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EVOLUTION OF THE COASTAL LANDFORMS IN THE KRISHNA DELTA FRONT, INDIA

K. NAGESWARA RAO and R. VAIDYANADHAN, Waltair

ABSTRACT : Studies of toposheets (scale 1:63,360), Naval Hydrographic charts (different scales), aerial photographs (scal s 1:60,000 and 1:20,000) of different years spread over about half a century, of the delta front of the Krishna river have brought to light changes in coastal landforms. Of particular importance are the spits, which grow into bars enclosing lagoons. Further addition of detritus brought by the distributaries of the river Krishna fills in the lagoons, thus resulting in the progradation of the delta.

Study of the different bands of the Landsat imageries together with the knowledge of the pattern of circulation of surface currents, and field mapping of parts of the spits has helped in understanding the mechanism of the growth of the spits. But for the occasional cyclones causing erosion, the net effect is mainly depositional. Over the past half a century, there has been a total increase of 30 sq. km. to the deltaic part of the Krishna.

Introduction

The river Krishna is draining into the Bay of Bengal through its four distributaries, building a delta in the process, on the east coast of India. Studies made on the coastal parts of the Krishna delta bring to light features like spits and bars at and close to the river mouths. Out of the four distributaries, the easternmost one does not show any conspicuous change at its mouth during the last 50 years, and hence is not included in the present study. The remaining three– the Krishna river, Nadimi Eru and the Golumuttapaya constitute the present active delta lobe. There is an increase of delta area by about 20 sq. km. between 1928 and 1968 and about 10 sq. km. more between 1968 and 1978 (Fig. 1 A, B, C). This addition of area is mainly due to the growth of spits and bars at the mouths of these distributaries nearly parallel to the present coast and subsequent filling up of the bays and lagoons enclosed by these spits.

Earlier, some studies were made of the coastal landforms at other delta fronts on the east coast of India. Mahadevan and Prasada Rao (1958) studied the growth of Godavari spit at the mouth of Gautami Godavari river near Kakinada, and inferred that it is due to the increase in sediment discharge through the river because of deforestation and subsequent soil erosion in the river basin resulting in an overloading of the littoral drift coming from south which is unable to carry it further and hence depositing in the form of the long spit towards north. Niyogi (1968) observes that progradation of Subarnarekha delta in Orissa State is due to the growth of spits and bars, which is the result of the reworking of the river sediments by littoral currents and waves and subsequent filling of lagoons, enclosed by these spits to become deltaic tidal flats. Babu (1975) has noted the growth of a sand spit at the mouth of the westernmost distributary of the Krishna river. Sambasiva Rao and

Vaidyanadhan (1979) have given an account of the new features at the mouths of the distributaries of Godavari river based on the study of toposheets, air photos, and field surveys.

The present study was undertaken to trace the stages in the growth of these new coastal forms in the Krishna delta front and to account for the progradation of the delta.

Methods of Study

In the present work, aerial photographs of 1968 on 1: 60,000 scale and of 1978 on 1:20,000 scale were studied. Toposheets of 1928 on 1:63,360 scale were available as the earliest record which give the then shape of delta front. For purposes of comparison, the features indentified from 1:20,000 scale airphotos of 1978 were brought to 1:60,000 scale with the help of an aerosketch master. The radial displacements in the aerial photographs is ignored and hence the scale of the maps are only approximate to one inch to a mile of the toposheet. Because the relief is rather low, relief displacements are negligible. As a matter of fact, there are no spot heights available of any point in this area of study (Fig. 1A, 1B & 1C) and no point is this area is likely to be more than 4 metres above mean sea level.

In order to get the actual dimensions, shape and relief of some of the spits, plane table mapping was done with microptic aledade in February, 1978 (Fig.3). Owing to the fact that these parts of the delta here are highly inaccessible, it was possible only to map the extreme ends of the spits.

Positive transparencies on all the four MSS bands of the Landsat imagery (23rd October, 1972) were studied to demarcate the turbidity levels at the shelf portions of the Krishna delta and to predict the possible direction of movement of the sediment. However, band 4 and band 5 are found to be the most useful for this study. General surface current directions in the Bay of Bengal (Fig. 1D) obtained from the Admirality charts (as reproduced by Ganapathi and Rama Sarma 1958) were compared with the data inferred from Landsat imageries (Fig. 1E). All the above pertain to the region at the Krishna delta front.

Besides these, toposheet of 1928, Naval Hydrographic chart of 1962, and aerial photographs of 1968 and 1978 of the coastal area, east of Machilipatnam were studied and all of them are brought to the same scale of 1:60,000 with the help of an aerosketch master to show the changes in the tidal creek and the coastal landforms here, if any.

Coastal Landforms

The coastal part of the Krishna delta shows features like ancient beach ridges, recent dunes, tidal flats, mangrove swamps, spits and bars.

1. Ancient Beach Ridges

Ancient beach ridges are the sandy ridges which lie almost parallel and inland to the present coast, representing deposits close to the former shorelines. A few of them could also be earlier spits and bars which are separated from one another by stretches of flat lowlying marshy areas, sometimes occupied by mangrove vegetation. It should be noted that the absence of sand ridges in Fig.1A is not indicative of their absence in 1928, but they have not been distinctively mapped as such due to the inaccessibility of the terrain. Their recognition now is mainly due to the availability of air photos of the different periods.

2. Fractures/Faults

Earlier, Vaidyanadhan (1973) has noted faults/fractures across these parts of the Krishna delta, besides recognising ancient beach ridges. Even though the fractures/faults are not marked in the figures of the present study, a few of them are identified from the aerial photographs during this study and also in the earlier studies by

the same authors (1978, p. 122). The rapid southern progradation of the delta is attributed to the fact that the faults here extend east-west and the southern parts of the coast/continental shelf must perhaps be slowly sinking, establishing a gradient in that general direction, facilitating movement of the river towards south along with its recent distributaries.

3. Spits and Bars

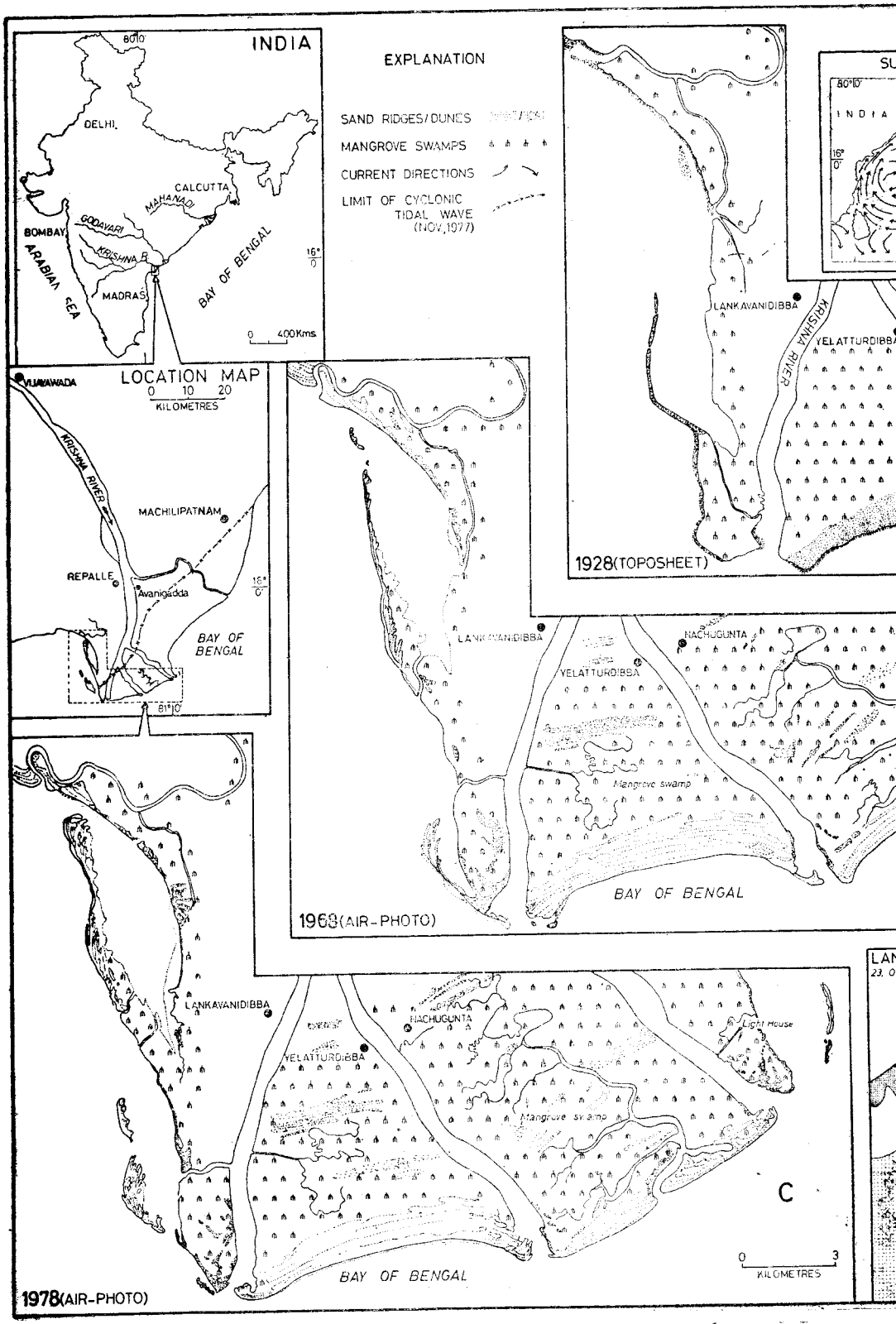
The most striking features in the Krishna delta front are the growth of big sandy spits. They are growing on both the sides of all the three distributaries (considered in the present study), among which the one developing to the west of the westernmost distributary is the most prominent (Fig. 1C). It is almost enclosing a lagoon which is being filled up rapidly (Nageswara Rao and Vaidyanadhan 1978). This spit is becoming a bar now in the sense that "a bar is a completed or extended spit which encloses, or nearly encloses a portion of the water body into which it extends" (Evans, 1942, p. 846). A second spit is south of the above in two stretches having become detached after the devastating cyclone which swept the area on the 19th November, 1977. A third spit on the eastern side of the area is also noteworthy. It is clearly seen in 1968 photo (Fig.1B) but much of it has been eroded out during the cyclone, hence only a small part is seen in the March, 1978 photo, detached from the mainland (Fig.1C). Apart from these three, the remaining spits are not prominent and changes in their configuration are not significant. A majority of these show hooked nature indicating successive additions at the tips of the spits, these being the result of the new material transported and deposited in that form due to refraction of waves.

Origin and Evolution

The origin and growth of coastal depositional features like spits and bars especially at the confluences of the rivers involves a variety of dynamic forces which are the result of cumulative action of both fluvial and marine processes. The fluvial action lies in the river discharge bringing in the sediments to the sea, and the marine action rests in the nature of currents, tides, and energy and direction of approach of waves to rework the sediments.

There are two distinctly different circulations of surface currents prevailing in the Bay of Bengal (Fig. 1D). A clockwise circulation starts during Jan-Feb. and fully establishes by April. During this period the longshore drift at the Krishna delta front is from southwest to northeast. But in this period the sediment discharge is not significant owing to the fact that dry climate prevails over the region. A counterclockwise circulation starts in August and fully establishes by October. During this period (Aug-Nov.) the area gets more rainfall which accounts to 64% of the total rainfall and during October alone it receives 22% of the annual rainfall (these figures are on an average over a period of 73 years of rainfall data). Hence during this Aug-Nov. period the discharge is more and so also the sediments. As the drift during this period is from the northeast to southwest, the sediments discharged into the shelf tend to move due southwest. Simultaneous activity by waves and tides which are almost perpendicular to these currents pushes the material towards the relatively calm bay on the western side of the delta wherein the sediment tends to settle in the form of an elongated spit. Moreover, the westernmost distributary is thought to be the major one as it carries most of the sediment and hence the growth of major sand spits here is only to be expected. Other spits at the mouths of the remaining distributaries are developing because of the deflection of the sediments by the waves and tides before they are carried away by the littoral currents and tend to settle on both the sides of the confluence.

These spits, especially on the western


INDIA
80°10
DELHI
CALCUTTA
MAHANADI
GODAVARI
KRISHNA R.
BOMBAY
ARABIAN SEA
MADRAS
BAY OF BENGAL
16°0
0 400Kms
EXPLANATION
SAND RIDGES/DUNES
MANGROVE SWAMPS
CURRENT DIRECTIONS
LIMIT OF CYCLONIC TIDAL WAVE (NOV.1977)
LOCATION MAP
0 10 20
KILOMETRES
VIJAYAWADA
KRISHNA RIVER
MACHILIPATNAM
REPALLE
Avanigadda
16°0
BAY OF BENGAL
81°10
LANKAVANIDIBBA
KRISHNA RIVER
YELATTURDIBBA
1928(TOPOSHEET)
LANKAVANIDIBBA
NACHUGUNTA
YELATTURDIBBA
Mangrove swamp
BAY OF BENGAL
1968(AIR-PHOTO)
LANKAVANIDIBBA
NACHUGUNTA
YELATTURDIBBA
Light House
Mangrove swamp
C
0 3
KILOMETRES
BAY OF BENGAL
1978(AIR-PHOTO)

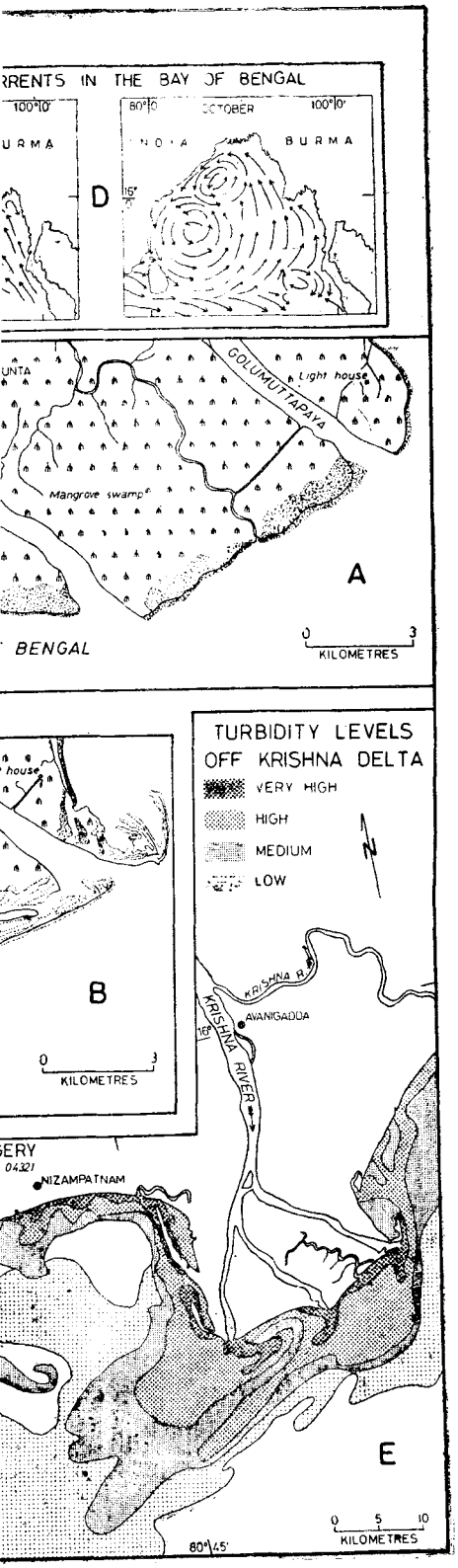


Fig. 1 : Stages in the growth of spits and bars in the Krishna delta front.

side, enclose lagoons of considerable extensions which are being filled by the sediments brought in through tidal creeks and by current. The simultaneous growth of mangrove holds the sediments. The progradation of the Krishna delta is mainly in this type of spit-bar-lagoon development and subsequent lagoon filling, at least during the Holocene period,

Cyclones cause a major havoc to the deltas on the east coast of India. They are, in this part, most devastating. For example, the recent cyclone of 19th November, 1977 was accompanied by extreme high tides which swept across the Krishna delta coast (limit of the tidal wave is shown in Fig. 1 in the location map) resulting in a great loss of life (about 10,000 persons and even more number of cattle died), and property.

A close comparison of 1968 and March, 1978 configurations of the coast (Fig.1B & C), shows not only the addition of new landmass on the westernside of the area, but also removal of landmass on the eastern side. The latter was mainly due to the cyclone.

The cyclone also opened up new tidal inlets, for example, the tidal creek near Machilipatnam (Fig. 2D). Study of toposheet of 1938 (Fig.2A), Naval Hydrographic chart of 1962 (Fig.2B) and airphotos of 1968 (Fig.2C) and 1978 (Fig.2D) shows successive stages in the migration of mouths of the inlet. The mouth of the inlet which was almost east of Bandar Fort was constantly being pushed towards the north by the growth of a spit across it each time. The recent cyclone created a new opening for the inlet east of Bandar Fort which has educed the navigation distance for boats by

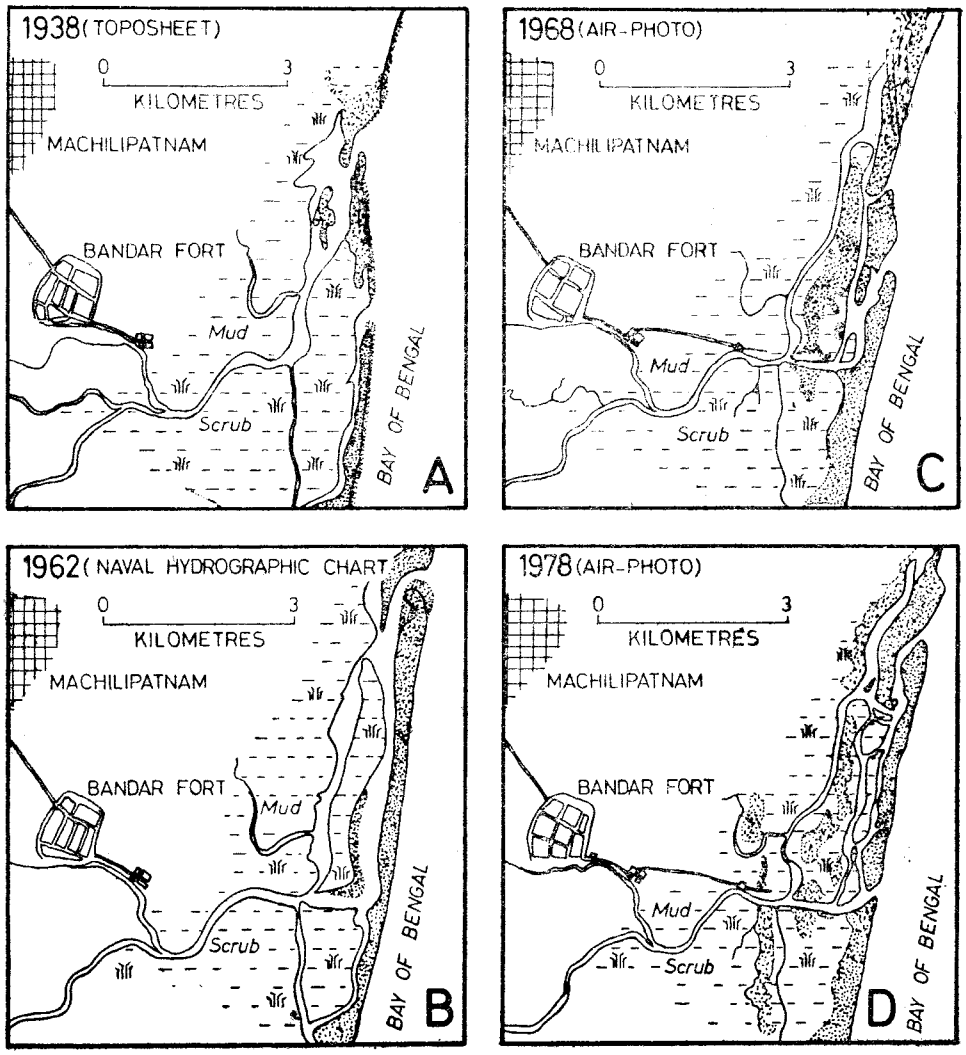


Fig. 2 : Stages in the evolution of coastal landforms near Machilipatnam in the Krishna delta.

about 2½ km. Perhaps, this is the only benefit, the area received due to the Cyclone! It is not unlikely that again a spit may develop across the mouth and push it towards north as has happenad in the past. This is evident from the positions of the three previous entrances of the inlet which are parallel to each other and to the coast, seperated by sand ridges. This growth of the spits/bars across the inlets is due to sediments discharged by the distributaries of the Krishna river, being pushed up by the littoral currents moving north along the coast here.

Conclusions

Study of the coastal parts of the Krishna delta has revealed new landforms whicq have not been hitherto described and accounted for. A comparative study of the

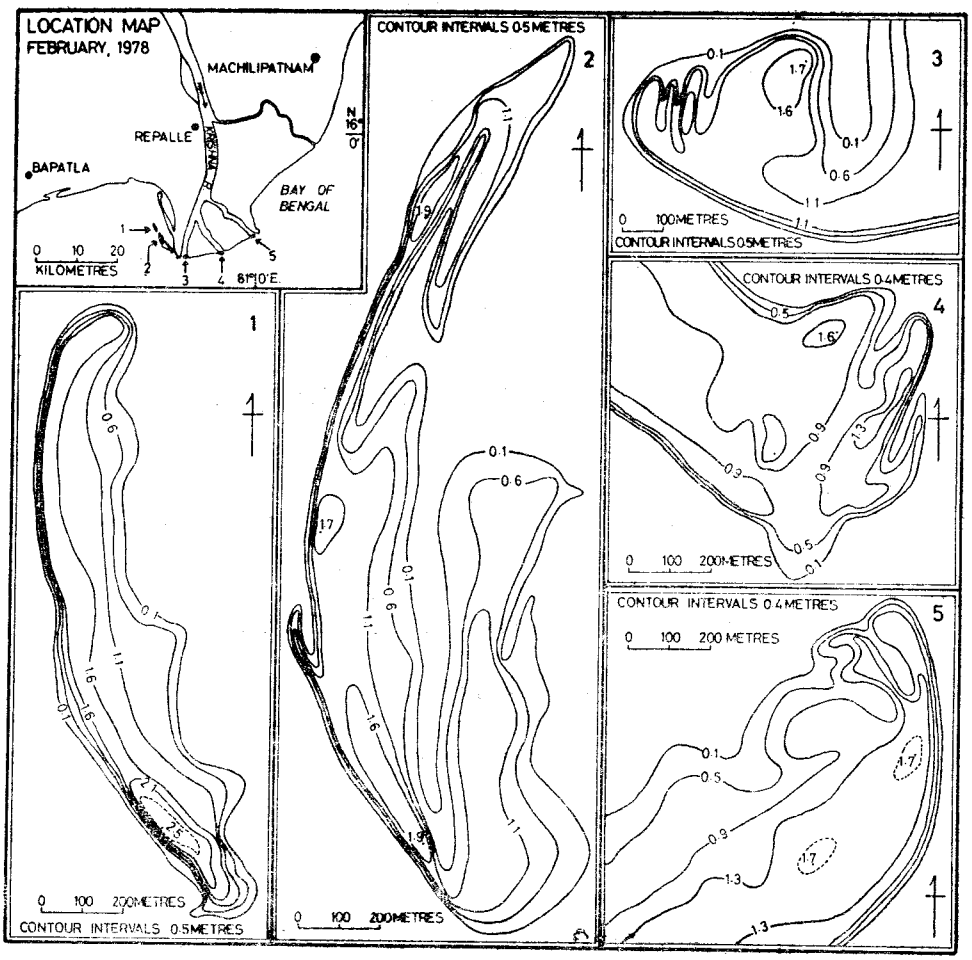


Fig. 3 : Forms of parts of the spits in the Krishna delta front.

previous records in the form of toposheets and aerial photographs makes it possible to arrive at the stages in the growth of landforms, at the delta front.

Provided that there are no major cyclones checking the normal growth of Krishna delta, the lagoon which is enclosed by the bar on the western side of the delta is going to be filled up very soon, and mangrove vegetation will occupy thus-formed delta area. The second spit further south will develop into a bar in course of time enclosing a lagoon.

Besides this lagoon filling, thc inter-distributary coastline also will be advancing south as has been in the past, due to accretion of material and subsequent sand ridge development.

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Addresses of the authors

1. K. Nageswara rao, ONGC Fellow, Andhra University, Waltair
2. R. Vaidyanadhan, Professor & Head, Dept. of Geography, Andhra University, Waltair