

SHORES OF THE CENTRAL WEST COAST OF INDIA — A CASE STUDY USING REMOTE SENSING DATA

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ABSTRACT

Geomorphological studies along the central west coast of India extending between Bombay to Goa, have been undertaken, using aerial photographs and LANDSAT imagery. Coastal features like active and abandoned cliffs, spits, bars, beach rock, beach ridges, littoral terraces, dunes, tidal flats etc. have been described and demarcated. Ground truth have been collected for all the features identified from remote sensing data. The coast, with abandoned cliffs, littoral terraces, beach ridges, tidal flats, can be ascribed to the possibilities of its continuous progradation. Whereas, the coastal tract with active cliffs, broad wave-cut terraces etc. indicate the retrograding coast. The shoreline of the central west coast, therefore, can be classified mainly as depositional coastal segments which are prograding, and erosional coastal segments which are retrograding along the cliffs and headlands.

Key-words: Geomorphology, remote sensing, west coast, retrograding.

INTRODUCTION

Marine scientists and coastal engineers recognised the shore zone as an element of highly dynamic physical system. In order to have a broad perspective of the morphogenetic set-up of the various coastal landforms, geomorphological interpretation of the central west coast of India has been carried out. However, special emphasis is placed on identification and classification of coastal landforms only. The study area comprises the coastal tract (N 14°48' to N 20°22') midway along the west coast of India (Fig.1). The coast is more or less straight and trends NNW- SSE. The coastline consists of sandy beaches separated by rocky headlands, cliffs, river mouths, and broad estuaries. LANDSAT imagery (1:1M, bands 4, 5, 6 and 7) and aerial photographs (scale 1:25,000 and 1:20,000) were used for interpretation. Extensive field checking was also carried out to confirm the data.

Landforms - description and classification

Based on remote sensing data and ground truth collection, the coastal features were identified and compiled in a map (Fig.2). The major morphological units identified include laterite mesas, active and abandoned cliffs, wave-cut platforms, rocky islands, tidal flats, beach rocks, beach ridges, dunes, spits and bars etc. The geomorphology and evolution of the area has been previously documented (Wagle, 1989). Coastal and offshore geomorphology of the area is described in Wagle, 1987.

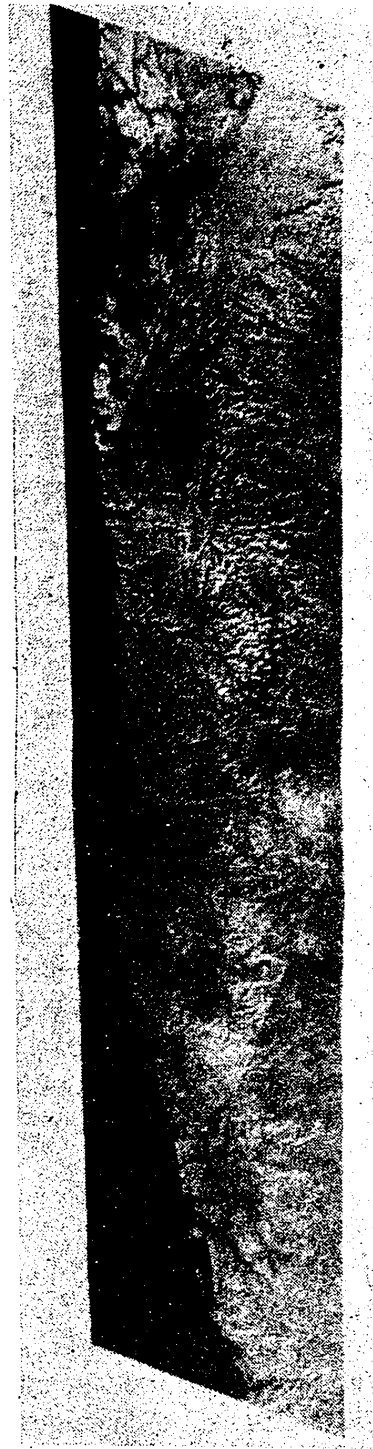


Fig. 1. Landsat mosaic showing the study area.

Remote sensing data was used to decipher the impact of coastal features on heavy mineral beach placers of the area (Wagle, Gujar, Mislankar, 1989). Distribution and dispersion of turbid waters on the western continental shelf of India is interpreted from LANDSAT images (Wagle, 1985). However, in the present study a special emphasis is laid on identification and classification of coastal landforms using remote sensing data.

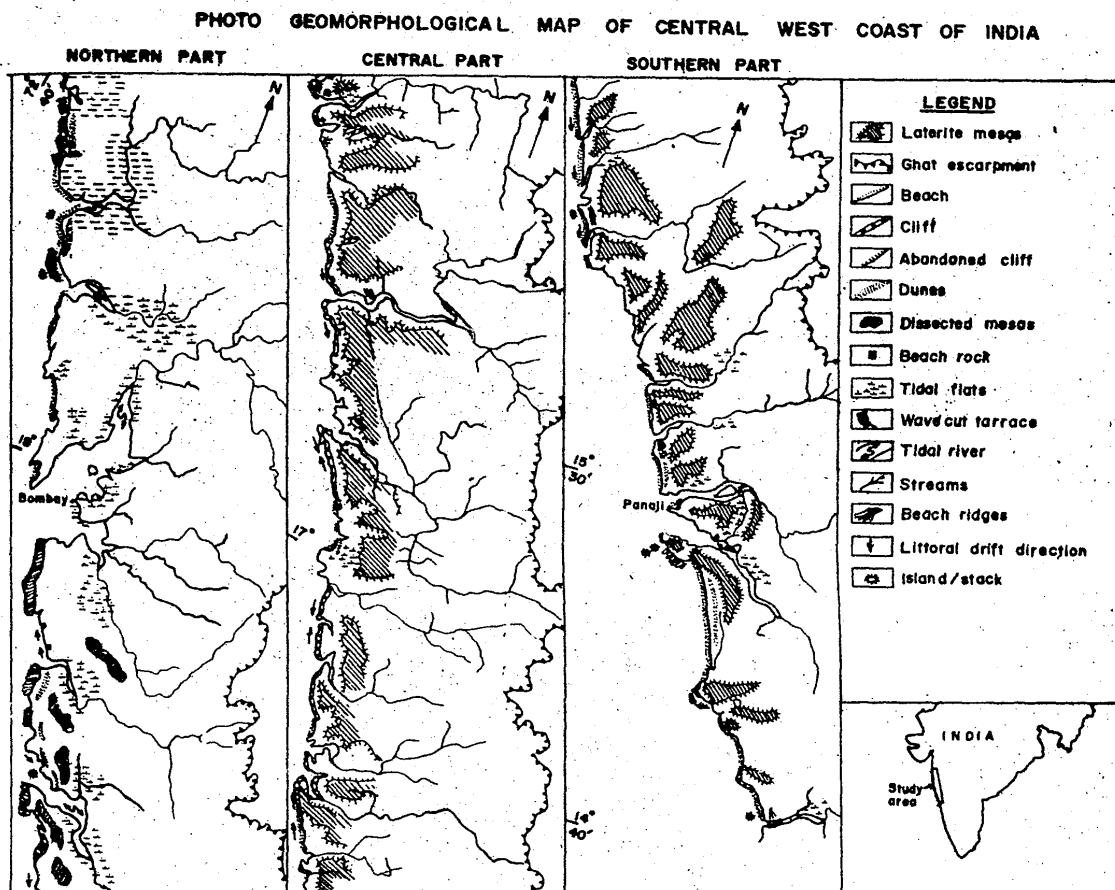


Fig. 2. Map showing the coastal geomorphic features of the area.

Mesas : The most prominent and impressive landforms along the coast consist of laterite-caped mesas (Fig. 3a). They are recognised on air photos by their light to medium tone, and relatively flat tops. The surface has a pitted appearance but the slopes are marked by dark tone due to dense vegetation. There is usually an abrupt fall along the coast presenting a cliffed coastline. The ground checks indicate that the height of mesas vary from 40 to 100 m from m.s.l. The laterite cover ranges in thickness from 20 to 80 m. Some of the laterites show relict joints and foliations indicating *in-situ* weathering of the rocks.

Cliffs : Another significant coastal feature is the presence of active as well as abandoned cliffs (Fig.3b). A majority of the active cliffs are the result of present marine processes. The rates of recession of cliffed coastlines vary with their elevation, rock resistance, geological structure and incident wave energy (Bird, 1985). Hence, the retreat of the cliffs is relatively more pronounced in the areas exposed to the direct attack of waves generated by southwest monsoon winds. The cliffs invariably have wave cut beaches at their base. The parallel retreat of these cliffs is helped by large cracks developed in laterite parallel to the coast.

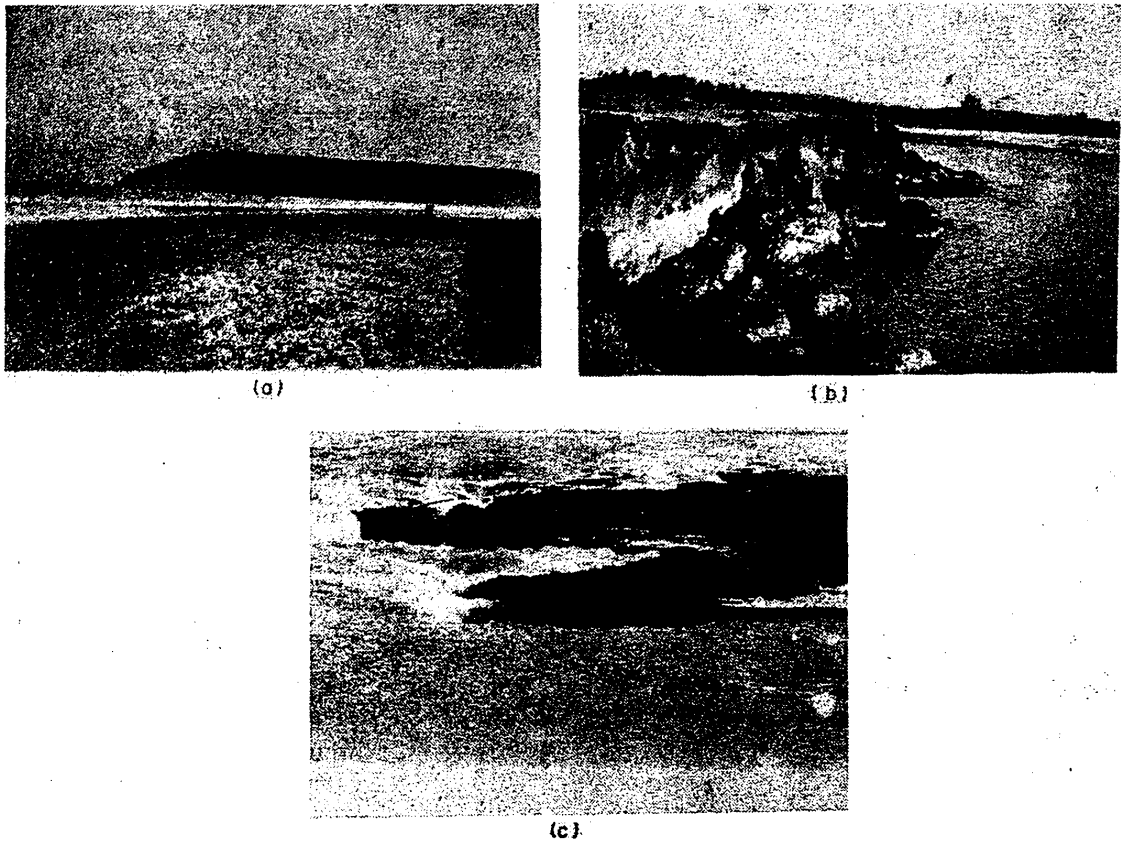


Fig. 3 (a) Laterite-capped mesas along the coast (Ratnagiri), (b) Cliffs along the coast (Malwan) and (c) Wave-cut platforms in the intertidal zone (Goa).

Abandoned cliffs of the same height are found at a few hundred metres inland from the present strand line, beyond the reach of contemporary wave action (Wagle, 1987). Some of these are as much as 1 to 2 km inland. They are fronted either by beach ridges, abrasion platforms or by littoral terraces. A fall of sea level might leave the previous beach as an abrasion platform or a littoral terrace with an abandoned cliff.

Wave-cut platforms : On cliffed coasts, the cliffs and headlands are bordered by wave cut platforms with gentle slopes (Fig.3c). They are easily marked on aerial

photographs. Some of these are covered with a thin veneer of recent alluvium. At least 2 to 3 levels of platforms can be marked along the coast. Some are in the intertidal zone but others are above the present day high waterline. These terraces clearly depict the regression of the sea level along the coast.

Rocky islands: Numerous rocky islands/islets and few isolated stacks can be seen on aerial photographs. They are within 1-2 km from / off the shore; the farthest being 6-8 km away. Based on lithological and structural identity between the mainland and the islands, it appears that these rocky islands represent the detached portions of coastal headlands that are now isolated from the retrograding coast. Aerial photographs show that some of the islands are connected to the mainland by means of tombolos or by alluvial deposits.

Tidal flats: Due to wide estuarine river mouths seawater encroaches during high tide and submerges the low lying areas adjacent to river mouths, forming the tidal flats. These are extensive, nearly horizontal marshy or barren tracts of land that are alternately covered and uncovered by water. Hence they are marked by dark gray tone on aerial photographs. Whereas the old tidal flats show a light tone with cultivated fields adjacent to the present tidal flats. They are 2-3 m above the present sea level. Some of these are not necessarily tidal flats but barrier flats. Barrier flats are usually due to emergence of the coast.

Beach: According to Ahmad (1972), about 55% of Indian coastline is beach-fringed. The beaches in the region are invariably sandy and have maintained a gentle gradient. Sandy beaches are found at bay heads, along straight shores, on the seaward side of sandbars, and between two promontories. This unit is restricted to a narrow belt ranging from a few metres to 200 m wide along the coast. It has been found that most of the stable beaches are backed by dunes or by narrow littoral terraces which are, in turn, at places backed by abandoned cliffs.

Beach rock: There have been several references to the occurrence of beach rock along the Indian coasts and the adjoining Andaman, Nicobar and Lakshadweep group of islands (Wagle, 1990). During the present study beachrock has been observed at several localities along the coast. Beach rocks are formed in protected and sheltered localities along the coastline. This rock has almost same general composition as the loose beach sand. It is friable to well cemented rock consisting of mineral grains, rock fragments and calcareous debris, cemented by calcium carbonate. It is formed in the intertidal zone or spray zone and occurs in thin beds (upto 3-4 m in thickness), more often as patches, dipping seaward at 5 to 15°. A wide range of hypotheses has been put forward to account for intertidal cementation of beach deposits (Guilcher, 1961; Kaye, 1959; Bathurst, 1971; Milliman, 1974; Hoppe, 1982). These rocks are completely exposed when the sea recedes. The subaerial processes of erosion which then follow, start destroying the rocks. If the depositional processes in the nearshore zone are more

effective than the subaerial erosion, in course of time, a thick apron of coastal alluvium conceals the beach rock formation, thereby checking their erosion by subaerial processes. This type of situation along the coast points to the heavy deposition and a stable sea level in recent period so that the beach rocks could develop in that period within the intertidal zone. The occurrence of beach rock in the intertidal zone as well as 2 to 4 m above the present day high waterline may perhaps indicate the minor fluctuation of the sea level. According to Hopley (1986), wherever possible beachrock as an indicator of former sea levels should be used in conjunction with other types of evidence.

Beach ridges and dunes : Four to five major beach ridges occur far inland from the present day shoreline. These are identified from the recognisable tonal variation in the photographs as well as in the imagery. These are a set of very low sandy ridges roughly parallel to the present shoreline, which represent the results of a continuous retreat of the sea. Thus each of them was a shoreline at one time. As these ridges are clearly pointing out the regression of the sea, they serve as a major evidence for sea level lowering or regression of sea in these areas.

A series of sand dunes that vary in size and degree of stability occur almost parallel to the coast. Within these dunes a set of old and recent/active dunes can be distinguished. Recent dunes exhibit a very light tone in airphotos, are located close to the beaches and rise to a height of about 10-15 m. They are generally devoid of vegetation or have only a very thin veneer of vegetation. Recent dunes uncut by wave action, indicate that this part of the shore is now depositional in nature and has been depositional for an unknown time, possibly more than several hundred years. The older dunes are marked by very dark tone and the tonal contrast enables their clear distinction from the recent ones. These dunes extend to about 1 to 2 km inland, stabilised by growth of thick vegetation.

Spits and bars : Along the study area we have many typical spits. These have been commonly attributed to movement and deposition of materials by longshore currents (Thornbury, 1954), particularly of the type that (Johnson, 1919) are called wave currents. They are seen to orient themselves and grow in direction of the dominant longshore drift. These geomorphic indicators give first hand information on drift direction. Several good examples of spits enclosing estuarine streams have been noted. Most commonly the axis of a spit will extend in a straight line parallel to the coast but where currents are diverted landward or usually strong tides exist, growth of spit may be deflected landward, resulting in creation of a recurved spit or a hook, which in turn bends inwards obviously under the influence of strong tidal currents. Based on these it is evident that drift along the coast could be noted in both north and south direction.

Wave behaviour : Aerial photography provides a perspective for wave behaviour in the coastal zone not often available from landbased or shipboard observations. Scales within the range of 1 : 20,000 to 1 : 50,000 have been found to provide enough

detail to observe many of the desired wave characteristics. Two trains of waves are recognised in the nearshore area at the time of photography : (i) - from WSW, which is dominant, and (ii) - from WNW, which seems to be subsidiary.

Drainage : Rivers draining the area originate from the Sahyadri ranges and have reached their base level of erosion within a distance of 20 - 30 km. They are under tidal influence for most of their length towards the coast. The drainage is dendritic. The rivers run mostly straight and those with sharp bends and meandering is a rare phenomenon. They have picked out the lineaments and lines of weakness in preference to the general direction of the slopes. The drainage network is predominantly in two directions following the regional trend. Though these rivers are having tremendous headward eroding capacity, as well as rainfall and climate is also favourable for the formation of delta, no delta is found developed anywhere along the coast. This may, perhaps, be due to small drainage basins, lower sediment supply and the estuarine conditions of the rivers.

River terraces : These are topographic surfaces marking the former levels of valley floor or flood plain. Tectonic and climatic changes are some of the important factors bringing in changes in the river channel dynamics. Field checks reveal that the horizontal or nearly horizontal alluvial terraces on either sides of the rivers are about 2 to 5 m above the present high water level and are covered with alluvial deposit. These terraces clearly depict the regression of the sea or lowering of the sea level along this coast.

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