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STAGES IN THE EMERGENCE OF THE COCHIN-KODUNGALLUR COAST-EVIDENCE FOR THE INTERACTION OF MARINE AND FLUVIAL PROCESSES

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The Cochin-Kodungallur coastal belt represents one of the few areas along the Kerala coast which is not much affected by erosion and consequent incursion of the sea—an emergent coast. This paper attempts at delineating the various features of the coastal zones developed, besides, ascribing a sequential chronological status to each.

Key Words : Cochin-Kodungallur; Marine; Fluvial

INTRODUCTION

THE palaeo-fluvial network of the Periyar river basin affords a detailed insight into the role of the fluvial processes and the extent of its interaction with the marine processes which led to the emergence of the coast. Sudden and heavy siltation and blockage of the palaeo-deltas and marshy tracts adjoining the palaeo-mainland has resulted in the present day sandy flats with sub-terranean carbonised wood and clay horizons dated between 30,340 $\pm$ 1860yr B. P. to 7050 $\pm$ 130yr B. P. A palaeo-coastline configuration is inferred from the alignment of these carbonaceous deposits. Subsequent development of the coast has a domination of marine processes over fluvial. Periodic regression of the sea leaves an emergent coast with linear sandy ridges alternating with troughs having a predominance of clay and organic debris. Palaeo-coastline systems signifying distinct intervals in the build-up of the coast are marked by back-barrier lagoons and linear river channels. On the basis of age data, lithovariation and morphometric characteristics (like linear sand ridges, strand lines and intervening troughs besides a distinct drainage network consisting of braided channels, ox-bow lakes and abandoned channels), linear coastal strips have been delineated as zones developed successively in the emergence of the coast. A tentative chronological sequence is also proposed for these zones.

Formation of present day offshore sand bars and coastal sandy spits at the mouth of the Periyar river have been analysed to identify the mechanism involving the longshore currents, the sediment laden fluvial currents and the consequent interference eddies generated may help understand the palaeo-processes that contributed to the development of the Cochin-Kodungallur coast.

The Kodungallur-Cochin coastal belt represents one of the few areas along the Kerala coast which is not much affected by erosion and consequent incursion of

the sea. An intergrated study including aerial photointerpretation of Cochin-Kodungallur area has been carried out to identify morphological units, processes and the mechanics involved in the phased build-up of the coast. The study forms part of the geological investigations carried out by the authors for the project of the Geological Survey of India on the role of fluvio-marine interactions in the development of the Cohin-Kodungallur coast.[1] Attempt is made to identify the various stages (represented by the appropriate coastal zones) during which the coast attained stability before further development. An approximate chronological sequence for the different phases of coastal development is also proposed.

Morphometrics

The morphometric signature of the area studied reveals a transition from the lowland (30m to 60m elevation) to the coastal landforms (0m to 30m elevation). The area near Alwaye and Edappally, well within the lowland morphometric zones has a weathered landform signifying a topography with a palaeo-dendritic drainage pattern maturing into a meandering and sluggish fluvial system. The topographic expression denotes fairly flat weathered profiles overlying a crystalline basement (the latter rarely exposed except in a few well sections). The thick lateritic terraces or flats describe the lowest planation surfaces (ranging from 30 to 60m level)—perhaps indicative of the final stage of upliftment of the Western ghats. The westward extension of these planation surfaces (sloping towards west) often grade imperceptibly into lateritic slumps and lateritic soil slopes which extend down below the alluvial cover. The lowland-coastal zone transition belt delineated in a NW-SE orientation shows a braided drainage network besides numerous palaeo-channels, ox-bow lakes and disconnected water bodies. The Onji todu offers a typical example of an abandoned channel. These abandoned channels are of significance in delineating zones of sudden sediment fill and will be dealt with later.

The coastal tract shows an advanced degree of river braiding wherein the channel bars in between the braided channels, with successive addition of sediment form large sandy flats subject to partial seasonal submergence. Extensive sand ridges or palaeo-barrier beaches with intervening swampy and marshy troughs mark the coastal morphology from Munambam to Cochin. In and around the Kodungallur area, the landform development typifies a regressive marine condition marked by closely spaced strand lines or linear sand ridges with intervening linear troughs. Essentially parallel to the coast, these strand lines are important in determining the intermittent equilibrium stages during regression of the sea consequent to coastal build-up.

Stages in the Emergence of the Coast

Stage 1

The Original Unsubmerged Landmass—The alignment of the Pullut river and the Varapuzha river approximately marks the earliest palaeocoastline or the configura-

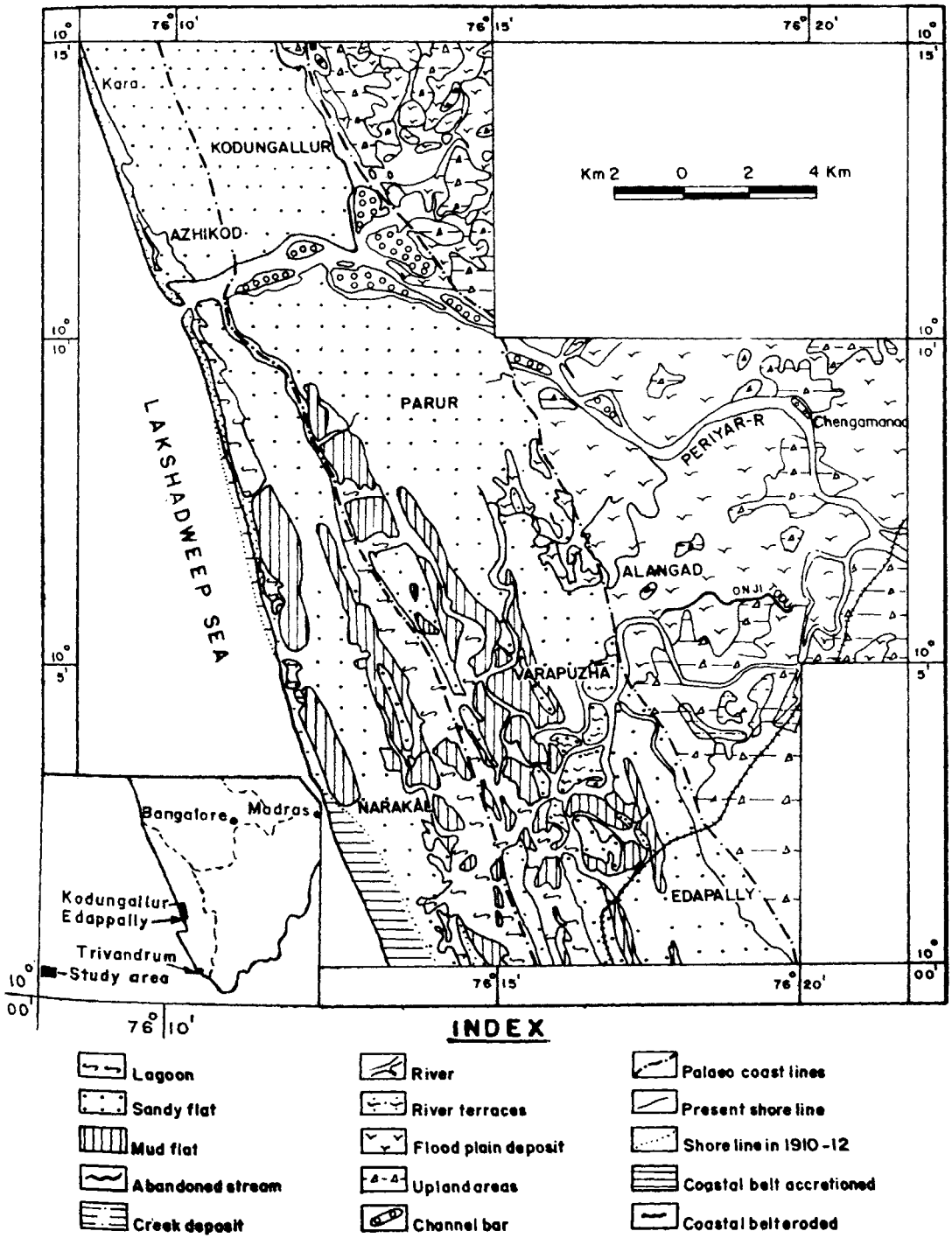

FIG 1 Geomorphological map of the coastal stretch from Kodungallur to Edapally, Trichur, and Ernakulam districts, Kerala State.

tion of the original unsubmerged landmass. Delineation of the palaeocoastline is primarily based on the occurrence of weathered lateritic profiles overlying a crystalline (charnockite) basement to its east. The lateritic terraces merge into lateritic soil slumps near the palaeocoastline. Intervening valleys and low-lying depressions are filled by thick alluvial piles of sand and intercalated carbonaceous clay horizons. Several locations north of Alangad, are all in continuous alignment and reveal sub-surface outcrops of carbonised wood. The carbonised debris, and assortment of barks, thorny branches, stalks of leaves, winged seeds and bits of trunk are seen in the form of peat or lignite. Associated with the carbonised wood are marcasite needles and pyrite tubules.[1] Intermittent monsoon produced fluvial discharge of a heavy volume of coarse (sand) sediments together with much organic debris, which, deposited in the isolated depressions was ideal for carbonification under reducing conditions.[2] Similar carbonised wood occurrences were ^{14}C dated to 7050 + 130yr B P.[7] Carbonaceous clay horizons in the Kurichi area further south have been ^{14}C dated to 30,340 ± 1860yr B P.[7] The notable difference between the two dates may be ascribed to the fact that they occur at two different levels both stratigraphically and chronologically.

Stage 2

Development of Zone-II—The 4 to 6km wide greyish sandy and clayey zone, essentially parallel to the present day coast (NW to SE) is an emergent sandy tract resulting from the heavy fluvial sediment discharge. The numerous rivers flowing from Zone-I into the sea formed a deltaic system. Successive growth of the channel bars gave rise to a braided drainage pattern, preserved even at present, because of the constant change in river course due to blockage of the river mouth through sediment deposition. This is well displayed by the distributaries of the Periyar and the Varapuzha rivers. Constant fluvial discharge aided the growth of the channel bars which developed into extensive sandy flats with intercalated carbonaceous clay horizons; this is typical of Zone-2. However, in the Kodungallur area, strand lines and linear sand dunes are evidences for a periodic cyclicity in the regression of the sea and indicate dominance of marine forces in the landform evolution. On the whole however, Zone-2 development in the second stage of coastal evolution evidences predominance of the fluvial regime over marine processes.

Formation of this zone is also chronologically correlated on the basis of historical evidences. The existence of the Kodungallur port is testified by the landing of St. Thomas, in 52 AD. The Kodungallur port was a centre of flourishing trade during the reign of Cheraman Perumal (*c.* 700 AD). The Kodungallur port was also used by the Portugese (*c.* 1600 AD) and then later by Tippu Sultan (*c.* 1800 AD). Thus the longspan of the port from the first to the eighteenth century bears testimony to the stability of the second zone throughout this period.

After the eighteenth century, silting of the river mouth necessitated shifting of the port from Kodungallur to Pallippuram, on the western margin of Zone-3.

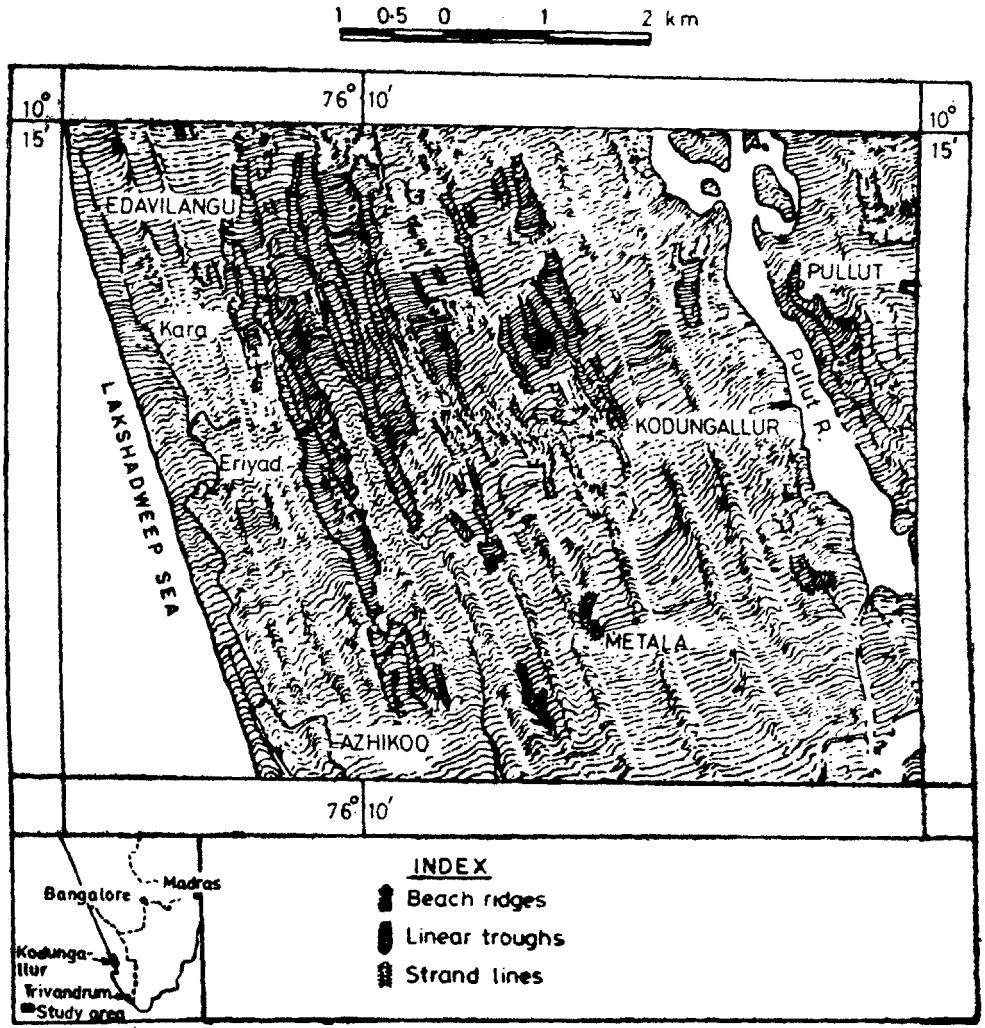

FIG 2 Relief map of the Kodungallur area, showing strand lines, beach ridges and linear troughs.

The latter, represented by the Tattapalli river channel marks the Palaeocoastline-2 which continues into the area north of the Periyar river as a NNW-SSE trending stream.

Stage 3

Development of Zone-III— Debouching of sediments into the Tattapalli river did not fill up the river because of the linear flow into the Periyar river in the north and due to its expansive connection with the Cochin estuary in the south. However, the heavy sediment discharge from the rivers and the wave action of the sea combined to facilitate sediment deposition to the west of the

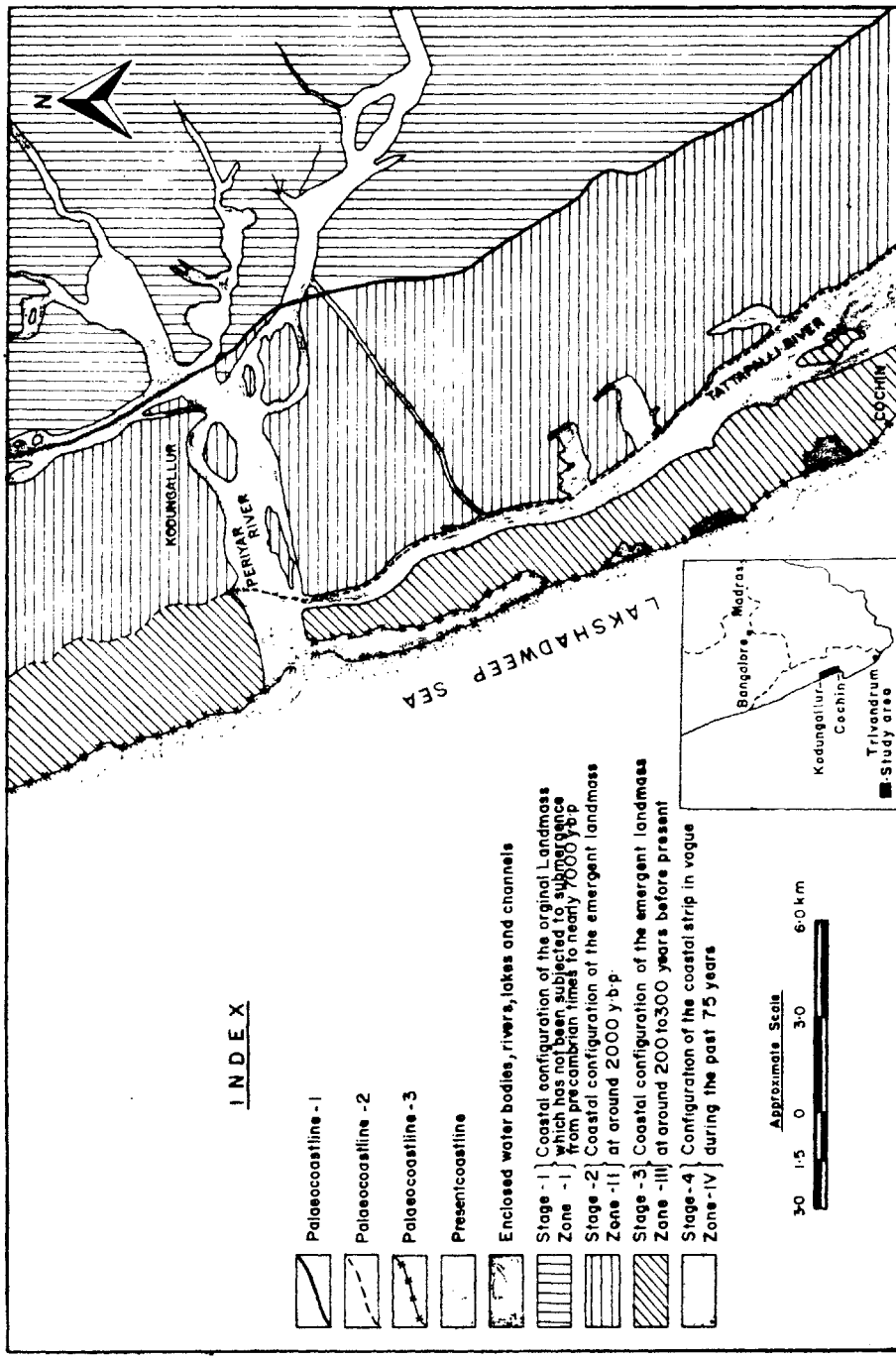

FIG 3 Stages in the emergence of the Kodungallur-Cochin coast, Kerala. A schematic representation.

present day Tattapalli river to form a linear, brown, silty sand zone, probably because of the high energy conditions prevalent in a dominantly marine regime.

Coastal development in the third stage is quite different from the earlier stages. From Munambam to Cochin, the axis of Zone-3 is represented by a mega-sand ridge with width variation in the range of 1 to 1.5km. The widening of this linear sand ridge to its present dimension is consequential to the formation of the succeeding zone (Zone-4).

The northern extension of Zone-3 evidences a formation dominantly dependent on marine processes with minimal fluvial interaction. The Eriyad, Azhikod and Edavilangu areas show strand lines or sharp linear sand ridges/dunes. These are very clear in the aerial photographs and present a typical landform morphology indicating periodic coastal development. The pronounced longshore drift parallel to the coast has a tendency to deposit the sediment load to the north and south of the rivermouth as linear sand banks parallel to the coast. A period of stability is ensured after the formation of a linear sand ridge. The succeeding monsoon produced a high sediment discharge from the fluvial system which was again distributed by the marine processes as linear sand ridges along the coast. The stable phase during the formation of two consecutive sand ridges contributed to the development of an intermediate linear through. The cyclic alternation of these processes gave rise to the typical coastal morphology of a linear sand ridge/dune alternating with linear troughs. The linear troughs accumulate organic debris forming a black carbonaceous clay. The extensive occurrence of sand ridges indicate a minimal role of fluvial agencies. Samples analysed from the linear sand ridges and flats are negatively skewed and provide added evidence for its deposition under marine condition.[1]

Stage 4

Development of Zone-IV—The final stage in the development or emergence of Kodungallur Cochin coast is manifest in the formation of Zone-IV, a linear sandy strip 200 to 700m, of recent age. Senthiappan and Rengamanner,[3] have inferred from the comparison on the shorelines that the sea has regressed by 1.2km in the coastal stretch about 4km north of Cochin and about 0.4m in the coastal stretch about 10km north of the Periyar river mouth. Beach profiling studies carried out by the authors along the Kodungallur-Cochin coast has registered local fluctuations affecting the coastline configuration of this sand beach as a seasonal phenomenon. Prabhakara Rao *et al*[4] also find that seasonal changes due to erosion in the beaches of Kerala is noted from April to August (south-west monsoon) and accretion thereafter. The development of Zone-IV, the linear sandy beach of Recent age must have taken place a long time after the formation of Zone-III. This is substantiated through the present day occurrence of large and disconnected linear water bodies in between Zone-4 and Zone-3. The line connecting these linear water bodies or '*Kayals*' mark the palaeocoastline-3, which existed before the formation of Zone-4. The mechanism involved in the formation of the coastal sandy strip (Zone-4) is dependent on the sediment

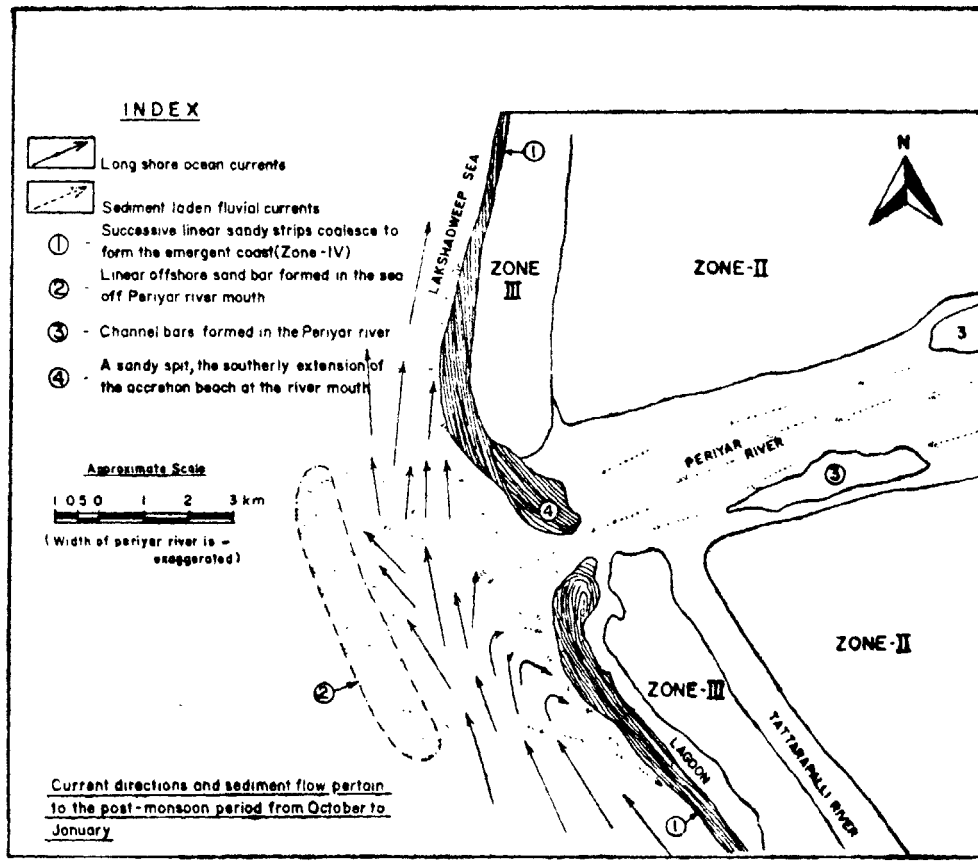

FIG 4 Generalised sketch map of the Periyar river mouth depicting the combined role of fluvial and marine currents in coastal accretion.

discharge of the Periyar river and its distributaries into the sea and the longshore drift of the ocean currents. Though Prabhakara Rao *et al*[4] propose a dominant north to south direction for the littoral drift, they also admit the seasonal reversal of the littoral drift all along the coast. During the present study (post-monsoon period) the longshore drift was NNW. The westerly flowing sediment laden drift is deflected by the NW drifting ocean currents giving rise to sediment laden 'interference' currents which in turn impinge at an oblique angle back on the coast to the north and south of the Periyar river mouth. This coastal build-up mechanism is prevalent in the post-monsoon period. The current direction is of paramount interest as it determines the direction of littoral transport. Machado and Baba[5] while dealing with the movement of beach sand in the Vizhinjam Bay, west coast of India have demonstrated that angularity of wave incidence is the major factor that decides the direction of littoral transport. Evidences for the formation of an offshore sand bar parallel to the coast and due west of the Periyar river mouth probably represent the juvenile stages in the formation of a sand strip. A parallel case has been quoted by Fitzgerald.[6]

Discussion

A study of the lithostratigraphy, landform development and the present day coast indicate that both fluvial and marine processes influenced the development of the Kodungallur-Cochin coast. The coastal tract (Zone-2) immediately adjoining the original landmass (Zone-1) envisages a dominant fluvial mechanism involving a very high supply of sediment load.

Zone-3 envisages both marine and fluvial processes evidenced by strand lines, linear sand dunes and palaeochannels; extensive and isolated water bodies progressively being silted up to emerge as a flat, partly submerged marshy tract.

The last stage of the development of the coast is observed in Zone-IV where successive sandy layers are seasonally added on to form a narrow sandy beach, a direct consequence of the interference of the sediment laden outflowing river currents and the longshore ocean drift, mainly in the post-monsoon period.

Thus we see that the development of an emerging coast starts with a predominantly fluvial mechanism, later transforming into an intrinsic fluviomarine interaction process and ending up as a dominant marine regime with the complete emergence and stabilisation of the coast.

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