CHAPTER - 8

CONTROLS OF COASTLINE EVOLUTION

CHAPTER - EIGHT

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INTRODUCTION

The picture of the evolutionary history of the coastline under investigation extends over a fairly long geological period, initiated with the breaking up of the Gondwanaland and having received its final touches during the early part of the Holocene epoch. Taking an overall view, the Quaternary period has obviously been the most important time span from the point of view of coastline evolution. The vast amount of clastic sediments that drained into the Arabian sea and their redistribuation by marine agencies have been surfeiting the littoral zone since the onset of Quaternary period. This coastal zone is not only the resultant affect of excessive supply of clastic sedimnets but has also been sensitive to various extraneous phenomena that have impreassed upon it since the late Pleistocene. Obviously, the coastline evolution postdates the Flandrian transgression and the present day configuration is the

cumulative effect of marine processes aided by various factors such as structural, sedimentological and eustatic.

STRUCTURAL CONTROL

Structural controls have provided the basic framework to the coastline, which in the course of its geological and geomorphic evolution, has attained its present configuration. Various crustal lineaments and the tectonic features of the trappean basement have not only played a significant role in determining the morpohology of the coastline, but have contributed substantially towards the drainage development, which in turn has controlled the nature and pattern of sedimentation along the different coastal blocks. The control exercised by the structural features of the coastline and its surroundings could be described as under :

I. The west coast fault (or to be more precise group of faults) comprises a major geofracture zone related to the breaking away of the Indian plate from the Gondawanaland and to its drifting away north east ward. The unique straightness of the west coast is an obvious manifestation of this major lineament.

II. The development of numerous major fractures in the trappean rocks, along which the rivers of the study area are now flowing, a phenomena of fracturing (tensional as well as conjugate shear) could be related to the plate movement. The same mechanism could be invoked for the joint pattern.

III. Neotectonism has, however, been more effective in this coastline segment. The occurrence of beach rocks at elevation varying from 2 to 8 meters above the present sea level and their local tilting on account of neotectonic activity that took place in this part of study area indicate the role or neotectonism.

IV. The coastal marine processes of transport and deposition, have rearranged these river borne debris along the shoreline.

SEDIMENTOLOGICAL CONTROL

The degree and extent of trap rock outcropping, rate of their erosion and denundation, slope of the continental shelf and intensity of wave action are the major factors that have influence the coastline evolution. Towards Vadhavan, Navapur, Danda, Satpati, Mahim and Usarni an extensive development of beaches is attributed to the reworking of vast amount of clastic sediments derived from the inland areas by waves. The beach slope at Navapur and Satpati is generally high due to coarseness of the beach sediments. Towards Vadhavan, Tarapur, Muramba and Mahim the cropping traprock has acted as buttress to dam the wave so that only the finer sediments are deposited to give rise to a gentle beach slope. The weathering and denudation of the trap rock have given rise to waveout platform that are more or less horizontal and are exposed during low tide. The beach around these regions is rocky and is made up of very fine sands. The

protective nature of these trap rocks has provided an ideal environment for the growth of mangroves that require low wave energy and abundance of mud. The stilt root of these plants entrap silt and clay and dampen wave energy to form mangrove swamps that transform into mudflats. Good example of growth of mangrove swamp is found at Tarapur.

Of the sediments that are drained into the sea, the sandy fractions are mostly distributed along the beach and foreshore whereas a good percentage of the clayey fractions are funneled into the deep sea. The overall gentleness of the shelf slope has enabled the finer sands to be driven back to the shore by longshore currents to give a gentle beach slopes. The nature of the coastline is substantially modified by the presence of creeks, estuaries, bays and headlands. Headlands are sites where the wave energy is usually dissipated, and are under constant erosion. The erosion is accompanied by net deposition in the intervening bays. The total effect is that the bays are gradually being filled resulting in a straightened coastline. Local climatic variations bring forth many changes that leave its impression either temporarily or permanently. During the rainy season when the rivers are in spate, large amount of terrigenous materials are fluxed into the sea to form huge shoals or beaches. During the stormy conditions, the sea waves impinge upon the berms and coastal ridges and eroded them to form steep cliffs. The absence of berms around Mahim and Vadhavan is due to the wave attack.

EUSTATIC CONTROL

Worldwide sealevel fluctuation during the quaternary period, due to alternating glacial and interglacial stages, are now universally accepted. It has been visualised that during a glacial period large amount of water is abstracted from the sea to form huge glaciers with the result that the sealevel falls. On the other hand, with the onset of deglaciation, the water that is locked up as ice is released causing the sealevel to rise.

The coastline of the study area, points to four strandlines, arranged chronologically in the descending order :

1. + 40 to + 45 m
2. - 20 m
3. + 2 to + 8 m
4. Present day sealevel

The above four strandline positions, could be corelated to the following stages of the quaternary :

1. Tyrrhenian (Transgression) - late pleistocene - 3,00,000 years B.P. (+ 40 to + 45 m)
2. Wurm (Regression) - 30,000 to 20,000 years B.P. (20 m)
3. Flandrian (Transgression) - 13,000 to 3,000 B.P. (+2 to +8m)
4. Present day (Regression) - Recent

For all practical purposes, the present day sealevel is more or less stationary (Gould and McFarlan, 1959; Byrne, et al. 1959; and Curray, 1964). It is further interesting to record that the

west coast as a whole in its various segments, points to considerable effect of neotectonism vis-a-vis strandline positions.

Each sea level fluctuation had its effect on the morphofeatures of the coastline. During the Tyrrhenian period when the sea level rose to about 45m, the small hillocks at the coastline were submerged and an abrasion platform was carved out in the intertidal zone of the prevailing coastline. It was at this stage foundations of the present day drainage were laid down. Numerous streams must have flowed down the steep trapean hills. It was during the subsequent slow withdrawal of the sea that the various streams impinging over the trappean platform, progressively extended their courses, few meandered at the coastal area. The fall of the sea level and the shifting of the strandline westward, were responsible for throwing the various river into disequilibrium, which started downcutting their valley floors and depositing huge amount of detritus at their mouths; this process was accomplished by cliff formation in the upper reaches of the rivers, and deposition of a thin veneer of alluvium over the planed trappean surface. The alluvial cover, must have been thicker near the river mouths, and these alluvial deposits progressively extended seaward.

The various river mouths characteristically dumped huge amount of cobbles and pebbles and at the time of the wurm low strandline, the rivers must have extended several kilometers

further west; the vast sheets of cobbles and pebbles, characterising extensive shoal areas in the vicinity of the mouths typically indicate the river action during the period of regression. The huge cobble deposits of Dahanu point to a low stillstand of the sea.

With the onset of Holecene transgression, the rivers were again thrown into disequilibrium and a new set of features were generated. Most of the coastal alluvium was either washed away or submerged under the rising sea except the few raised within the mudflat. It is visualised that the fluvial sediments that were drained into the sea were reworked by longshore current and a linear sand shoal, in the intertidal zone, was formed parallel to the coastline that accreted gradually into a barrier ridge. The ridge has integrated itself with the coast during the last phase of the Flandrian transgression.

The beach rocks appears to have been deposited when sealevel was raised during the Holocene transgression. A combination of wave action and longshore drift brought about redistribution and redepostion of material generated along the shelf as well as added by the rivers from land ward side or brought from the Gulf of Cambay by tidal currents. This transgression also gave rise to a new set of equilibrium wherein the bays, estuarises, laggons formed were filled with fluvial and marin sediments. The present day sealevel being more or less static, the excess of deposition prograded the shoreline seaward. During this phase, the rate of

deposition overtopped the rate of transgression and river sediments and littoral sands have accreted to form bars.

EVENTS OF COASTLINE EVOLUTION

On the basis of the synthesis of all available informations on the coastline under study, the author has been able to work out a fairly clear picture of the stages and events of the coastline evolution.

These have been chronologically summarised below :

I. During the early part of late Pleistocene (Tyrrhenian - 300,00 years B.P.), the first major transgression took place, which submerged the trappean terrain for several kilo-meters inland. The rise of the sea, significantly attained a height of about + 40 to + 45 m above the M.S.L. The drainage network was not well developed and the stream, flowing down the hill top, carved out V-shaped valleys of small width. Wave action carved out a plantation surface at the high strandline above which cropped out detached hill tops.

II. With the gradual withdrawal of the sea, during the wurm period (30,000 to 20,000 year B.P.), the eroded trappean platform was exposed to subaerial processes of erosion and deposition. Since the sealevel fell to about - 20 m, the major streams extended their courses westward and started downcutting their valley floors. Towards the hilly terrain, cliff formation was initiated. At the coastal area, small

hillocks that were exposed subaerially gave rise to a new generation of streams, especially of the lowest order. Owing to this regression, the streams became very energetic and subsequently deposited alluvium of considerable thickness at the coastal areas and further offshore. Since the carrying capacity of the streams increased, large amount of cobbles and pebbles were transported into the sea. Towards the coastal areas, the trunk streams were taking more or less straight courses with very minor meandering or sinuosity.

III. With the rising sea, during the Holocene period (13,000 to 2,000 year B.P.) a new set of geomorphic features were developed at the coastline as well as inland. The rivers were thrown into disequilibrium due to the drowning of their mouths. Their lengths were abstracted and their mouths were, consequently, chocked up with the result that the vast amount of sediments carried by them were dumped at their mouths with very little reworking by nearshore processes. The extensive cobble and pebble deposits north of Dahanu were the result of their sluggishness which, prior to transgression, were carrying their detritus load several kilometers westward. The coastal alluvium was in undated by the rising sea and was subsequently washed away. At some places, especially at higher elevations, a few isolated patches were unaffected by the rising sea, that gave rise to relict features. It was during this period that the ridge formation started. These river sediments that were dumped

at coastline were reworked by longshore currents. Waves that gave spilling breakers, with fairly long period, having relatively weak back-wash, initiated the ridge formation. the finer sediments carried by the swash were entrapped within the interstices of the coarser ones and in due course a linear sandy ridge developed parallel to the coastline. As submergence continued, the barrier ridge was partly convered with sea water and the area landward were inundated to form lagoons. The infilling of the lagoons by marine as well as fluvial sediments gave rise to tidal flats. The higher strandline of the holocene period is marked by raised mudflats, and littoral concrete, all lying at altitudes between 2 and 8m above the M.S.L.

IV. The present day shoreline is characterised by a slight regression of the sea. This phenomenon has significantly given rise to a new set of conditions that have been marked by features characteristic of the new strandline. The slight regression of the sea has, once again, rainforced cliff.

V. Marine processes and Sediments nature have combined to give rise to diverse factors characterised by modification of the shoreline and erosion of the coastal ridge. The headlands and protuberances are gradually being straightened by breaking waves. Such wave action, reinforced by gusty winds, has undermined the coastal ridge and the dune with consequent cliff formation at the high waterline.