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Sedimentation and Morphodynamics of a Tropical Coast Facing the Bay of Bengal of Northeast India

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The study illustrates the present day sedimentation history and morphodynamic changes of sedimentary facies along the tropical Talsari coast of Orissa (lat.21° 20´ N; long.87° 25´ E), bordering the northern fringe of the Bay of Bengal(Fig.1) .The intertidal and supratidal areas of this 1.5km long siliciclastic coast is characterized by east-west oriented, shore-parallel, five linear sedimentary facies along a south to north transect from the seaward to the landward direction, These include i)an intertidal sandy beach, ii) a sandy barrier bar with aeolian sand at the bar crest, iii) a supratidal marsh, iv) an intertidal mudflat having three biozones marginal to a tidal creek that traverses the upper foreshore in an east-west direction and, v) a mature dune field. The 350-400m wide mudflat bordering the creek margin is sheltered between a 250-300m-wide beach- barrier bar facies seaward and coastal dune facies landward.

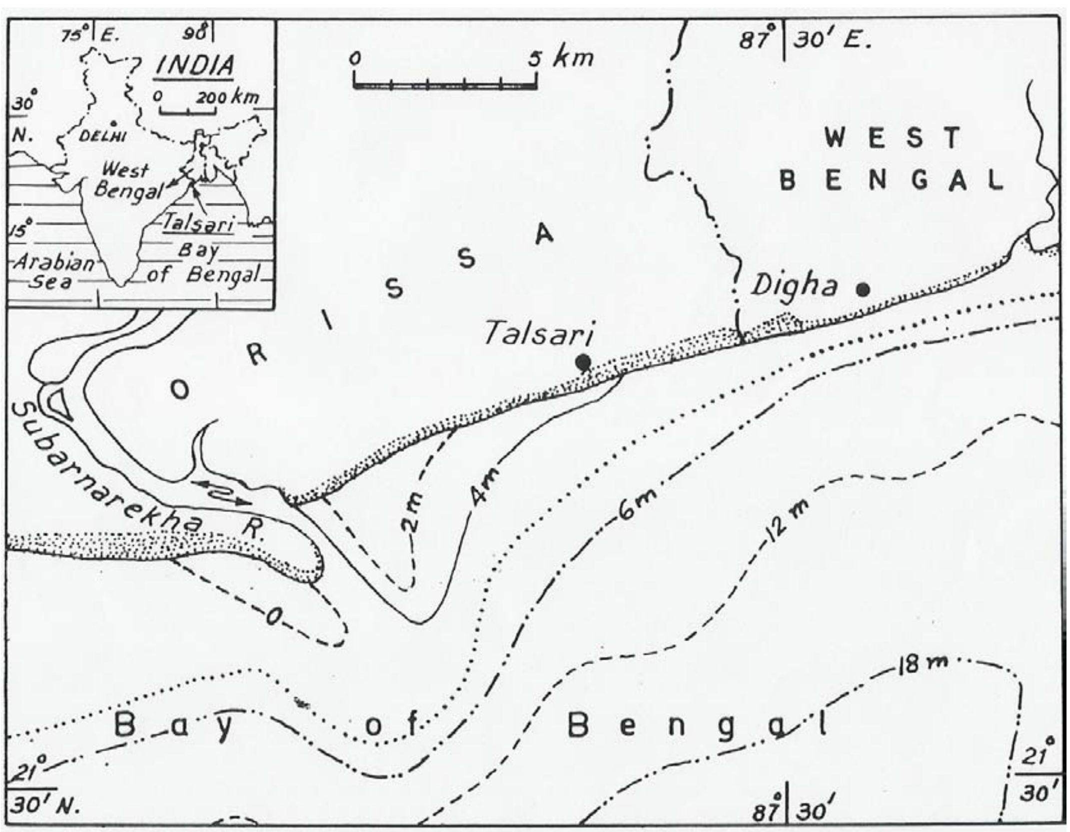

FIG.- LOCATION MAP OF THE STUDY AREA AROUND TALSARI, ORISSA.

Being contiguous to the sandy beach of Digha in the east and the confluence of non-perennial Subarnarekha River and the Bay of Bengal in the west, the Talsari coast is comprised of sand, mud and mixed facies grading from one to the other. The supply of mud comes from the Subarnarekha River which joins the sea from the northwest direction. This mesotidal (spring 3.2-3.8 and neap1.8-2.3m) tropical oceanic coast experiences semidiurnal tides with slight diurnal asymmetry and three major seasons viz., winter(Nov.-Feb.), summer (Mar-June) and monsoon (July–Oct.). Winter temperature ranges from 12- 22° C and summer temperature from 26-36°C, relative humidity ranges from 75-90%, and annual rainfall ranges between 1450- and 2210mm. Two dominating prevailing winds during SW and NW monsoon lead to southwesterly and northeasterly wind having max. velocity of 16.5-50km/h and min. velocity of 10.6-11.8km/h. Salinty of open sea water ranges from 21- 35‰ and Ph is alkaline (7.6-8.2). Tidal current velocity lies within 0.7- 1.8 m/s. 2-3 cyclonic storms affect the coast every year. Littoral drift is eastward; cyclonic storms often initiate large-scale littoral drift helping huge sediment deposition for the growth of the Subarnarekha delta.

The present paper is aimed to focus the following objectives:

i) Identification of diagnostic physical properties of each facies as a process-response coastal system occurring in a low-lying tropical setting,

ii) Examination of the state of stability of intertidal mudflat occurring in a sheltered area,

iii) Determination of various physical, biogenic and anthropogenic factors leading to modification of the coastal geomorphic units, and

iv) Examination of the role of macrozoobenthos towards changing the physical properties various sedimentary facies by the coupling of physical forces (waves, tides, longshore current and wind) in one hand and biogenic activities related to animal-sediment interaction on the other.

The granulometric properties of each facies reflect the mode of sedimentation in each area undergoing variable exposures and inundations, and reworking of sediments in each zone both by physical and biogenic processes. The foreshore beach is made up of medium to fine sand; the subaerial barrier bar is generally fine sandy; intertidal mudflat with three distinctive zonations are mostly made of mud to mixed mud material with a small fraction of biogenic matter; the creek bottom is composed of coarse to medium sand, and the mature dune is made of fine sand and silt.

The sedimentary facies associated with the intertidal mudflat are governed by both tidal and aeolian processes. The suspensional material at high tide in the creek settles at different levels of the marginal mudflat and forms gently dipping laminae of mixed mud and sand deposits. There is a general decrease in grain size from the Upper to the Lower flat demarcated by high to low water marks. The intertidal mudflat is divisible into three subenvironments based on bio-communities sustained in each zone. The mudflat maintains a seaward slope with gradient ranging from 3-4°. All the three subdivisions, the Upper, Middle and Lower mudflats are easily distinguishable in the field by virtue of their characteristic topographic positions, number of tidal inundations, granulometric properties, physical and biogenic sedimentary structures.

Deposition of suspended material derived from upstream of the Subarnarekha River under the influence of semidiurnal tidal fluctuations in the creek provides material for the formation of the mudflat. Lateral accretion is pronounced on the inner concave bank of the sinuous creek to produce crescentic tidal point bars. Flood and ebb tidal flows through the creek are evidenced by the occurrence of flood-and ebb-oriented ripples and megaripples and reversing of some current ripple structures.

Patchy mangrove bushes and saplings of mangroves and mangrove associates occur in clusters on the Lower mudflat, whereas marshy vegetation like *Porterasia sp. salicornia sp. and Sueda sp* cover larger portions of the Upper mudflat (Bhattacharya and Sarkar, 1996). The organic carbon content in the substrates ranges from 0.75-0.90% to 1.95-2.40% from the Lower to the Upper mudflat This is obviously attributed to more marshy vegetation cover from the from the Lower to the Upper mudflat (cf. Chen and Wisdom, 1997). Longer exposure time of the Upper mudflat due to lesser number of inundation in a tidal cycle favored greater rate of evaporation attributing to higher sediment salinity from the lower (1.1-1.8.‰) through the middle(2.0-3.1‰) to the upper (2.7-3.8‰) topographic levels.

The functional activities of different macrobenthos in the intertidal mudflats seemed not only to be responsible in creating a variety of bioturbational structures of different magnitude and types but also were important in controlling the net sedimentation processes in coast by maintaining a dynamic equilibrium through stabilizing and destabilizing the substrates. The profound activities of large bioturbators like *Diopatra sp*(polychaete*), Thalassina sp*. (ghost shrimp) *and Ocypode sp*.(ghost crabs) with their high population densities play an important role in the sediment churning processes. *Diopatra sp.* transports deeper sediment to the surface through conveyer belt mechanisms. *Thalassina sp.* digs deep vertical burrows and produces selective grain size segregations at different depth levels along their burrows. *Ocypode sp*.dig burrows up to 45 cm depth; ploughs surface sediments by grazing, pellatization and ejecting ingested sediments the burrowing activities all the macrobenthos cause biogenic subduction in the mudflat producing surface undulations on their substrates. The ploughed mudflat surface with matting of fecal pellets and ejected mud mounds undergo resuspension during flood tide. This enhances lateral and vertical exchange of material without changing the net sediment budget of the mudflat.

The Upper mudflat of Talsari is flooded by high water spring tide .The spilling of aeolian sand from the barrier bar contributes fine sand to the mudflat during the dry months of the year. This results in some coarsening of the Upper mudflat material (Mz=5.2-6.0 phi). Very thin debris of organic detritus intercalate with the muddy layers. The zone is chiefly characterized by vertical accretion of sediments both from tidal and aeolian sand fall-out. Physical sedimentary structure includes small dome- like blisters due to trapping of gas or air in the sediments. Burrows of ghost shrimp profusely disturbed the laminae.

The Middle mudflat is inundated twice daily and is dominantly constituted of silt and clay (MZ=5.6-6.2 phi). Sand carried during high flash flood, deposits fine sand lenses which often intercalate with the mud layers. Bioturbation of substrates is chiefly accomplished by the activities of polychaete worms of which the commonest are the tube–dwelling and tube–building species of *Diopatra* and *Euclymene*. The tubes enhance sediment deposition by decreasing the bed shear stress. A large number of mud crabs and gastropod species create surface unevenness by producing mounds and trail marks.

Occupying the space in between the creek margin and the lower boundary of Middle mudflat, the Lower mudflat undergoes semidiurnal tidal inundation revealing exposures only during the lowest low tide. Mud (Mz= 6.4-6.8) constitutes the dominant size with a subordinate proportion of very fine sand. The substrate acts as the habitat for clams, mussels and spiraled snails. The most abundant bivalve is *Marcia pinguis* which often keeps press marks on the mudflat surface. Intricate trail marks of gastropods produce surface channeling through which water drains during waning tides. The laminae maintain inclination parallel to the creek slope and the surface is transversely traversed by numerous erosional rills and gullies.

The morphodynamic modifications of the various zones of the coast are accomplished by aeolian sand spilling from barrier bar and mainland beach, choking of creek mouth by sandy shoals and human interference related to fishing, tourism and other recreational and commercial activities .