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# MORPHOLOGY AND EVOLUTION OF THE CENTRAL WEST COAST OF INDIA

B.G. WAGLE

National Institute of Oceanography, Dona Paula, Goa 403 004

## ABSTRACT

Based on photo-element analysis such as tone, texture, shape, size, form, pattern and associated features, the coastal geomorphology and processes operating therein are discussed. Erosion and accretion features indicate that the coast is prograding along beaches and retreating along cliffs and headlands. Based on the disposition of landforms, the present coast is neither of emergent nature nor of submergent nature, but it is a combination of both. The emergent features are extensive surfaces of marine abrasion, wave cut terraces, raised beaches, beach rock, beach ridges etc. The submergent nature is inferred by the presence of drowned river valleys, occurrence of offshore islands etc. The contrasts in the coastal features appear to have resulted due to a combination of changes in the sea level, climate, lithology, structure and local tectonic movement. It can be concluded that maturity has not been reached as the embayed nature of the coast has not yet become straight and the shore lines have not receeded beyond the heads of the original base.

Key-words : Geomorphology, West Coast, Konkan Coast.

## INTRODUCTION

A study of the geomorphology and Quaternary history of the coastal and nearshore areas is of considerable importance for the planned development of coastal areas. Aerial photographs and LANDSAT images provide a valuable rapid and accurate tool for the study of coastal geomorphology. Generally greater details of the coastal configuration and nearshore features are discernable on the photographs than that using field observation for short duration.

Wilkinson (1871), Blandford (1872), Foote (1876) and Lake (1890) while describing the geology of the Konkan and Malabar area have marginally touched the morphology of the coast. Feio (1956), Arunachalam (1964), De Souza (1965, 1968), Radhakrishnan (1967), Ahmed (1972), Dikshit (1976), Dessai and Peshwa (1978), Sriram and Prasad (1979, 1980), Karlekar (1981), Wagle (1982) and Prabhaker Rao, Raju and Nair (1985) studied the coastal features and discussed the various geomorphic problems of the central west coast.

The present study area comprises 700 km long coastal tract of Goa and Maharashtra between 14°48' and 20°22'N along the west coast of India (known also as the Konkan Coast). Physiographically the region can be broadly classified into: (i) the coastal tact consisting of beaches, rugged sea-cliffs,

small isolated pocket beaches, recent broad alluvial plains, vast estuaries, older spits, dunes, beach ridges, broad hard rock wave cut platforms etc.; (ii) the tract between the coast and the ghats, i.e. the "sub-ghats" region and (iii) the high ranges of western ghats rising to elevation 900 to 2500 m above m.s.l. The present study deals with the geomorphology and evolution of the area under the first category.

The area has tropical maritime and monsoon type of climate. It is equable and moist throughout the year with regular and sufficient rainfall during the southwest monsoon season. The annual rain fall is of the order of 250 to 300 cm.

## MATERIAL AND METHODS

The study is based essentially on visual interpretation of aerial photographs and LANDSAT images in a variety of forms and formats supplemented by ground truth collection.

Uncontrolled mosaic of photographs (1960, 1:50,000; 1973, 1:25,000; 1975, 1:20,000; 1977, 1:50,000 approx) of coastal areas of Goa and Maharashtra were prepared by matching the images of the overlapped portion to give continuity. This was followed by a study of the area run-wise under the mirror stereoscope and the geomorphic details were transferred on kodatrace and later compiled into a map.

## RESULTS AND DISCUSSION

Following geomorphic units were identified :

| Marine | Fluvial | Aeolian |
|---|---|---|
| Laterite mesas | Drainage | Dunes (recent & old) |
| Cliffs | Ghat escarpment | |
| Wave-cut platforms | Denudational hills and inselbergs | |
| Offshore islands | River terraces | |
| Tidal flats | Channel bars | |
| Beaches, beach rocks and beach ridges | | |
| Spits and bars | | |
| Waves | | |
| Longshore drift | | |
| Turbidity flow | | |

An understanding of the evolution of a landform results from information of its size and shape, its location relative to other landforms and the material of which it is made. The west coast of India is marked by large hills boarded by narrow alluvial plains followed by an indented coastline with arcuate bays, estuaries and a few sandy stretches separated by rocky head-

lands. In Goa, the minimum distance between the ghats and the sea is about 40 km, which increases towards north, but several isolated hills rise in the coastal tracts between the ghats and the sea. The Western Ghat scarp on the east form a long unbroken escarpment possibly resulting from recession of scarp over a long period of time.

The present study provides some information about the geomorphological development of the area after the outpouring of Deccan Traps, and as elsewhere in the country and particularly in the west coast, the Pre-Deccan Trap geomorphological history of the area is obscure. After the outpouring of the traps, the coastal tracts witnessed epirogenic movement, headward erosion, recession of scarps, superimposition of the streams, lateritization, submergence, emergence, progradation and retrogression (Wagle, 1982).

The prominent landforms in the coastal region are the laterite capped table-lands, with a gentle seaward slope and there is usually an abrupt fall along the coast presenting a cliffed coastline (Fig.1a). The climate, particularly rainfall, has played a decisive role in the process of lateritization and

Fig.1a - Laterite table-lands with cliffed coastline

indirectly contributed to a specific type of coastal development. These lateritic mesas mark distinct levels from 40 to 100 m which are significant in presenting the geomorphic evolution of the area. The levels particularly the one at the 100 m and above are very high and without any evidence of marine abrasion or deposition. It is difficult to explain their origin due to eustatic changes. It is also difficult to date these surfaces as these are carved in unfossiliferous crystalline rocks. The origin of these mesas can be explained in the followisng stages : (i) the coastal tract was peneplained before the

outpouring of the Deccan Traps, (ii) the Deccan Traps covered the peneplained surface, and (iii) fluvial and marine erosion initiated the removal of the trap blanket from west to east leaving behind plateau like surfaces at different heights which form the present mesas. The retreat of the Deccan Trap is confirmed by the west flowing rivers which are rapidly eroding headwards and capturing the well-established drainage on the older plateau surface (Wagle, 1982).

Due to the removal of the basaltic cap the streams flowing on the basalt started following the structural weakness and trend of the earlier peneplained Pre-Cambrian surface. Most of the streams have subsequently followed faults, fracture lines and the synclinal axis giving a fine example of structurally controlled drainage. At the same time due to the weathering and removal of the lava flows from west to east the Dharwarian rocks were again peneplained and when the topography and climatic conditions were favourable, extensive lateritization took place. *In situ* formation of laterite is also evidenced by the clear transition from parent rock to laterite and the presence of relict features of the parent rock in the laterite.

The presence of laterite beds forming the abrasion platforms in the inter-tidal zone (Fig.1b) as well as at a depth of 20 to 34 m below the present sea

Fig.1b - Abrasion platforms of laterite

level along the estuaries can be attributed to the Quaternary rise of the sea level giving rise to drowned valleys. Similar drowned valleys have also been reported along the west coast in adjacent areas (Vaidyanadhan, 1968).

The coastal geomorphic features often raised a question whether this coast is of emergence or the present outline has resulted from submergence. It

looks more complicated due to the presence of both emergent and submergent features along the coast. The submergent nature of the coast is inferred from the presence of drowned river vallyes with steep sides which have aided location of the fine harbours along the coast and the penetration of tidal water for a considerable distance upstream from the sea. Another evidence that supports the idea of submergence is the occurrence of quite a number of offshore islands, some of which were inselbergs on coastal plains or detached portions of headlands due to erosion or tectonic activity but have since been changed into islands because of drowning of the low lying areas around.

The emergence features of the coast (Fig.2) are (i) extensive surfaces of

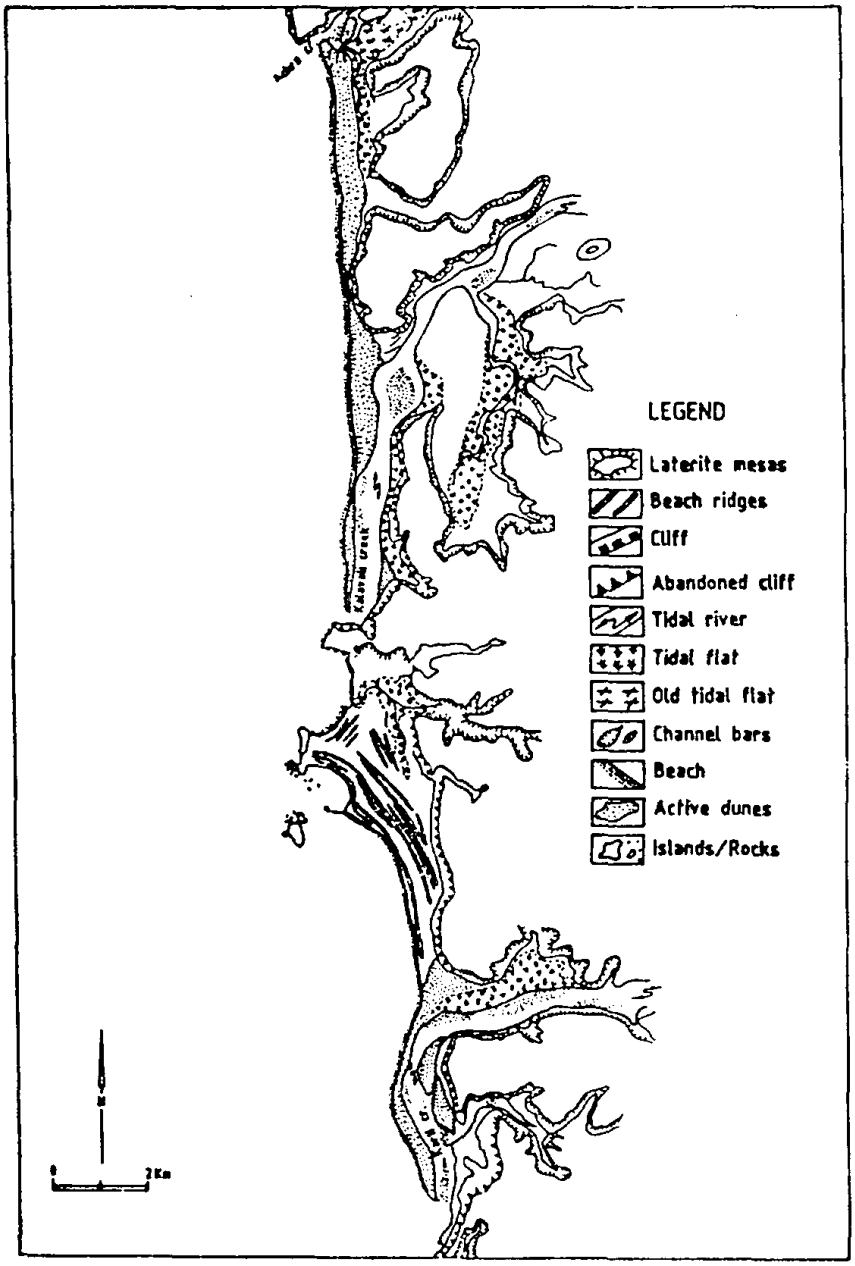


Fig.2. Map showing the progradation of the coast

marine abrasion in the northern sector (north of Bombay), (ii) wave cut laterite terraces and conglomeratic laterite beds beyond present sea level. These lateritic beds mainly consist of rolled gravels, and cobbles of laterite with some other rock types cemented by hydrated iron oxides, (iii) raised beaches, (iv) extensive beach rock exposures, (v) series of beach ridges of dune ridges extending for several kilometres at a stretch and (vi) vast sandy plains and marshy beds.

Though it is not clear whether the coast has been affected by one or more sequences of submergence and emergence (since Quaternary period), it is important to bring here the presence of laterite beds, in between marine and fluvial sediments at different levels (-20 to -34 m) below the hydrographic zero. The presence of raised beaches in the immediate neighbourhood of the region of subsidence at many places of the western side of the islands indicate the emergence. Two submerged marine terraces in Bhagwati Bay near Ratnagiri (Karlekar, 1981) at two different levels (the first at the depth of 6 - 8 m BSL and second at about 14 m BSL) capped by two metre thick laterite and then by recent sediments are the evidences of different periods of subaerial weathering conditions before the sea deposited the overlying sediments.

According to Kale and Rajaguru (1985), the sea level along the west coast reached very close to the current sea level 5000 to 6000 years BP. Since then the sea level seems to have oscillated to positions, both above and below the current level. Radio-carbon dates from Mirya Bhatti (17°29' N and 73°13' E), Devgad (16°22' N and 73°34' E) indicate high sea level upto 3 m during the historical period. Many dates from Konkan reflect a minor regressive phase about 2,200 to 2,800 years BP when the sea level fell low by at least 1-5 m. The age of most of the coastal beach rocks range about 5,200 and 1,100 BP (Ghate, 1986). The stratigraphic location and radio carbon dates of wood specimen of Colva Beach (Goa) suggest a lower sea level than the present during mid-Holocene (Kale and Rajaguru, 1983). Based on this data, it seems that approximately 6,000 years BP should obviously be taken as the time at which the present day shoreline began to form. It seems that the sea level has not varied widely, by more than 10 m, over the last 6,000 years and it has been within the limits of the existing coastal zones.

The basalts in the vicinity of Bombay having high degree of weathering under the tropical conditions and rapid erosion, present a contrast to the chemically more resistant Pre-Cambrian rocks and laterite in the south. The fluvial activity in the non-lateritic parts of the north has been more effective and has developed vast plains. These were later trimmed and shaped into plains of marine abrasion after a rise of sea level. Due to subsequent fall of sea level (1-5 m) again these plains were subjected to subaerial weathering and fluvial deposition. Where the rocks were relatively resistant to erosion or protected from powerful ocean waves the coast and the upper part of the shelf were essentially submerged, only partially modified or remained unmodified by the sea and have retained the original topographic and structural features of the land.

Sands derived either from the erosion of the coastline or by fluvial action prograde from the headlands and islands in the predominant direction of longshore transport forming bay mouth barriers during the spit stage (Fig.2). In the early stages of bar development two shorelines really exist, an outer one in front of bar facing the sea and inner one behind the bar along the initial coast, but when the bay mouth bar closes a coastal re-entrant, the inner coastline ceases to function and the enclosed body of water is converted into lagoon or marsh, which in time is filled with waste from the land. Within the sandy emergent coastline the aerial photographs clearly depict the present and the paleoshoreline. The latter is almost parallel to the present shoreline and represented by steep rocky abandoned cliffs at places 5 to 6 km inland.

The coast with broad beaches, old and recent dunes, and old beach ridges indicates the progradation of the coast specially along the beaches. At the same time the portions of the coast, with cliffs and wave cut terraces under formation, depict that the hilly region of the coast (cliffs and other promontories) is under constant attack of the waves causing erosion leading to the regression of the coast. It may therefore, be concluded that the coast is prograding along the beaches while retreating along the cliffs and headlands.

The physiographic features noted above represent the Late Youth stage of the coastal development. It is clear that the coast has not yet attained the maturity because it still shows the embayed nature and the shorelines have not reached beyond the heads of the original bays.

Abnormal straightness of the sandy and rocky coast for a considerable stretch forces to look into the possible influence of a fault (West Coast fault) on the evolution of the coast. Krishnan (1953) opined that the west coast of India represents a fault scrap of probably Miocene age. But with the available data it is difficult to establish as to what extent the fault had influenced the coastal evolution.

Based on the present geomorphic features no satisfactory classification can be formulated without taking into account dominant relative emergence or submergence. It may be difficult to decide which of the either has been the most significant along a specific sector of the coast. Thus, it appears that the coast is neither of emergent or of submergent nature but is of mixed type. The contrast in the coastal features appear to have been formed by a combination of changes in sea level, climate, lithology, structure and local tectonic movement.

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