave energy and its velocity; long shore current and wind speed which control littoral transport; sorting and deposition of placer minerals in suitable locations (after Rao et al., 2001).

VARIATION IN CHEMICAL COMPOSITION

Khondalite Group

The Khondalite Group is composed of Garnetiferousbiotite-sillimanite gneiss, with occasional bands of cale-granulite and quartzite. Charnockiteis acidic to intermediate in composition. Khondalite group formed with metamorphosed mafic igneous complex.Khondalite group is represented by Khondalite (Quartz-Feldspar-garnet-sillimanite-graphite gneiss), calcgranulite and quartzite which occur as impersistent bands within the khondalite.

Charnokite Group

The Charnockite group consists of acid. Laterites are mostly developed on khondalites and rarely on charnockites. Charnockite group of rock is older than other two groups. Charnockiteisvarying from highly acidic to intermediate. Charnockite zones are found in eastern part of Baster Craton.Charnokite zone is covered by khondalite zone and migmatite zone.

Migmatite Group

Most new part of this area is Migmatite zone. In the central part of Eastern Ghat Belt is characterised by Migmatite zone. Migmatite zone variesfrom highly acidic to inter mediate banded genesis-garnet, biotite-gneiss.

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Plate 1: Micro Topographic Features in Red Sediment Area of Bhimunipatnam

DISCUSSION

The nature of the lateritic terrain of Bhimunipatnam depends on the geological setting of eastern Ghat belt. Khondalite, Charnokite and migmatite rock groups are the main source of garnet manganese, rhodonite, sillimante, opdalite, monzogranite, granodiorites and tonalite which are very common in the red sediment areas. Distribution of sediment texture and mineral vary from lateritic upland of Bhimunipatnam to Bhimlli beach.

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Comparative Study of Sediment Texture and Chemical Characteristics of Minerals between Badland and Beach

Sediment Texture

There is a difference between sediment texture ofBhimlli beach and sediment of badland of Bhimunipatnam. Heterogeneous geological settings of Eastern Ghat belt are controlled over sediment quality in this area. Grain size depends on erosional agents and erosion rate. From textural analysis it is found that the particle size has no trends. Particle size is fluctuating from badland to Bhimlli beach due to different type and uneven distribution of rocks.According to sediment gradient, grain size gradually decreases from source to sea. Grain size distribution is very erratic in Bhimunipatnam badland area. After analyzing the collected data (source JMM 47 A, 2011) it is found that grain size shorting is very poor. In between badland and Bhimlli beach there is no consistency in grain size distribution. In badland area the particle size varies from 310 μm to 450 μm.

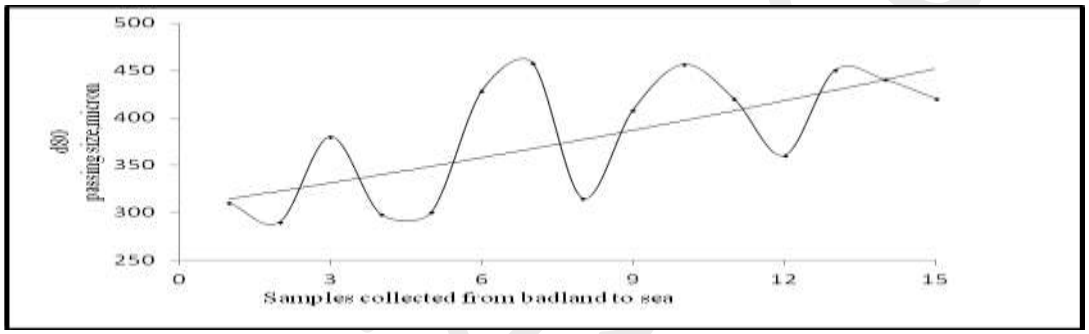

Figure- 2Grain size distribution from badland to Bhimlli beach(modified after Laxmi et.al .2011)

In beach sediment grain size varies from 360 μm to 420 μm.This irregularity may be the result of fluvial erosion from badland to sea as well as wind action from sea to lateritic terrain.

Minerals Distribution between Badland and Bhimlli Beach

Chemical composition of minerals depends on its source. By nature,Fe_2O_3 and TiO_2 are highly oxidized and leaching rate is lower than garnet. Ilmenite concentration is higher than garnet in badland area because garnet is highly leached off from lateritic terrain and deposited in beach. Concentration of Rutile continuously decreasing towards the beach(fig 3). Ilmenite, and zircon concentration also decrease continuously from badland towards beach.

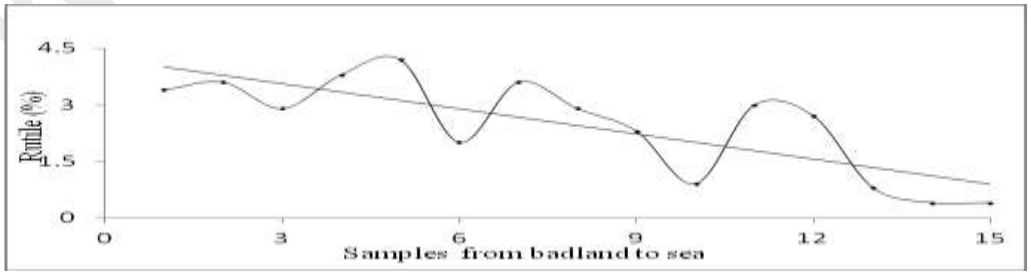

Figure- 3Distribution of Rutile from badland to Bhimlli beach (modified after Laxmi et.al. 2011[9])

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Badland of Bhimunipatnamis characterized by different types of minerals namely apatite, calcite, laterite, quartz, vermiculite, and white-clay. Concentration of laterite and quartz are relatively higher than other heavy minerals nearly 35000 ton.

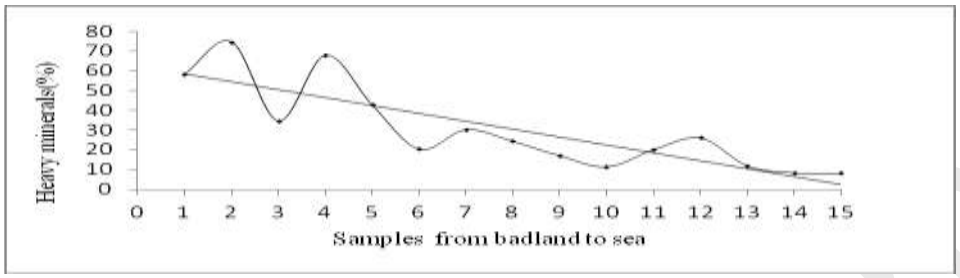

Figure- 4Distribution of heavy minerals

Heavy mineral concentration is very high in N and NW part of Bhimunipatnam badland. In middle part of the badland, heavy minerals concentration became lower due to high surface runoff. Eroded minerals are deposited near Bhimlli beach. In N and NW part of badland, heavy mineral concentration is 55% to78% and in middle part it became 10% to 20 %.

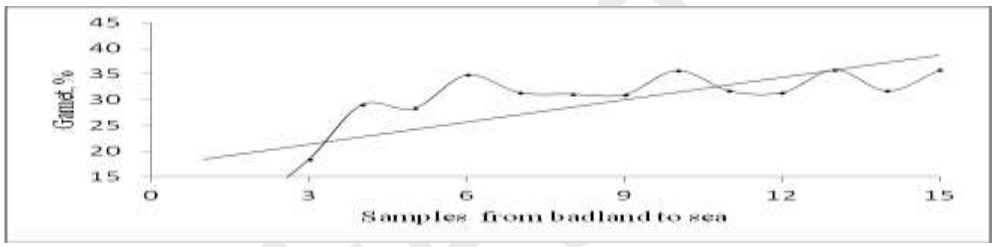

Figure- 5 Distribution of Garnet from badlands to beach(modified after Laxmi et.al.2011).

Garnet concentration continuously increases towards sea beach. Garnet highly dislodged from its province (EGB) through surface runoff. Part of the minor mineral group, garnet was carried out by the gulling process and deposited thereafter, in the back duneal areas. But in case of heavy mineral,it continuously decreases towards sea beach.

Plate- 2: (1) Finer sediment and lighter minerals (2) Ripple mark in back dune (3) Coarse grain size and heavy minerals (4). Wave cut platform

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In this lateritic rugged micro topography, different types of minor minerals are also found namely garnet, rutile, RM,BS, gravel, ordy earth and ordy sand. Siliminite,garnet are leached off from badland and deposited in Bhimlli beach, thus garnetand Siliminite concentration are high in beach material.

Eroded Red Sand Mound Profile

The south eastern slope is steeper and more erosive than the north western slope. Thus, vegetation cover is higher in north–western side. Maximum elevation in this area is 90 meter. However, near beach, the elevation is <10m. In eroded red sediment moundswhere, calcium carbonate concentration is high, are consolidated and resistant to the drainage and stand erect like pillars amidst. Eroded red sand mounds are situated discretely in this red sand area. Height of the eroded mounds are near about 20-28 meter. The upper most layersis mainly composed of red sand.

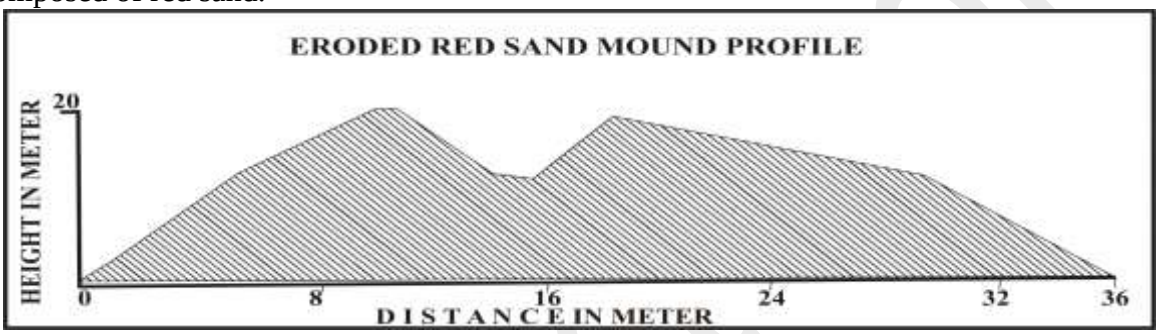

Figure-6 Eroded red sand mound profile showing the variation of slope

Profile of Bhimlli Beach

Bhimunipatnam is a rocky coast. Bhimlli beach is situated just opposite side of red sediment area of Bhimunipatnam.Distance between Orissa -Andhra Pradesh high way and water line of Bhimlli beach is near about 88.56 meter.Bhimlli beach is characterized by various erosional and depositional coastal features. Wavecut platform is formed due to high energetic wave action but in case of formation of beach and dune, aeolian and coastal action both are in operation. Berm is formed by swash deposition characterized by mixing population of sand. In Bhimllibeach, sediment grain size maintains sediment gradient. Coarse grain and heavy mineral deposition are found in back duneal part and in berm area. Rift and drug forces of wind play an important role in maintaining sediment gradient. Heavy mineral concentration is high in back dune part.

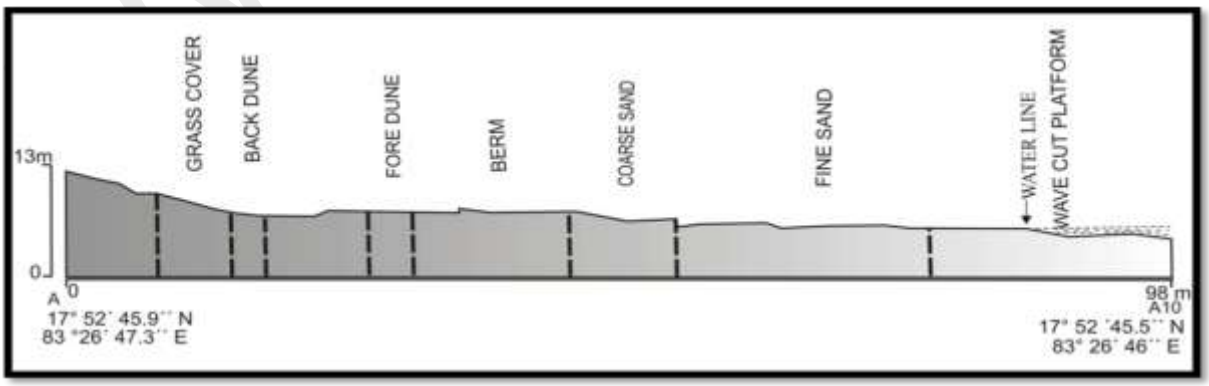

Figure- 7 Profile of Bhimlli beach showing different coastal features.

CONCLUSION

The discussion can be summerised by saying that the study area belongs to a semi-arid tropical badland which has got a strong influence of slope and resistivity of the composing rocks. The nature of the terrain of the badland is also depending on its geological setting. The petrological composition has got a direct control over the geomorphic processes which is in operation in this area. Mainly the rills and gullies are the main fluvial networks which are the real architects of the study area and they have given rise to different micro-topographic features. The most interesting feature lineament is an important controlling factor of this badland area which directly controls the trajectories of the rills and gullies. Another interesting feature is that the Orissa badland also belongs to the same type of origin, but the heavy mineral deposition rate is low in this Bhimunipatnam badland areas. Here the rate of erosion is very high due to the slope factor which varies from 6% to 8% whereas, the Orissa badland is flat with modest slope condition which leads to high chance of heavy mineral deposition.Siliminite and garnetareleached off from badland and deposited in Bhimlli beach. Garnet and sillimanite concentration continuously increase towards sea beach.

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