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# LANDFORMS IN THE LOWER GANGA BASIN

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ABSTRACT : The Lower Ganga Basin is, in fact, a structural basin. Encased by a rim of hard rock formations, the basin has been in-filled by alluvial deposits brought mostly by Ganga and its tributaries. The different stages of its formation, its morphological charcteristics, patterns of landform, drainage network and denudation chronology, role of the fluctuating pleistocene shore line etc. are the various factors that have been studied. Theories and views expressed by various workers on the above aspects pertaining to the region have been analysed and some observations of the present author have also been included.

The course of the Ganga takes a bend south eastward near the Rajmahal trap formations making-up Rajmahal Hills in North Bihar and weaves a distinctive pattern very different from the rest of its course. This, in fact, is the Ganga Delta area, perhaps the largest in the world and is a well demarcated phase in the spread of the Ganga over the entire lengh of North Indian Plains. The area influenced by the Ganga just after its diversion north of Rajmahal Hills can, therefore, be termed as Lower Ganga Basin.

The Basin is encased by a rim of harder formation,—Archaean Granitoid Plateau interspread with Gondwana sedimentaries and Rajmahal Traps in the west and its northern frontiers merges imperceptibly in the Brahmaputra plains A sizeable belt of Lateritic-Ferralitic formations encloses the Basin all around, occupying continuous stretches of surfaces with distinctive physiographic characteristics. Popularly known as Rarh Plain in the western edges, Barind in the north, these formations take the shape of edges, as it were of the Ganga Delta. Within this physical frame work, the Ganga Delta with its intricate patterns of streams ond tributaries, flat monotonous plains, interfluvial whale backs, levees and marshes, has stretched itself.

The Lower Ganga Basin is, in fact, a structural basin as well. Core samples of bore holes taken at different points of the basin and the structural trends of the formations at the edges of the basin indicate that the extremely thick (1500-2000 m) alluvial deposits of the present day has resulted from in-fillings of a geosyncline. Extensions of the Archaean formations in the west along with lava flows make up the base of the Geosyncline.

The Lower Ganga Basin with broad characteristics as enumarated above had been attracting the attention of Geologists and Geomorphologists who have studied the basin from various points of view. An important work on the area is that of K. Bagchi ( 1944 ), emphasis of his study being on the physiographic expressions of the different stages of delta formations. This was preceded by an analysis of the River Systems of the region by S. C. Mazumdar ( 1942). A systematic

study of the Quartenary Geology of the Basin that has influenced the landforms was made by J. P. Morgan and K. G. Mc-Intire ( 1959 ), B. Banerji ( 1964 ) attempted to identify morphological units existing in the region. Some analysis of the sub-surface structure based on core-samples of bore holes and their influence on morphogenesis of the basin was presented by S. Sengupta ( 1966 ). A comprehensive treatment of all aspects of the morphology of the Basin was attempted by S. C. Chakraborty ( 1969 ). The latest wark on Geomorphic mapping of the region based on photogrammetic studies and field work was made by D. Niyogi, Sarkar & Mallick ( 1970 ). Subsequently Niyogi, Mallick and Bhattacharya made a detailed study of the stratigraphy and lithology of the lower ganga basin and the adjoining areas ( 1972 ).

The present paper would aim at making a synthesis of studies made by earlier workers and also put forth some other observations that may add to the existing knowledge of the area.

**Topographic Expression**

Topographically the basin is a continuous monotony of flats sloping gently towards the south starting from an elevation of nearly 30 m at Balurghat Plains it comes down to about 20-25m on the west Bhagirathi Plain leading to as low as 4m south of Calcutta. An east-west cross section of the Basin relicts the same arrangement, the relatively higher lateritic belts with elevations of above 70m yields to the west of Bhagirathi Plains of 20-25m down to the lowest region of 4-6m. In consideration of areal extent the region with the lowest elevation ( 4-6m ) is most extensive and covers a major part of the Basin. It is so very flat that a mere 4m. rise of the sea-level would submerge Calcutta and its environs.

The contrast in the landforms is mainly brought about by the intercation of soil characteristics and the stage of the of the existing drainage pattern. The binding edge of the delta described earlier as Rarh Plain of the western fringe or Barind plain of the north, popularly known in Geologic literature as older alluvium has a rolling topography and a capping of laterites. Erosin has carved out of this plain broad undulations and has given the belt a dissected appearence. The ferallitic content of the soil acquired at places probably by long and continued exposure to sub-aerial conditions, has resulted in the formation of a typical and distinctive character of landform. The east flowing rivers have cut deep into the Tertiary surface, depositing the worked out sediments into their flood plains at various levels producing thereby a set of terraces. This adds to the distinctiveness of the region. Termed as pleistocene uplands by some authors, this has been considerably notched by newer alluvial deposits all along its course. Patches of land beyond the lateritic formations extending up to the River Bhagirathi or the Damodar Plains have also been described as pleistocene uplands ( by Niyogi & others ). This area is distinctive in the sense that fluvial geomorphic features such as natural levees or abandoned channels are relatively few yet has the appearance of a plain formed completely of alluvial deposits.

The scenery changes very much in the Lower Damodar plain or the Lower Rupnarayan Plain where the streams tend to assume a tangled pattem, streams of one river system encroaching upon that of the other, and the usual occurrence of natural levees and man made embankments, intersperced with seasonal or all-weather marshes.

East Bhagirathi Plain, ( termed as old Padma Alluvial Plain by Niyogi ) displays fluvial Geomorphic features that one can expect in an area fomed out of abandoned courses of rivers. Extremely meandering rivers, innumerable ox-bow lakes, marshes and other waterbodies of various shapes and sizes, linear alignment of settlements on natural levees and embankments bear testimony to the fact that the region was subje-

cted to the activities of several shifting rivers to produce a text book example of the landscape of an area of mature shifting rivers. This region thus holds a very distinctive landform and covers a wide area in India and Bangladesh.

The alluvial plains in the northern edge of the basin namely Balurghat Plain and Gaur Plain of West Bengal extending as far as Bogra in Bangladesh provide yet another assemblage of distinctive landforms. Created by the joint action of the rivers Ganga and Mahananda the two alluvial plains are now separated by a north-south running narrow interfluve Bearing elevations of 30-40 m and marks of ancient rivers flowing through various dead or decaying channels, the region portrays the scenery of a mature landscape. The typical natural levees, point-bar ridges and back swamps are there, but the terrace like elevation and separation from the main stream have resulted in a more subdued expression of those fluvio-morphological features.

A series of marshes occuring along east of Calcutta moving east through Jessore, Khulna and Madaripur cover considerable stretches of land. Formed on depressions on the surface, they are more or less permanent features. Very typical of lowland formations these features bring a variety in the scenery.

The intricate pattern of a maze of disjointed islands occurring in between courses of drainage channels form the southern coast-line of the basin and is a very typical land-form of deltaic formations. Most of the islands have a substantial part clothed with mangrove forest, which covers up the low marshy character of the land that they support. In high tide a major portion of the land gets sub-merged, giving the area the appearance of a vast sheet of water with trees propping up here and there. Encircled completely with saline water, they present a very grim and desolate surrounding.

The Central Zone of the Delta, the Dacca-Faridpur tract, north of the line of marshes has the look of typical riverine country. The main rivers of Madhumati and Padma drain the area along with numerous tributaries. The tributaries carry lesser volumes of water; but their effect in giving the zone a look of a 'stream in every step' is not in the least minimised.

**Drainage Pattern**

Two distinct systems of drainage have evolved in the region, the most elaborate and dominant being that of the Delta proper and those on the eastern and western marginal lands.

The river system of the Delta has devoloped in between the the two main streams of Bhagirathi/Hooghly and Padma/Meghna which fan out in two directions to form a large triangle with its apex at Gaur and the base spread along the coast line of Bay of Bengal. Bhagirathi / Hooghly is comparatively weaker among the two, both from the point of volume of water and length the Padma / Meghna system dominates, yet topographic evidences and descriptions obtained from ancient scriptures agree to the fact that the Bhagirathi / Hooghly was the original course of the Ganga. Gradual splitting off in its course at the apex of the present delta gave rise to the river Padma. The history of the formation of delta is intimately connected with bifurcation of streams one after another starting at the apex region, the silting up of their channels in due course and formation of fresh channels. The resultant pattern of drainage that has evolved is that of a maze of streams of various magnitudes flowing in several directions, maintaning more or less, a south-easterly trend. The sources of their supply of water are the two main streams. Siltation and the extent of tidal influence has an effect on the flow and vigour of the streams. The drainage density is fairly high. The two rain streams branch off from the Ganga from which they receive their main supply of water. In addition the Bhagirathi/Hooghly receives important tributaries originating in the

uplands and Plateaus of Eastern India. The Padma, on the other hand receives most of the rivers of North Bengal originating in the Himalayas and the mighty Brahmaputra.

Of the streams joining Bhagirathi from the west the most important are Mayurakshi, Ajay, Damodar, Dwarkeshwar, Rupnarayan and Kasai, mightiest and longest among them being the Damodar. The Damodar also forms the boundary between the two systems of tributaries, the rivers north of it have followed an easterly or even north-easterly course to join the Ganga while the Damodar along with rivers south of it follow a southern or south-eastern course. The two different directions of the slope of the land as is apparent from the above perhaps indicate that the two sets of streams were evolved independent of each other and have different histories of formation. The southern group of rivers have played a direct role in adding to and building up the delta. The Damodar is specially notorious for changing its course. Air photo studies reveal that the river, particularly its lower course, has progressively shifted westwards the formation of the Damodar delta has further accentuated the shift towards west. In keeping pace with the shifting of the master stream i. e. Ganga other stream courses got adjusted.

The group of streams joining the Ganga from the west, flow over the lateritic formations and the Pleistocene surface leaving on their courses evidences, in the form of terraces, of changes of their base levels from time to time. The delta proper which is much younger in age in comparison to those rivers was built up gradually. The course of the Bhagirathi / Hooghly had to keep on adjusting itself with the growth of the delta, bringing in turn its effect on the drainage pattern on the pleistocene surface.

The drainage net-work developed on the delta attains the typical pattern of criss crossing channels up to a distance inland where tidal influence is operative. Beyond the tidal limit the streams are narrow and except for maintaining a flow in the south/south-easterly direction, the pattern weaved by them is irregular.

The drainage pattern in the eastern border of the basin is complex. The main stream Ganga or Padma receives the mighty Brahmaputra and the Meghna from north. The trememdous increase in the volume of of water is reflected in the from of very wide channels and the braiding of the rivers. Being under the influence of two mighty streams, bringing varying quantities of water and silt the Padma shifts its course quite frequently. Information available on it reveals that the river shifted both towards east and west in different segments of its course.

Shifting had also been the nature of Bhagirathi. Intense meandering of the main stream and its tributary, the Jalangi from the east with a maze of ox-bow lakes and silted meander channels is very significant. Perhaps this phenomena is an indicator o-the relative maturity of Bhagirathi in compaf rison to other streams of the region. The Jalangi with its tributary, the Bhairab connects the two sides of the apex of the Delta. That this region formed the earliest core of the Delta is also manifested in the drainage pattern developed there and the area adjacent to it moving down the Delta. The river Madhumati perhaps formed the eastern margin of the next significant stage that occurred in the formation of the Delta. The arrangement of streams changes again, east of it in the remaining portion of the Delta.

**The Extension of the Pleistocene Shore line**

Although confirmatory evidences in the form of wave-cut platforms are very feeble, the extent of the sea and its processes of inundation and recession when properly worked out would throw more light on the history of formation of the rivers and their functions in building up the plains. Air-photo analysis of the region made in the National Atlas Organisation recently

revealed indications of estuarine conditions extending far upstream on the courses of some of the rivers of the western uplands. Further investigation of evidences to establish Pleistocene shore line is in progress. Niyogi ( 1972 ) has made an attempt to demarcate the Pleistocene shoreline of the Lower Ganga Basin and has also assigned approximate geological age to the various stages of recession of the Pleistocene shoreline. He endorsed the views expressed by Chakraborty and according to him the laterite formations were the shore lines of the Middle pleistocene sea, the highest level attained in the phases of transgression and regression of the Pleistocene Sea. Correlating the changing character of the surface deposits with the stages of regression he has suggested the extent and boundaries of subsequent shorelines. Evidences of valley cuts and fills along the main river valleys of the region forms the basis of his suggestions.

Inter relation of the main stream of Bhagirathi with the streams existing on the Western stable surface which is much older in age makes an interesting study. The main stream has captured the entire series of the streams from the west which, because of its volume, was in an advantageous position. The two directions of flow of the western group may be indicative of two stages of capture.

**Denudation Chronology**

Before making any attempt to analyse and establish the denudation chronology of the area, the various processes that have acted at different stages and at different times in evolving the Lower Ganga Basin of today need be understood.

The Region is made up of a relatively stable and older landmass juxtaposed with a wide and extensive structural basin that has undergone several tectonic movements. Recent geophysical measurements and deep bore-hole studies have thrown some light on the depositional and tectonic history of the basin. Both the eastern and western margins of the basin are lined up by a series of faults which again endorse the structural movements that took place at different periods.

A study of the core-samples of a wide range of locations in the basin has enabled the geologists to establish the history of the formation of the basin from the late Jurassic early Cretaceous age. The most significant events, of course, have been the major tectonic movements occurring in the region during Mid Miocene and early Pleistocene periods causing subsidence and emergence of a substantial portion of the landmass synchronising with the active and stillstand periods of the abve trectonic movements. The deposits, therfore, were both of marine and estuarine condition later stage. Upward movement of the land mass at which gradually yielded to the more predominant fluviatile depositional agencies at different stages of formation is well recognised; the elevated tract of Madhupur, an area of about 1600 sq. miles north-west of Dacca, bear testimony to one of those movements. It is estimated that during early Pleistocene times only some deeper parts of the Bengal Basin experienced shallow marine coditions complete recession of the sea from the entire area probably occurred in late Pleistocene.

The lateritic platforms that almost form a rim round the Lower Bengal Basin represent a very significant stage in the evolution of the Basin. They are of higher elevation with a more mature and dissected appearance and have so close affinity in their lithologic composition that one tends to believe that they were once lands connected to each other. Chakraborty ( 1968 ) believes that these landmasses, Rarh tracts of west Bengal and the Barind plains of the north once formed the coast line of Pliocene Sea. The laterities of Midnapur and Burdwan show fossil evidences of Miocane age. Chakraborty is inclined to treat the lateritic formations as major agencies in shaping the post-Pleistocene surfaces of the

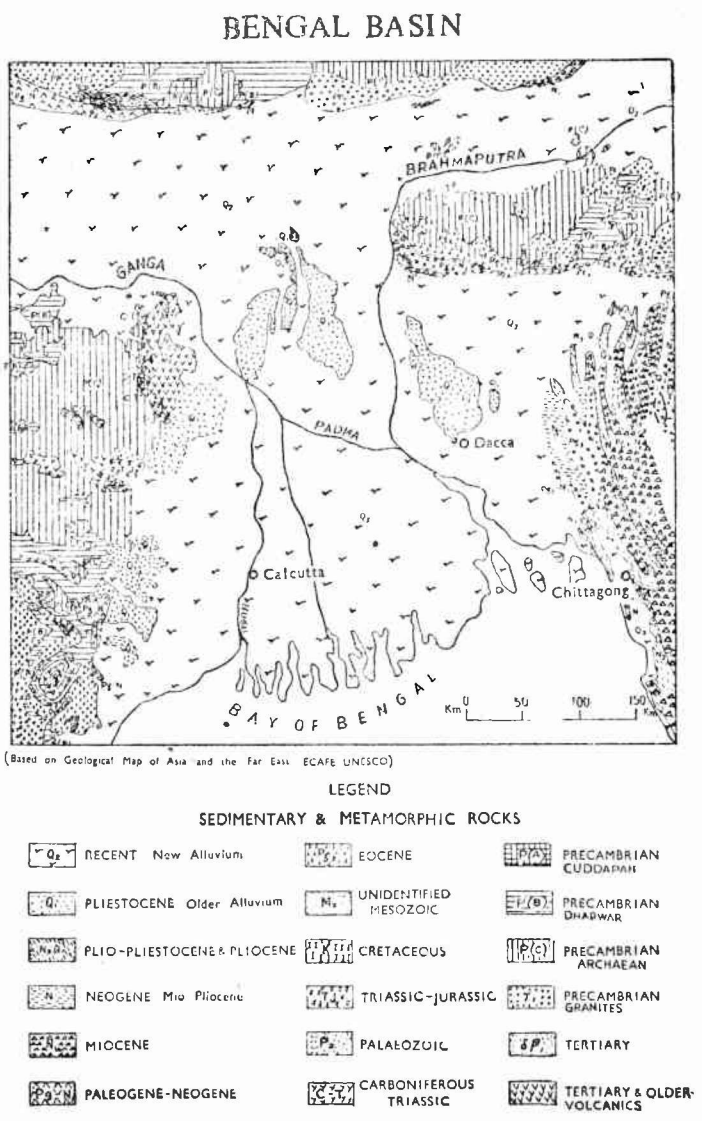


Fig 1

entire region. These land forms he envisages subdivided the Bengal Basin in the late Pleistocene period into three broad tracts, each supporting a local base level of erosion having limited points of contact between them These were–

(a) The North Bengal unit existing between Himalayan foot hills and the Barind.

(b) The Sylhet unit covering Assam Hills and Naga Lusai tract.

(c) The South Bengal Basin having an open sea in the South.

The spatial distribution of these regions justify their separate evolutionary histories but how far the lateritic landforms were effective in keeping them disconnected with each other is perhaps to be examined in more detail.

The Rarh tracts of West Bengal stand out as a surface that enjoyed sub-aerial conditions for a length of period only next to

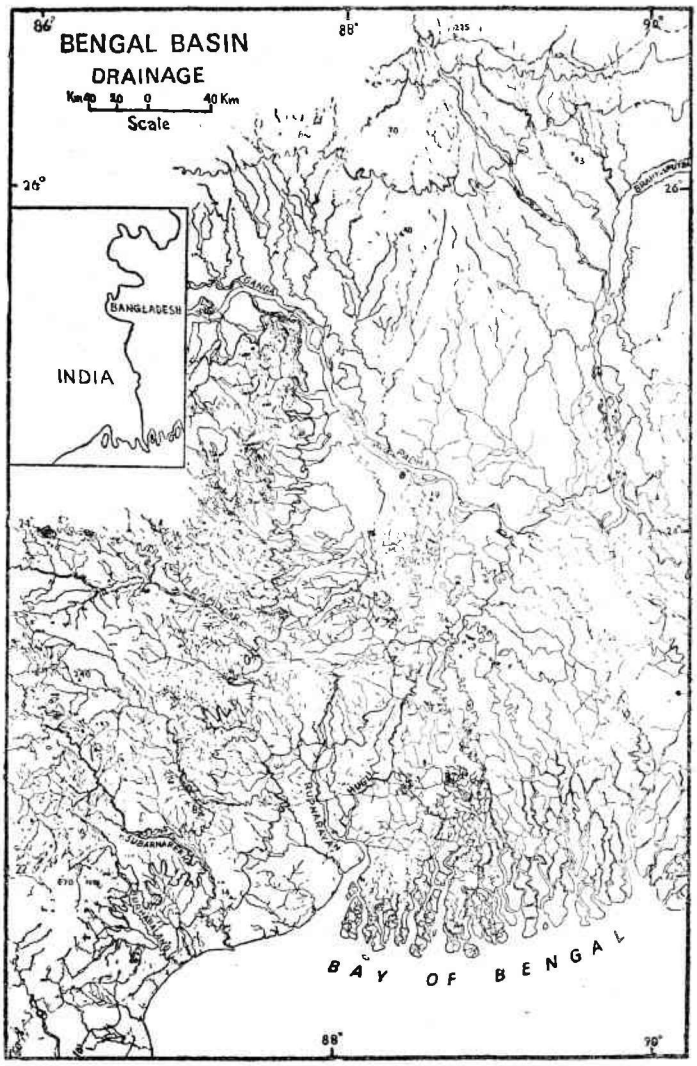


Fig 2

the lateritic formations. Their relative maturity in comparision to the recent deposits on the Delta, with higher elevations and broad undulations ascribe to them a distinctive position.

It has been established that the Delta has been formed out of the joint action of the riverine and marine agencies. Riverine action would only be operative when the marine influence ceases or is reduced to insignificance. In this region that had oscillating phases of transgression and regression, the mode and the period in which the final recession of the sea took place would determine the ultimate character of the landform. From the general south-east north-west axis of the delta, it may be surmised that the building up of the same conformed to that axis. There is general agreement on the proposition that in early Pleistocene time most of the Basin except some deeper pockets were free from inundation and that complete recession took place only in late Pleistocene. The present

day drainage pattern is, therefore, a devolopment on the late Pleistocene surface. As described earlier, the region had experienced tectotnic upheavals on several periods, the last significant one being in nearly Pliocene which again must have disturbed the land-sea relation and the drainage base levels. The main builder of the Delta, the Ganga, could perhaps exert its full influence only after late Pleistocene. The Indo-Brahm river of the Teriarty period as described by Pascoe could only be diverted to this direction perhaps in Pliocene.

The Delta region as it appears today seems to have been formed by fusing together several other river deltas in addition to that of the Ganga which formed independently. Thus the deltas of Rupnarayan and Damodar in the west merge in to the main delta of Ganga, the deltas of Meghna and Dhaleswari, join it from the east, of course, which of these came first is difficult to establish.

The shallow continental shelf, the tidal influence acting for upstream and heavy silting of river mouths indicate that marine deposits have a part to play in building the delta. Extensive marshes starting form near Calcutta through Jessore, Khulna and Madaripur which are evidences of gradual elevation of the delta are quoted by some authors to form the limit of and building by estuarine fluviatile agencies. These are in fact depressions on the land surface and since drainage channels flow across them and adjacent lands down to southern region, these can not be taken as the margin between the two systems. The chronology of denudation can only be worked out with some accuracy on the uplands west of the Basin. Detailed maps or air-photographs are not available for a major part of the Delta, neither for the lands bordering its eastern frontiers to facilitate working out the chronology.

As described earlier the belt of lateritic-ferralitic formations forming the rim of the Lower Ganga Basin is the highest and oldest surface of the region. The lateritic uplands in West Bengal, Barind in North Bengal and the Tripura upland lateritics, occurring at elevations of 250–300 metres with accordant summits at places are lands having longest periods of sub-aerial denudation, and they stand out as holders of oldest surfaces of the area.

The Rarh plains, the older alluvium of Geologic literature comes next in sequence. With elevations of nearly 250 metres, its spread is rather patchy. The colour of the soil, its texture and composition and the gently undulating landform that it produces make the zone all the more distinctive. Rivers flowing through the zone cut terraces at different elevations. Niyogi has identified four stages namely 75m, 61m, 79m, & 34 m. terraces. Interpolation of those levels to the surrounding area might provide some clue to the erosion stages. The oldest part of the Delta, the Malda-Gaur region with elevations of 30–35m is perhaps the next surface that attracts attention. Terraces have also been demarcated of the landform exising here which indicate its relative maturity over the rest of the Delta.

Studies of the Quartenary geology of the Lower Ganga Region with special empahsis on stratigraphy and deppsitional characteristics made by Niyogi and his associates (1972) have enabled them to demarcate four stages in the formation of the deltaic plain namely (a) Laterite formation (b) Old delta plain formation. (c) Young delta plain formation (b) Recent formations. The lay out and orientation of the formations maintain a general north east–south west trend and their limit lines are in sympathy with the present day coast line. The morphological analysis and the gelogical history of the Bengal Basin fairly corroborate with each other to indicate a chronology of events in the evolutionary processes that have acted in giving the Basin its presnt shape and form.

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