CHAPTER-III

GEOMORPHOLOGICAL PROCESSES AND FORMS

Introduction:

The evolution of every landscape depends upon the action of the endogenetic processes through there are further perceptible effects of the exogenetic processes. Though Davis in his cycle concept advocated the role of exogenetic processes exclusively in the evolution of landscape with possible interruptions of endogenetic ones and also Penck on the other hand considered the evolutionary processes of landscape in the light of the concurrent phenomena of both of them. The entire landscape evolution theory is deducted on such principles.

A proper evaluation of the geomorphic processes is the fundamental key to the understanding of the landforms. By the term, process includes all the mechanical and chemical weathering processes and all the erosional and depositional phenomena by which the earth's surface undergoes modification. These processes broadly coincide with the major climatic zones with the assemblage of some distinct types of landforms. "Individual landforms of the earth's surface, however, are the result of exogenetic processes, caused by climatic conditions and ultimately by solar energy".¹ But within the system of assemblages of landforms dominated by distinct climatic characteristics all

the geomorphic processes are not of the same importance. Some of them are the wide-spread and intensive processes largely dominating the landform characteristics to which Tricart and Cailleux (1973)\(^1\) used the term "dominant processes" and they are accompanied by some "subsidiary processes". If we investigate a small unit, the climate varies little and the variation of the geological formations and relief especially slope and aspect largely affect the processes.

The study region lies in the tropical humid climate dominated by monsoon rainfall. Regarding the major geomorphic processes in such climatic zones Bödel (1948) includes the area under the sheet wash zone\(^2\) and Peltier (1950) under the zone of moderate chemical weathering.\(^3\)

Though the concept of a tropical zone with an exclusive group of distinctive weathering processes has not been supported by many schools of thought\(^4\), detailed study of the geomorphic processes in the tropical zone have been carried out by C.A. Cotton (1961)\(^5\), M.F. Thomas (1974)\(^6\), C.P. Morgan (1976)\(^7\) and others. The

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2. Bödel, J. (1948) - op. cit., p.114, fig. 7.1.
characteristics of the tropical humid region have been reflected in the typical denudational processes, manifested in the weathering profiles and other geomorphic features. The different geomorphic processes in the tropical humid region identified by the above mentioned authors are chemical and mechanical weathering processes, laterisation, mass movement, fluvial erosion and deposition, slope wash, rill and gully erosion etc. In the present study, we observe that among these processes, some are dominant in a particular geological, pedological and tectonic settings while the rest are subsidiary and vice versa (table 27).

Geomorphic processes -

The varied landforms of the Mayurakshi basin such as erosional plain, monadnocks, escarpments, tors, badlands, laterite capped hillocks, terraces, floodplains etc. obviously owe their origin to the interplay of endogenetic and exogenetic processes within the framework of the physical set up and climatic parameters (12).

Weathering -

Though the weathering processes are grouped under the headings of chemical and mechanical processes in theory, but for practical purposes both the processes are intermingled in doing the denudational works.

The study region falls under the zone of moderate chemical weathering. Therefore oxidation, hydration and hydrolysis are the predominant weathering processes here.

1. Ibid.
Different rocks with different resistivity to erosion respond to the chemical weathering processes according to their bonding, internal stress and fracture. Though ordering of rocks according to their susceptibility to chemical weathering is not yet worked out satisfactorily, it is found over the Mayurakshi basin under study that coarse grained granite, Khondolitic gneiss, porphyritic granite and gneiss, dolerite dykes, calc gneiss etc. have generally formed hillocks, while micro-granite, gneiss, para amphibolite, amphibolite interbanded with pyroxene granulite have formed low lands. In case of the latter, the weathering processes are thoroughly carried on resulting in the predominance of Kaolinitic clay in association with iron and aluminium sesquioxides.

The basaltic surface has been weathered to form a clay of montmorillonite group.

As sandstone is made up of the less readily weathered and least easily decomposed materials, the region composed of sandstones are steep-sided hills.

Block disintegrate on and exfoliation of the granitoid rocks are found in abundance on the summits, valley sides and even on the ground surface where rocky outcrops are found. These are the products of both mechanical and chemical weathering.

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Weathering of Basalt (Rajmahal highlands)

The north-east of the dissected upland consists of basaltic lava flows. Although Ollier demands separate type of geomorphic provinces within basaltic areas, it seems that climate is rarely responsible for this variation of landform and the provinces mainly due to the different physical and chemical composition of lava (see ch.II).

The region occupied by the lava flows forms a flat-topped topography with steep scarps and slopes. The character of the lava determines the lines of drainage. The softer lava has been eroded away in many areas of the river valleys and the underlying shales and sandstones are exposed (fig.12). Near Nalhati (Dt.Birbhum) to the eastern part of the Rajmahal the basaltic rocks look as prismatic blocks and the ridge crests of the blocks have a tendency to be rounded in form (plate 1). It seems that this roundness of the ridge crests owes to the humidity of the area. But in the neighbouring areas where columnar joints are prevalent in the rocks (ss ch.II), decomposition leads to the formation of large boulders which hide the underlying sedimentary rocks. "The level land in Moorcha and Mujwa pass is hidden beneath confused admixture of trap and shales."

The soils formed over this basaltic region are clay, clay loam to loam, dark brown to black in colour and present prismatic pod like structure. The clays are generally of the montmorillonite group.


SELECTED WEATHERING PROFILES IN THE MAYURAKSHI RIVER VALLEY

DEPT IN INCH | INCH = 2.54 (CM)
The depth of the regolith varies from 35.56 cm. to 96.52 cm. (fig. 3). This variation is due to the character of the lava. A transformation of basaltic rocks through decomposed rocks and gravels to shallow soil profiles is conspicuous which proves the penetration of weathering in basaltic rocks.

Weathering of the sedimentary rocks of Gondwana formations (Ramgarh hills) -

To the southeast of the Rajmahal highlands, the Ramgarh hills and surrounding region have been formed of sedimentary beds of Talchir, Barakar and Dubrajpur stage. As they consist of different types of sedimentary rocks like white and grey sandstone, white and grey shales, carbonaceous shales, conglomerate, hard quartzose grit etc., their different susceptibility to weathering produces different types of landforms.

"As sandstone is a sedimentary rock composed of material which has already been at least one phase of erosion, transporation and deposition, it tends to be made up of the less readily weathered and the least easily decomposed and hardest to dissolve particles of the original parent rock."¹ But the cement of sandstone is more easily decaying particle than the parent rock.

Under the seasonally wet climate of the Ramgarh hills, the landscape has been intensively dissected by fluvial erosion and isolated hills have been formed. The hills have steep slopes and the rivers cut through V-shaped channels with steep banks (fig. 39).

The red sandy soils have developed over sandstones characterised by coarse & fine sand fractions and the clay minerals being coated with oxides of iron forming a red or yellow or reddish yellow colour. The texture varies from gritty coarse sandy clay to gravelly loam. Considerable amount of gravels remaining from the decayed sandstone may be present in the soil. The C horizon is a zone of decayed parent material with sandstone boulders. The depth of regolith is varying - at Banspahari (P.S. Sikaripara) is 0-17" (0-43.18 cm) and at Ramjan (P.S. Sikaripara) it is 0-12" (0-30.28 cm). At Banspahari decayed rocks are present even in the 4"-17" (10.16 cm.-43.18 cm) section of the soil profile and at Ramjan they are present in the 12"-42" (30.28 cm. -121.42 cm) section (fig.30). This proves that the sandstone does not undergo intensive chemical weathering and can not develop deep regolith characteristic of the tropics.

Besides sandstone, shale is the important partner of the sedimentary group and consists of while and grey shale and carbonaceous shale. As the rock is impermeable, weathering is intense only on the surface, but with the prevalence of joints and cleavage weathering penetrates down the profiles. In the study area, the Gondwana beds including shales have some inclinations and the edges are almost exposed to water penetration. The soil profile at Manasapahar (P.S. Sikaripara) developed on shale shows depth of regolith upto 11" (27.94 cm) (fig.30) and soils developed are loam and silty loam PH increases form 5.6 to 6.2 with depth.

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1. Ball, V (1877) - op.cit., pp.175-205.
In the Ramgarh area, conglomerate consisting of quartz pebbles are resistant to weathering and those with the decomposed feldspar let the pebbles readily scatter out.

Weathering of Granite rocks (Dissected plateau) -

To the west of Mayurakshi basin, the dissected plateau and the residual hills consist of Archaean rocks (see ch.II). Among these Archaean rocks granite and gneiss are most common which by mineralogical composition and structural variation, comprise of biotite granite-gneiss, sillimanite granite-gneiss, hornblendse gneiss etc. When the accessory minerals are orthoclase, microcline and muscovite, the rock is very resistant to chemical decay, but those with feldspar and biotite are susceptible to weathering, while those containing olivine and hornblende are prove to deep weathering.¹

Joint Patterns of granite -

Associated with the intrusion of the mass and with its cooling and later during the tectonic movements characteristic joint pattern develop.² The granite-gneisses of the Chotanagpur region has gone thørough at least three phases of deformation leading to the development of a number of joints and fracture lines over the Archaean terrain (see ch.II).

These joints are of several types - (1) vertical joints which divide the rocks into blocks; (2) Pseado bedding

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². Ibid.
planes\(^1\) and sheeting or curvilinear joints which develop generally as a result of unloading.\(^2\) It seems logical that simple unloading is not sufficient to account for curvilinear sheeting and sheeting appears as a result of compression and tension of rocks resulting from climatic phenomena. But the present day weather conditions alone is not sufficient to promote such type of weathering and the climatic changes through the long geological periods with alternate heating and cooling is mainly responsible for such type of sheeting. (3) Different textures and tiny faults develop 'Potential joints as described by Chapman.\(^3\)

The alternation of granites -

Granitic areas of the Mayurakshi basin are characterised by deep regolith, tor formation, residual hillocks and particular type of soil formation predominantly laterisation.

(1) Differential weathering -

Differential weathering on the granites and granitoid rocks of varied texture result into a number of residual hillocks of varied shape and dimension. In the upper catchment of the Matihara basin coarse grained granites and granite-gneissic rocks form the residual hillocks like Trigkut Pahar (467.56 mt), Asnaha Pahar (394.72 mt), Gidharia Pahar (357.53 mt) etc. The

\(^1\) Bhattacharya, B.P. (1975) - op.cit., pp.41-47.
\(^3\) Chapman (1978) - 'The control of jointing by topography' in J. Geol. 4,552-8.
The same rocks formed conical hillocks in Dhobhi river basin which are Harida Pahar (294.74 mt.), Lagwa Pahar (457.81 mt), Makarkenda Pahar (482.19 meter), and Kajwa Pahar (413.00 mt). In the former river basin Tilsuri Pahar (310.59 mt) is formed of para amphibolite and the hillock (361.49 mt) near Dumri of Khondolitic gneiss. In the Sapchala-Satgarh range porphyritic hornblende and porphyritic gneiss have formed hills with steep slopes, while rounded hills are made of amphibokites interbanded with pyroxene granite. From Dumka to Ranibahal granite-gneisses formed several conical hills.

(2) Tor formation -
"Tors are isolated masses of rock consisting of either a single or of numerous joint blocks displaying varying degrees of angularity and roundness".1

In Mayurakshi river basin with the predominance of granites and granitoid rocks, tors are common features of weathering. Tors are common on the grounds and on the summits. The relative relief of the Dumka where tors are studied, is 100'-200' (30.48-60.96 m) and the blocks are of 10'-15' (3.05-4.57 m) height and width. The ground tors are piles of angular blocks resting on general peneplain surface.

The presence of the joint system and the susceptibility of grants to chemical alteration are key to the understanding of the formation of this controversial landform. There are many theories which throw light upon the formation of tors. Among these the most important is Linton's "two stage process theory, 1 - rotting of rock by chemical weathering and exhumation of rock decay by running water. Gibson (1981) shows a strong correlation between joint alignment and tor alignment. 2 The development and behaviour of the 'Granite tors in the Sudeten Mountains' are in accord with Linton's theory. 3 It is also found that in the aforesaid region the growing density of tors varies positively with that of the river valleys. 4

Though tors are not always confined to any particular type of rock formation, most of the tors in the Mayurakshi basin are found on the granite rocks. The abundance of feldspatic minerals, presence of joints and the susceptibility of the rock to both chemical and mechanical weathering offer ideal conditions for the tor formation.

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EVOLUTION OF TOR
(A SCHEMATIC DIAGRAM)

A. Joints have been extended by shearing & tensional forces, during the earth movements.

B. Ground water penetrates through the joints and the rocks are rotted to a greater depth.

A. Due to tertiary earth movements and prolonged weathering processes, pre-existing joints are accentuated and formed disintegrated blocks.

C. River valley formation.

B. Emergence of joint blocks as a result of ground surface lowering and removal of debris by surface wash and rainwater.

A & C. Tors comprised of blocks exhumed from regolith following further surface lowering.

B & D. Partly modified form of Linton's model.
Stages of evolution (fig. 31) -

1. The vertical and curvilinear joints have been extended by shearing and tensional forces during the earthmovements.\(^1\)

2. Ground water penetrates through the joints and the rocks are rotted to a greater depth.

3. The Tertiary earthmovement results into accentuating the disintegrated blocks.\(^2\)

4. The removal of debris by rainwash and running water and the tors are exposed.

The situation of the ground tors of the Mayurakshi valley advocates in favour of the 'two-stage theory' of Linton. They often appear on level surface of hard granites. Their walls rise abruptly above the surface. There are evidences of stripping of the rock rubbles and regoliths (Plate 3). But the weathering profile around the tors at Patabari (near Dumka) does not indicate any type of deep regolith formation. Here, at 0-7'' (0-17.78 cm) depth of profiles the soil is loamy sand. From 7'' to 40'' (17.78 cm-121.92 cm) decomposed rocks are present with 10% soil and at 40'' to 50'' (101.6 cm-127.0 cm) only decomposed rocks are present and so on (fig. 30).

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Development of soil as a weathering product on the
Archæan rocks (table - 23, 24)

As "there is no generally agreed distinction between weathering and soil formation"\(^1\) and the process of their formation are related to each other, weathering of the rocks can not be studied without taking account the study of the soil profiles.

Soil profiles developed over the micaceous quartzites, schists, phyllite, hornblende schist and gneisses are red and yellow soils (see Ch.II). The surface horizon of the soil has a yellowish red, yellow or red colour and the texture varies from loam to silty loam. The B horizon has a yellow to red colour and blocky structure, soft nodular iron may be present in this horizon.

The red soils are generally derived from granite, granitoid gneisses and quartzites. The red soil group has subdivisions according to topographical sites-gravelly soils on the upper slopes, sandy soils on the medium slopes and loamy soils on the lower slopes (see Ch.II).

Laterisation -

The main soil forming process of the region, laterisation is associated with high temperature and high humidity but a pronounced drought condition for a part of the year. Laterite may be defined as "a compact to vesicular rock composed, essentially, of a mixture of hydrated oxides of aluminium and iron with small amounts of manganese, titania etc."\(^2\) U.S. Department of Agriculture

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\(^1\) Ollier (1974) - 'Weathering', p.135, ELBS
gives the definition of the lateritic soil as the deep red soil having very thin organic layer resting upon highly weathered mineral, relatively rich in hydrous alumina or iron oxide or both and poor in silica.¹

The granitic-gneissic and basaltic rocks of the plateau to the west have undergone a long period of latosolization giving rise to the extensive lateritic soil zone.

The high rainfall helps the solubilization and leaching of the silica from the profile leaving a clay enriched in hydrated oxides of iron. With the progress of the laterization, the vegetation begins to disappear which facilitates the leaching process and removal of humous.² "The high temperature prevalent in the area subject to dry and wet climates cause a dehydration of iron and aluminium rich clay which tend to harden to differing degrees of hardness."³

The lateritic formations are commonly associated with the following types of landforms :-

1) The highly weathered gneissic plateau,
2) The high ridges and slopes between the river valleys.
3) Over the lower terrain of older alluvium and Tertiary formations.

Due to prolonged erosion, the laterite over the plateau area composed of igneous and trap rocks have been eroded and carried

² Banerjee, B. (1964) - 'Soils of West Bengal, in G.R.I. Vol. 26, No. 3.
VARIATION OF SAND, SILT & CLAY WITH DEPTH IN SOIL PROFILE

**DT. BIRBHUM [PLATEAU FRINGE]**

- **Dhana (P.S. Sainthia)**
- **Layek Bazar (P.S. Bolpur)**
- **Nalharti (P.S. Nalharti)**

**DT. MURSHIDABAD [ALLUVIAL PLAIN]**

- **Kasipara (P.S. Bharatpur)**
- **Bhandara (P.S. Kandi)**
- **Rohena (P.S. Barwan)**
FIG No. 32

VARIATION OF SAND SILT & CLAY WITH DEPTH IN THE SOIL PROFILE

JALBE SERIES

MAJIHA SERIES

PARKHETA SERIES

INDEX

- - - - SAND

- - - - SILT

- - - - CLAY

VILL. SEMARIAS
(HILL SLOPE)

VILL. BARATANR
(FOOT HILL)

VILL. PHARASIMAL
(FOOT HILL)

MAYURAKSHI SUB CATCHMENT IN DUMKA MUFA SIL (Plateau)
VARIATION OF SAND, SILT & CLAY WITH DEPTH

FIG. No. 32

PUGWAR SERIES

VILL. NAWADIHA (MEDIUM SLOPING LAND)

SAND SILT & CLAY IN PERCENTAGE

VILL. SABA L PUR (LOW LYING LAND)

SAND SILT & CLAY IN PERCENTAGE

VILL. MURTANGA (RIVERINE ALLUVIUM)

MURTANGA SERIES
away by the running water, wind etc. and deposited over the lower terrain of the older alluvium and Tertiary formations which are again cemented to form a compact mass. Thus there are high level laterites resting on the igneous and metamorphic rocks at whose expense they have formed and low level laterites over older alluvium and tertiary formations, "formed in the usual way of detrital deposits."  

**Weathering Profiles**

The weathering profiles show a change from bed rock to decomposed rocks ultimately to soils. In some places weathering penetrate to a greater depth, at Paharudih (P.S.Raneshwar) semi decomposed rocks are present at 38" (96.52 cm) to 68" (172.72 cm) depth and so on. But in some areas the profiles are shallower, e.g. at Naya Para (P.S.Raneshwar), 0-3" (0.762 cm), is gravelly loamy sand, at 3"-19" (7.62 cm-48.26 cm) morrum of quartz and feldspar and at 19" (48.26 cm) to 52" (132.08 cm) bed rock granite is present. The profile at Kuspahari (P.S.Sikaripara) presents an ideal picture of transformation of bed rock to soil —

**Table - 13**

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Texture</th>
<th>pH</th>
<th>Permeability</th>
<th>Water table (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-17.78</td>
<td>Loamy sand</td>
<td>6.0</td>
<td>0.2</td>
<td>Wet-sun</td>
</tr>
<tr>
<td>17.78-35.56</td>
<td>Sandy loam</td>
<td>6.4</td>
<td>0.2</td>
<td>17.5—63.58</td>
</tr>
<tr>
<td>35.56-82.82</td>
<td>Morrum</td>
<td>6.6</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>83.82-116.84</td>
<td>Decomposed rock</td>
<td>6.1</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>116.84-152.40</td>
<td>Semi decomposed rock</td>
<td>6.4</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>152.40+</td>
<td>Bed rock</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DISTRICT-MURSHIDABAD (Alluvial Plain)

BHARATPUR - P.S.(KASIPARA)

DEPTH IN INCH

R$_2$O$_3$ IN %

(12'92 CM) 48

KHARGRAM - P.S.(ASALPUR)

DEPTH IN INCH

R$_2$O$_3$ IN %

(12'92 CM) 48

BHANDARA - P.S.(KANDI)

DEPTH IN INCH

R$_2$O$_3$ IN %

(10'6 CM) 48

NABAGRAM - P.S.(MABARAKPUR)

DEPTH IN INCH

R$_2$O$_3$ IN %

(12'92 CM) 48

RAHENA (P.S. BARWAN)

DEPTH IN INCH

R$_2$O$_3$ IN %

(12'92 CM) 48

VARIATION OF R$_2$O$_3$ WITH DEPTH
The variation of depth of regolith indicates that depth of weathering is not related with the degree of alteration. The depth of weathering also depends upon the joint pattern of the rocks. In some rocks weathering firstly penetrates to a certain depth following the penetration of water and then extends upwards.1

The texture of the soils on the granite rocks show an increasing tendency on percentage of clay and silt with depth while sand decreases (fig. 32). In the region of granite rocks and older alluvium, the R2O3 is high near the surface and decreases downwards (fig. 3a, b). This is a proof of the laterisation of these rocks.

2.5 Fluvial geomorphic processes -

Although fluvial geomorphic processes have been treated separately in ch. IV, an appreciation of them is necessary in the present context.

The overall landform pattern of the Mayurakshi basin has been resulted from the fluvial geomorphic processes. Over the Chotanagpur plateau comparative higher drainage density forms a large number of ridges and spurs. The river banks are high and steep as a result of degradation. In the plateau fringe area an erosional plain has been formed. Terraces and entrenched meanders are the impact of fluvial erosion over the uplifted surfaces. In the central Mayurakshi basin, flood plains begin to form along a narrow longitudinal zone.

Fluvial deposition is predominant in the lower Mayurakshi valley. The older alluvium zone is the older floodplain of the river whereas newer alluvium is deposited in narrow strips beside the rivers. The rivers moving in a meandering fashion changed their courses leaving ox-bow lakes, meandering scars and forming levees and anastomosing courses. Opinions differ about the formations of the depositional plain. Some attribute the delta building process to be responsible for its formation, though some geologists are not agreeable to this point. Rather they suggest the name "alluvial cone" or "alluvial fan" for this depositional plain of the Mayurakshi.¹ But this sedimentary layer was laid down by the Mayurakshi, Ajay etc. prior to the existence of the Bhagirathi and was deposited in the estuarine, marine and brackish conditions.² These along with the shape of the plain, the absence of a lateritic horizon and the admixture of round pebbles of heterogenous rocks with lateritic pebbles indicate that the landform originated as a composite belt of delta of the Chotanagpur rivers.³

"Amongst these mini-dealas the largest is that of the Mayurakshi".⁴ The zone of the newer alluvium is the moribund delta of the Bhagirathi. The elogated beels have been formed due to the change of river course.

1. Bagchi, K (1944) - 'The Ganges delta', pp.8-19, Univ.of Cal.
2.6 Rill and Gully erosion

Rill and gully erosion is one of the dominant geomorphic processes in the Mayurakshi valley forming bedland topography in several places. Field observations agree with the definitions adopted for the characteristic gully in that they are steep-walled, occur on valley sides, width varies from 0.3 mt. to 1 mt. and depth is greater than 0.6 mt. shape varies from V-shape in the fine textured soils to U-shape in the soils of coarse texture.¹

Gully erosion depends upon several factors,² i.e. (1) the presence or absence of vegetation cover (2) the character of terrain, (3) soil and geology (4) the character of precipitation (5) type of overland flow.

(1) Forest cover resists soil erosion. The canopy minimizes the effect of downpouring, the roots bind the soil particles and the grass cover provides a protective cover of the soil particles.

In Dist. Birbhum and Santhal Parganas deforestation is a problem creating rapid soil erosion. In the Mayurakshi basin the area with natural vegetation is about 12% of the total area. The rate of deforestation in Birbhum is higher than the rate of afforestation (see ch. II). The extension of the cultivated land also exposes the soil to the processes of erosion. High velocity of precipitation during the monsoons causes heavy surface run off which in its turn causes the formation of shallow pits in which erosion is concentrated. When the storms are frequent, the backward erosion causes the extension of the river valleys.

(2) **The character of terrain** -

Over the erosional Chotanagpur plateau, the terrain is undulating. Slope is steep and nearly vertical on the banks of the rivers, roadside and canal banks. Gully erosion is intensive in these areas. Besides these, at the foot hill zones and at the edge of the plateau, gully erosion is intensive over the slopes of more than 40° to 50°.

(3) **Soil and Geology** -

The soil over the Archean terrain and Rajmahal trap are liable to gully and rill erosion because of their chemical and physical characters.

Gully erosion is predominant on the red soil over the granite-gneisses as well as on the laterite and lateritic soils, on the older alluvium and on the sticky clayey soil of the Rajmahal lavas which under the pressure of moisture gives way to gully erosion during the rainy season.

But in the areas of red and yellow soil over the quartzite, micaceous schists, hornblende schists and gneisses over the Chota-nagpur plateau and the newer alluvium of the Gangetic plain gully erosion is absent.

(4) **Effect of rainfall.**

This area is liable to monsoon shower from mid-June to mid-October. Average annual rainfall is 1500 mm. Spatial variation is concentrated in the period of south-west monsoon. The period from April to mid-June is the season of thunderstorm. The effect of heavy shower on the dry soil results into intensive
soil erosion. "The intensity of soil erosion is directly proportionate to the amount of rainfall." The water acting as lubricants moistened the soil particles. The depth to which subsoils are loosened varies directly with the amount of water. Another thing which is important to soil erosion is the nature of precipitation. During monsoon period torrential downpour gives rise to loosening effect of the soil due to the splattering action and the bulk of the water is disposed as surface run off associated with top soil erosion and consequent gully erosion.

**Area of occurrence** -

Throughout the Mayurakshi basin where the slope is greater than 40 or 50, soil erosion is in the form of rills and gullies. The rill and gully prove areas are mainly the riversides, canal banks, road sides having an almost vertical slope. Over the region of coarse grained soil and sparse vegetation two types of erosion take place. In times of heavy rainfall, flat slightly sloping surface is subject to sheet erosion.

Gully and rill erosion is predominant on the banks of Tepra and Siddheswari. Erosion on the bank of the Mayurakshi river upto Dumka. In the region of Rajmahal trap, rill & gully erosion is present on the banks of Dwarka and Brahmani throughout the plateau fringe (Plate -12).

The laterite cover of the plateau fringe area resists erosion. But the rapid destruction of natural vegetation and occurrence of steeper slopes cause intensive gully erosion. It is very severe on the right bank tributaries of Kopai from 23°41'N and 87°37'E and has resulted in a badland topography to the north of Binuria.

CROSS SECTION OF GULLY (ROADSIDE) SANTINIKETAN

I. C.S. AT THE SOURCE

II. C.S. AT THE MOUTH

FIG. 34
Sri Niketan, Surul, Santiniketan and Makrampur. Another badland topography has been developed by the Bakreshwar in between the Ahmedpur-Katwa Rly. line below Labhpur and Bakreshwar. These zones of gully erosion does not cross the 150' (45.72 mt) contour line.

Field investigations show that the picture of gully erosion is now partially different from that which we get from the topographical sheets surveyed in 1922-23. Though in some areas gully erosion has been checked by afforestation, it is found that the banks of canals completed during the completion of the Mayurakshi project is now under rill and gully erosion(11, 12).

Morphology of the gully near Santiniketan(13, 14, 15, 16).

1. Slope of the land - 6°
2. Soil

<table>
<thead>
<tr>
<th>Texture</th>
<th>Percentage of</th>
<th>pH</th>
<th>R2O3</th>
<th>SiO2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand</td>
<td>SiA</td>
<td>Clay</td>
<td></td>
</tr>
<tr>
<td>Sandy</td>
<td>78.41</td>
<td>10.45</td>
<td>11.25</td>
<td>6.0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>35.80</td>
</tr>
</tbody>
</table>

3. Natural vegetation - grass.

4. (i) Width of the gully at the source - Maximum - 4 mt. minimum- 1.7 m
   (ii) -do- -do- mouth " 4.5 " 1 mt.

5. (i) Height of the gully at the Bank of the source - maxi. - 1 mt
   (ii) -do- -do- mouth - maxi. - 0.6 m.

Though the period of maximum gully erosion is during the rains, it is not possible to demarcate any pronounced change of the gullies which the author surveyed during the April with the same observed after the rainy conditions.
EVOLUTION OF GULLIES
(A SCHEMATIC DIAGRAM)

1) DEVELOPMENT OF A SET OF PARALLEL RILLS AND VEHEMENT SOIL EROSION OF THE UPPER CRUST BECAUSE OF SCANTY VEGETATION OR DEFORESTATION.

2) THE PRONOUNCED ENTRENCHMENT OF THE RILLS WITH ITS NETWORK OF TRIBUTARY SYSTEM BY THE PROCESS OF CROSS GRADING AND MICRO PIRACY.
3) Further Valley Enfrenchment and Scarp Retreat

4) Ultimate Formation of Badland Topography

FIG 35 (CONTD)
The origin, headward extension, whole set of consequential changes and adjustments of the drainage basins are dependent upon the dynamics of the rills. Once established, the rills begin to extend their valleys by headward erosion. The largest and the deepest of them is the strongest one and stream capture and micropiracy causes the establishment of the branching system of gullies. By headward erosion they reach the edge of the scarps (plate 12). Now the general tendency is to extend the profile over the water-divides. But different lithology (hard lateritic cap) causes the formation of two different slope of gullies of gullies - one at the slope face and another over water divides where the two slope facets interest a district knickpoint is present (fig. 12).

Deochanda Experiment station of the D.V.C. indicates that the soil loss from 50 ft. long cultivated plots on 2% slope vary from 1 to 14 times according to the farming practices and the splattering action of rain on bare soil is responsible for 80% of soil loss while 20% may be lost during surface run off.1

The process of gully erosion acts over various lithology with degrees of resistance to erosion. But the activities are restricted to the rainy periods only. In the period of rain the gullies carry debris and soil downwards which are made loose by hydraulic action. Gully erosion is predominant mainly on the uplands and erosional plain.

As a result of endogenetic forces plateaus and plains, fluvial valleys and ridges, granitic structural domes, water divides etc. are formed and volcanic eruptions occurred. But their original forms have been modified by denudational processes. Extensive erosional plains, monadnocks, residual hillocks, dissected plateau, deep and narrow valleys, badlands, terraces etc. are the outcome of erosional processes, while depositional processes have formed flat valleys with flood plains.
The morphological forms of the Mayurakshi basin can be divided into:

1. **Degradational features** - Tors, residual hillocks, scarp, erosional plain, erosional slope, v-shaped river valley, badlands, water divides and terraces etc.

2. **Aggradational features** - Laterite capped surface, depositional slope, flood plain, levee, riverine islands, bars and shoals.

3. **Riparian features** - Entrenched river valley with occasional meanders, distributary system, ox-bow lake, cut off, back swamp, abandoned channel and meander scar.

Although the evolution of most of the geomorphic features have been discussed earlier in terms with the geomorphic processes in ch.III or with the analysis of drainage basin in ch.IV, some important features are described below.

**Terraces** -

"River terraces are topographic surfaces which mark former valley floor levels."¹ So they are the products of the concurrent processes of sedimentation and valley side erosion. These micro relief features like terraces and floodplains are produced by the Mayurakshi and her tributaries which are the main agents of erosion and deposition.

The nature of the present terraces suggest the impact of the base level change which resulted into alterations of aggradation and recurrent downcutting particularly from Tertiary to recent period.

A narrow belt of terraces along with narrow floodplain occupies the area of Mayurakshi valley near Dumka. Terraces are also present along the river valleys like Brahmani, Dwarka, Kopai and Bakreswar. Along the Mayurakshi and its tributaries are - (1) Elevated bed rock terraces and (2) a complex of lower alluvial terraces. It is evident that the phases of alternative erosion and deposition have reflected themselves on the alternative downcutting and aggradation in association with the tectonic movements. From the previous study of the geological history, it is seen that this part of eastern Chotanagpur plateau suffered from upliftments, warping and tilting (ch.II). From the long profiles of the rivers we get the idea of the base level changes thereby initiating a new cycle of erosion (fig. no.77). The production of a new base level is responsible for a certain amount of planation upstream thus accounting for the formation of terraces along the Mayurakshi and her tributaries. The rate at which the terrace development has taken place depend upon the resistance of the rocks. The bed rock terraces beside the Mayurakshi near Dumka has formed of hornblende-gneiss uncovering the laterite crust. The gullied surface, the low residual hillocks and the erosional plain around Dumka are the evidences of a prolonged period of erosion.
CROSS SECTION OF THE MAYURAKSHI RIVER (Near Naya Dumka)

SECTION-I

RIGHT BANK

LEFT BANK

LOOSE SOIL
BED ROCK
SAND
SAND
SAND
WATER
WATER
SAND
BED ROCK

LATERNIC PROFILE
WITH RILL EROSION

HEIGHT IN M.

0 20 40 60 80 110 130 150 170 190

HORIZONTAL SCALE 1 CM:10 M

VERTICAL SCALE 1 CM:2 M

FIG. No. 37a
SECTION - 2

RIGHT BANK

LOOSE SOIL

BED ROCK

SAND

SAND

WATER

LEFT BANK

TYPICAL LATERITIC PROFILE

BED ROCK

HEIGHT IN MT.

0 20 40 60 80 100 130 150 170 190 210

FIG. No. 37b

HORIZONTAL SCALE 1 CM : 10 M

VERTICAL SCALE 1 CM : 2 M
The terraces along the river Mayurakshi at Bijoypur Ghat near Dumka are two in number and 0.5 km. long. The terrace No.1 is bed rock terrace of 1 mt. height and the terrace no. II having the same height is one cut through the lateritic crust. From the cross sections I and II along the river Mayurakshi near Dumka, we get the existence of two terraces on both sides of the river which is suggestive of paired terraces (fig. 37). The knickpoint of the long profile of the river Mayurakshi at 300' (91.44 mt) also supports the development of the terraces as a production of downward erosion of the river as a result of base level change. The steep and high banks of the Mayurakshi in this section is also suggestive of the valley entrenchment. Mention should be made of the rapid valley entrenchment of the Brhamani over the trap rocks. Near Masania (87°32'30" E: 24°16'30" N), the river passes over Barakar sandstone and shale while trap rocks rest on both the sides at a high elevation (fig. no. 12).

Alluvial terraces are common along the Mayurakshi and her tributaries towards the lower reaches of the valley which have been affected by regional rejuvenation of the drainage. These low terraces again may be subdivided into (1) upper (2) middle and (3) lower terraces. The landscape of this part of basin represents an erosional plain composed of residual hillocks, intensive gully erosion, rocky outcrops and entrenched meanders.

Along the Kopai valley three terraces (1 km. long) are found, although in some areas their existence is lost due to human
CROSS SECTION OF THE KOPAI

I. AT GOWALPARA

II. AT BALLAVPUR

U.T. • UPPER TERRACE
M.T. • MIDDLE TERRACE
L.T. • LOWER TERRACE
F.P. • FLOOD PLAIN

NO. 36 a
interference. Near Goalpara, terrace No.1, 1 mt. high is formed of coarse sand, No.II has an elevation of 1 mt. formed of alluvium, while terrace no.III of 0.5 mt. height consists of lateritic soil (fig.3). The cross section of the river Bakreswar near Behera shows the remnants of two terraces along the rivers of which the lower one is of 1 mt. height and the higher one of 1.5 mt. height (fig.4). The author has identified the remnants of two terraces along the Dwarka river valley near Margram of Birbhum district. The lower terrace is formed of alluvium while over the higher one lateritic gravels are scattered (plate.16). A flight of two terraces have been identified along the Brahmani river (fig.18).

From these studies it is assumed that the terraces are continuous along the river valleys although they are found as remnants and in many places they are totally absent due to human interference.

The terraces of the lower reaches are the parts of the older deltaic plain and the younger deltaic plain. The upper terrace being a part of the older deltaic plain is composed of older alluvium. The soil profile is mature, highly leached, well drained and of moderate acidic reaction. The colour is reddish. Calcareous and limonitic concretions are scattered over the surface. The lower terrace is formed of recent alluvium and lies within the areas of high floods. The soil is immature, sandy and yellowish brown.
CROSS SECTION OF BAKRESHWAR AT
AT BEHERA, BIRBHUM
These terraces of the lower basin is suggestive of valley entrenchment in the former floodplains. The steep and high banks even at the lower reaches formed due to the valley entrenchment may be attributed to the enhancement of stream energy by tectonic movement.

Mention should be made of the long profiles of the Mayurakshi which is complex owing to the disturbance of a number of breaks (fig. 77). The partial profiles marked by the breaks belong to separate base levels of erosion.

Besides these the presence of terraces along the rivers in Eastern India such as the terraces along the Damodar river valley as identified by Sen (1978) and along the Subarnarekha valley by Mukhopadhyay (1980) supports the rejuvenation either due to eustatic or tectonic changes. Smith (1944) attributes the formation of terraces as the lowering of stream grade by piracy under special circumstances.

**Flood Plain -**

The flood plain of the Mayurakshi in the lower catchment includes most of the features typical of an ideal flood plain (fig.no.36). These are :-

(1) The river channel,

(2) Ox-bows representing the cut-off portion of meander bends,

(3) Point bars

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(4) Meander sears.
(5) Abandoned channels.
(6) Natural levees.
(7) Back swamps.

The channel of the Mayurakshi, now may be called as misfit. The channel is narrow in the wide bed. Even during the rainy season the river flows in a narrow trickle. This owes to the regulated flow due to the construction of the dam at Massanjor and supply of irrigation water through the canals so that the natural channel gets a low discharge (fig. 43). But the river bed much wider in cross section than the present channel bears the evidence of former high discharge.

However the floodplain is associated with the bankful stage. Leopold et al. (1964) observed that with a diversity in physiographic settings and size, most of the rivers enjoy bankful stage at recurrence interval of one to two years.1 The Babla at the outfall of the Bhagirathi attends its highest stage from the last week of August to the first week of October. Although the discharge of the basin is controlled, in 1971 and 1978 it has crossed the flood danger level and during 1973 and 1977 it was at a close proximity to the danger level. (Fig. 45). Flood occurred in the Mayurakshi valley in the years, 1956, 59, 71, 73 and 78 within a period of 1956-78.

Levee

During the flood period the river overflows and stretches the sediment load all over the floodplain. When the floodwater subsides the velocity is much lower than the rising period and only

the finer sediments are brought back to the channel, while the coarser debris are deposited at a distance from the river side to form natural levees. Therefore "the formation of levees owing to the process of accretion of silt is rather the most ubiquitous phenomena, a feature observed along the present as well as the abandoned channels." ¹

Although the man made embankments along the present channel of the Mayurakshi renders the identification of the levees the cross sections of the Mayurakshi and her tributaries in the flood plain area near Kandi show the existence of natural levees (fig. 5.3). The Babla - the united flow of the Mayurakshi, Brahmani and Dwarka has a Yazoo type of junction. The river runs parallel with the Bhagirathi for some 18 miles (28.96 km.) and then meet the later near Ketugram of Burdwan dist. This owes to the existence of levee beside the Bhagirathi river.

Point bar and shoal -

In the lower part of the Mayurakshi and her tributaries, point bars and shoals are found. These are associated with river meandars. In this part, owing to a low velocity of the river the sediments are accumulated at the slack water portion i.e. the convex banks of the channels.

Although these are the features typical of the flood plain of a river, due to the low velocity and flushing nature of the river a shoal has formed in the river Bakreswar at its upper part near the hot spring of Bakreswar (plate 25).

Basu, S.R. (1972) observed a shoal near the concave bank of the Kopai near Taltora near the railway line at the close proximity of Shantiniketan. Though the river has a perennial flow during the rainy season of about 450 cusecs during 1954-55, during the post dam period the two canals carry away 225 cusecs of water regularly during the rains, while the peak discharge is about 225 cusecs. The river cannot carry away the loose siliceous debris which, even can not come to the convex side. Basu holds the view that the formation of the shoal owe to the low velocity and discharge for which the sediments are being deposited where "the impinging turbulent flow collides with the retarded incidental flow."^2

The flushing nature of the river along with low velocity and discharge in the floodplain have caused to form the point bars and shoals. After the construction of the dam and barrage owing to low velocity and restricted discharge, the number of point bars and shoals have increased in the case of all the rivers of the Mayurakshi valley.

**Back-swamp, ox-bow lakes and abandoned channels:**

The ox-bow lakes, abandoned channels and meander scars are associated with the river meanders which have been analysed in details in the section of drainage basin analysis. These are prevalent in the floodplain of the river Mayurakshi and her tributaries and maximum in the valley of Kopai and Dwarka. The north-easterly flowing Dwarka swings to the east from \(87^\circ50'\)E and from this point the river changes its course frequently within Murshidabad and Birbhum


2. Ibid.
districts. The area within these two districts are full of ox-bow lakes and devoid of any route or settlement. After the meeting of Kopai with Bakreswar the united flow called the Quiye Nala leaves numerous cutoffs and ox-bow lakes which point to the intensive development of meandering pattern and shifting of river course (fig.4).

The origin of the abandoned channels owe to the change of course of the Bhagirathi which has shifted the outfall and therefore the distributary channels of the Mayurakshi have changed their course leaving the former one.

A noteworthy feature of the Mayurakshi floodplains is the presence of large bils elongated in a north-south fashion. Among the beels the noteworthy are Hijol, Paton, Belun, Langalhata and Karul. The langalhata is a marshy area between Koiya and Babla at the Birhmun-Murshidabad border. During the monsoon a large part of this low lying area is submerged by water. The Hijol is a saucer shaped depression near the confluence of the Mayurakshi and Dwarka, covering about 130 sq. miles (336.7 sq. km.) and a depth of 6.10 mts., in some areas.

These beals act as flood detention reservoirs. When the Bhagirathi is in flood, the water brought down by the rivers of the Mayurakshi-Dwarka system can not find their way and head up in the Hijol, Belum, Patan, Telkar etc. beels and distributary channels of the Mayurakshi. Thus a number of badk swamp ones have been created in this part of the Mayurakshi valley.