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Sediment characteristics in the depositional environments of the Krishna delta, east coast of India

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Investigations on six vibracores collected at active sedimentation area in the southwestern margin of the lower Krishna delta indicate that the sediments are sands (3 ϕ) to mud (8 ϕ), well-to-poor sorting with or without bioturbation. The presence of parallel and cross bedding and interbedded sands in the vertical facies represents intense tidal reworking and storm events, respectively. The sedimentation process and progradation of the delta are controlled by the successive repetition and formation of spits and lagoons. 11 ref.

The study of modern depositional environments will devise effective progradational environmental strategies. Such studies throw light on establishment of sediment characteristics, facies relationship and depositional process of the deltas. To gain the knowledge about the deltaic progradational pattern, the southwestern Krishna delta was selected as an investigated area. No attempt has been made so far on the facies relationship of the modern deltaic environments of the Krishna delta. This paper focuses on depositional history of different litho units, their inter-relationship and progradational pattern of the lower Krishna delta.

Materials and Methods

The southwestern Krishna delta covers an area of 127 km² receives the river transported sediments by main channel of the Krishna river. Six vibracores, one each were collected in different environments viz: beach, mud flat, lagoon, mangrove swamp, tidal creek and estuary of the Krishna delta (Fig.1). The 63 mm diameter and maximum 243 cm long vibracores were cut longitudinally into two equal halves and each half was cleaned and examined for sedimentary features. The half core to be archived was photographed to produce a photolog and the other half was sampled at distinct lithologic intervals. A total of 27 sub-samples were collected and preserved in pre-cleaned polyethylene containers. These sub-samples were dried in the oven at 80-90°C and powdered in an agate mortar. Textural analysis of sediment samples was carried out¹ and percentages of sand, silt and clay

fractions were determined. The statistical parameters such as mean size, standard deviation (sorting), skewness and kurtosis were computed². The organic carbon and calcium carbonate contents of the powders were estimated, following El-Wakeel & Riley³ and Kemp⁴.

Results and Discussion

The vibracores collected are 162 cm long in the beach, 171 cm in the mud flat, 170 cm in the lagoon, 152 cm in the mangrove swamp, 243 cm in the tidal creek and 215 cm in the estuarine environments. Photologs are given for the representative portions of important features which are discussed in the present study.

Beach—Core A (Fig.2A) corresponds to the beach facies and show typical conditions of high energy, fine sediments at backshore and coarse sediments at foreshore. Frequent overwash during floods effect no vegetation growth on spits. Medium grained, well sorted sands occur in the upper 15 cm part of the core are bioturbated. The sediments below 25 cm are sands showing typical burrowing and vertical sequence of sedimentary structures with a gently sloping. Thin laminations, cross and parallel bedding are prominent features at bottom. According to Reineck & Singh⁵ cross-bedding may result in moderate to high energy depositional environments.

Mud flat—Core B (Fig.2B) is located in the mud flat area and can be differentiated by lithology. The sediments are either muddy or sandy and characterised by bioturbation. The bioturbated

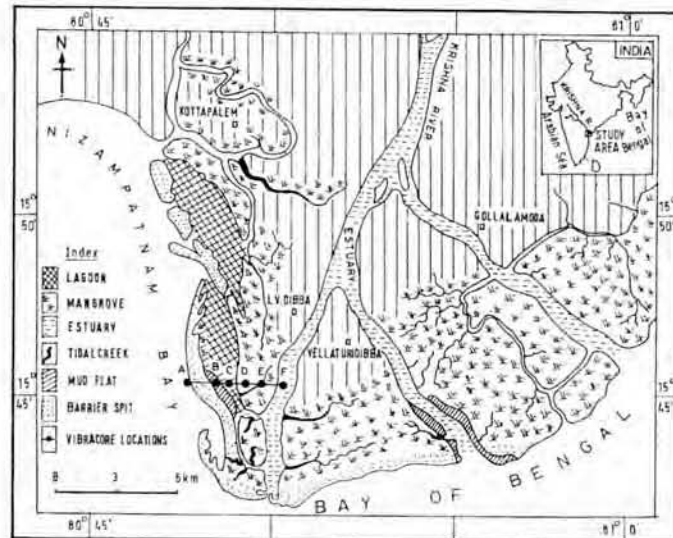


Fig.1—Location, aerial distribution of depositional environments and vibracore locations

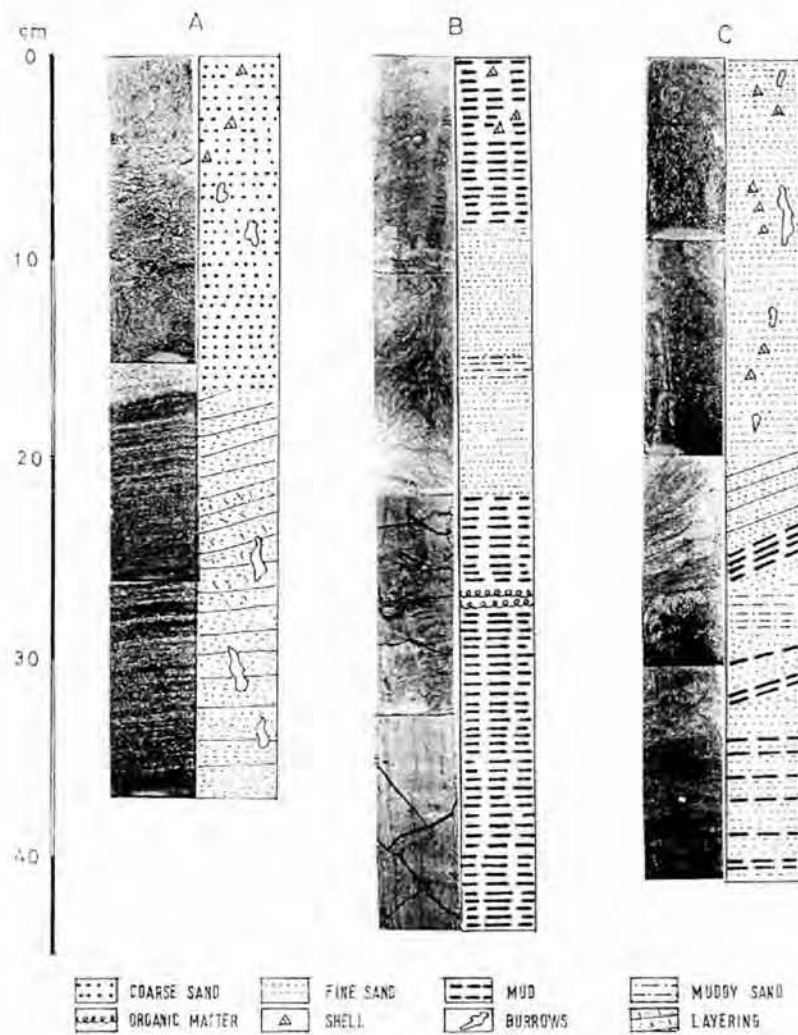


Fig.2—Facies of A-beach, B-mud flat, C-lagoon

sediment facies alternate with clean non-bioturbated sands; this occurs either due to washovers or in areas close to tidal inlets where the muddy sands can occasionally be covered with clean sands.

Lagoon—Core C (Fig. 2C) is from the lagoon facies and corresponds to the subtidal zone of the backbarrier. The lagoon is bounded by spit in the east and mangrove swamps in the west and slowly covered by mud flats and mangrove swamps. Sand is the dominant constituent (80%) of the facies. Since the location being close to tidal inlet, the finer constituents are often winnowed by ebb and flood tidal currents. The crossbedding indicates

development of high angle lagoonal island.

Mangrove swamp—The sediment core in Fig. 3D shows cyclic pattern of sedimentation sequence like muds alternate with clean sand layers. The mean size of the sediment is 3.08ϕ at the surface and increases to 7.13ϕ at the bottom. There is a 5 cm thick fine sand zone at 10 cm depth from the top result from the high sediment supply during the spring and/or storms. The organic matter and CaCO_3 shows antipathetic relationship but organic matter positively correlates with clay content of the sediment. The surface clay facies shows light color in photography due to more effect of oxidation and less organic matter.

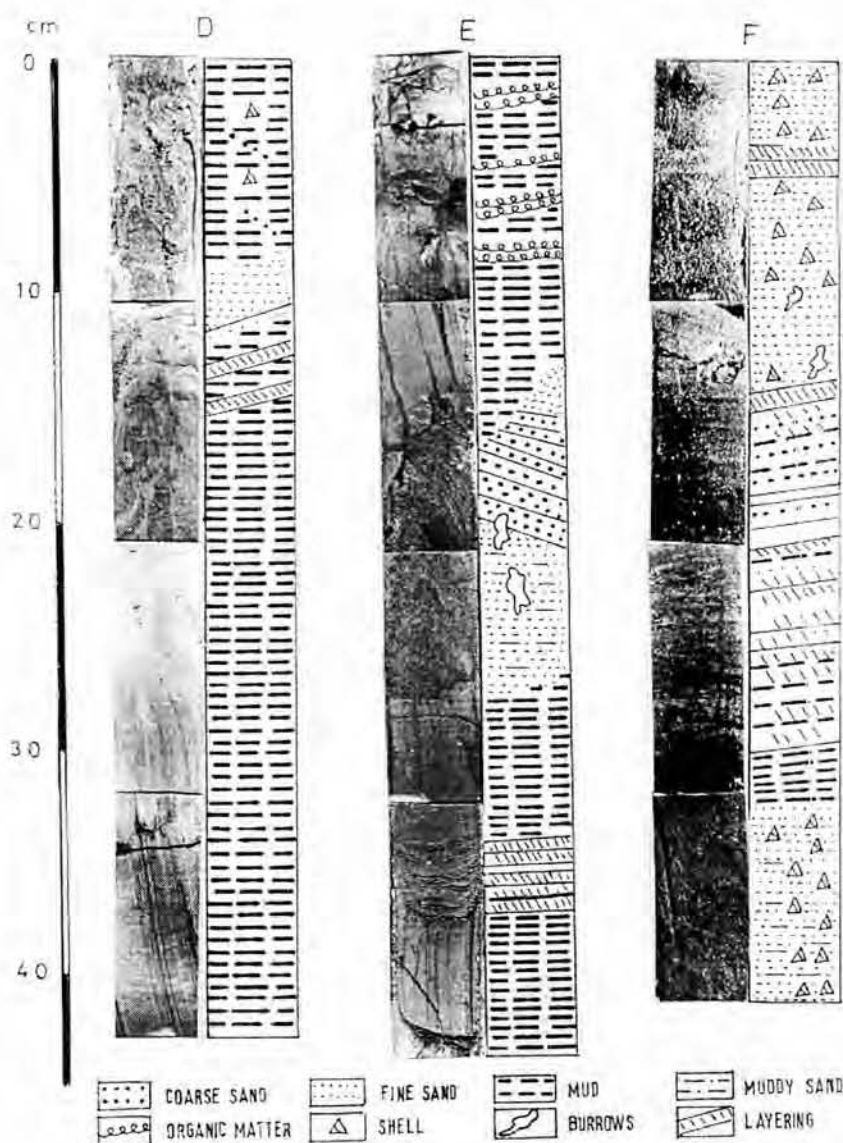


Fig.3—Facies of D-mangrove swamp, E-tidal creek, F-estuary

Tidal creek—Silty clays are widespread in a core collected from the tidal creek (Fig. 3E). Shell fragments are numerous in the sandy facies (size ranges from 3ϕ to 4ϕ) contain bivalve burrows. This type sequence is rarely observed in this environment due to remoteness of the source of supply. Occasional presence of sands may indicate their introduction during storm or by washovers. The top silty clay layer is saturated with water but dense and compacted below the sand zone. The silty clay zone is generally massive and internally structureless. Organic rich layers are present at the top silty clays. The bottom silty clay facies is characterised by low content of organic matter.

Estuary—The core collected from the estuary (Fig. 3F) shows variation in sediment composition. The sediments are homogeneous, red, coarse to medium sand without bioturbation at the middle. Thin laminated clay-rich zones on top and bottom are bioturbated. The middle silty clay layers are generally laminated. Parallel contacts between different beds of similar sediments suggest the repeat of similar depositional conditions. The bottom silty clays contain abundant shell fragments because they are reworked by intense tidal action. The alternate sequence of sands and muds with cross-bedding are considered to be development of lateral tidal bar based on their morphology⁵. Percentage of organic matter decreases consistently with depth but CaCO_3 shows an increasing trend.

Evolution—Krishna delta is a progradational delta with its southwestern part along with lagoon-barrier system. Since the post-Flandrian transgression of the sea level about 7,000 yr BP, the sediments have accumulated in 4600 km² deltaic area. This mass of detrital material has contributed to the filling of the bay in the southwestern portion of the system, causing deltaic progradation. The historical evolution determined from field observations revealed an increase of land 20 km² at a growth rate of 0.58 km² y⁻¹ between 1928-1968 (ref. no. 6) and 14 km² at a growth rate of 0.74 km² y⁻¹ between 1968-1987 (ref. no. 7, 8). Thus, the progradation has occurred with the barrier development and subsequently continuous lagoon filling process occurred since Holocene period.

Facies sequence—The sedimentological data from six vibracores permit us to construct the environmental sequence along a longitudinal profile (Fig. 4). The most recognisable facies and

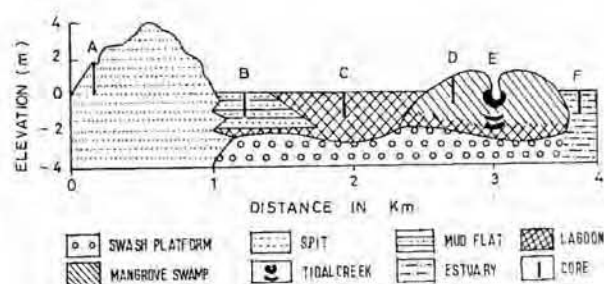


Fig.4—Lower deltaic environmental profile

development of environments in a delta is swash platform. The sediments here are coarse to medium sands, well sorted with many shell fragments. The waves are responsible for the migration and accretion of swash bars that build the barrier spit from the barrier island. The fronts of the sandy spits lie directly on swash platforms. After formation of spits, the lee side is formed as a lagoon and shadow areas are gradually developed with mud flats and mangrove swamp facies. The incision of spits and lagoons through time on the delta front has resulted in a high degree of lateral facies variability in distinct sedimentary environments. This facies pattern represents how the system progressively shallows producing sediment aggradation. The given pattern is repetitive in the southwestern part of the Krishna delta, depending on the successive formations of spits causing movement of the coastline and progradation of the delta. These facies compare well with the models of Piedras river mouth⁹ in the southwestern Spain, barrier lagoon complex in western Bight of Benin¹⁰ and Guadiana river delta¹¹. The morphological and sediment characteristics differ from one environment to the other and reflect the effect of the local hydrodynamic conditions.

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