CHAPTER VI

FLUVIAL GEOMORPHIC CYCLE
The fluvial geomorphic processes leave their imprints on the existing landscape and thus help to understand in the construction of development of landforms. The present chapter dealing with the fluvial geomorphic cycle of the Lower Ken basin gives significant clues for the presence of various erosion surfaces and also helps in understanding the geomorphic history of the region. It has already been discussed in the previous chapter that a number of landforms have developed due to the action of the fluvial erosion in the region. The present chapter deals with the various stages of fluvial action and geomorphic cycle. For the better understanding of geomorphic cycle of erosion, it is essential to apply the various morphometric techniques.

Slope Analysis

The slope analysis is one of the important aspects of the geomorphic study. In recent years considerable
amount of work has been done by several geomorphologists on the behaviour and development of slope. The 'uniformation' or parallel retreat school and 'climate control' or slope decline school of thoughts are led by some authors for the evolution of slopes. The slope decline school of thought followed by Davis (1909) emphasises that slope flatness is continuous during the progress of erosion cycle from youth to maturity to old age. According to him the valley sides are reduced under weathering and surface creep to smaller and smaller angles. Penk stated (1924) that steep slopes retreat without loss in their angle and that steepness disappears only when upper part of the ridge is consumed. It is still controversial whether slopes are influenced by parallel retreat or decline gradually with the sequential stage of geomorphic cycle. Penk's ideas were further testified by King (1947) and has stated that in hot semi-arid regions parallel retreat of slope is prominent. King's suggestion is more favourable for slope evolution in the region under study. Ideas very similar to those used by Penk has been formerly discussed by Von Engel (1940), Melton (1960) and Schmunk and Chorley (1966) in the various regions in detail. Keeping this in view, an attempt has been made to analyse the different aspects of the slopes in the Lower Ken basin. The study of slopes can be dealt with in two ways, namely analysis of regional slope of an area and the evolution of hill side slopes.
Regional Study of Slope: The study of regional slope is one of the fundamental aspects of geomorphic research. As a matter of fact slope analysis is the study of landforms. Slope development is the result of geomorphic processes. For the understanding of the processes of land form evolution study and analysis of slopes, their profiles and removal of land-waste across them, is a rational prerequisite. The processes of streams development are also decisive in slope development. A better understanding of topography of a region is provided only by a detailed contour map of the region. From the contour map of the region, steep and gentle slopes could easily be demarcated. The slope maps however, provide a useful visual impression of the geomorphic features and the region may be delineated into different slope categories.

A number of geomorphologists have suggested, various methods of slope analysis, but the contribution made by Smith (1935), Raisz and Henry (1937), Wentworth (1930) are noteworthy. In the present study the method proposed by Wentworth has been used, which properly represents the slope morphology of the area under study. The quarter inch topo-sheet of the basin was used for this purpose. In the present study of slope the base map has been covered with the grids of one square inch and the average slope per square mile has been calculated by the Wentworth's method for each grid of the map.
By looking at the average slope map (Fig. 15) of the basin it is evident that there are marked variations in the degree of slope. The direction of slope has been found from southwestern to north-eastern with a variation in degree of slope. It is noticed that the maximum slope and also variation in slope are found in the south-eastern and south-western part of the basin which is about 5° and above. Traversed in the middle part of the basin is the area of moderate slope, i.e. between 2° and 3° degrees. In the same way as we move to the northeast plain of the basin we get minimum slope or gentle slope below 2 degrees. From the slope map of the basin

The control of lithology and relief may clearly be seen on the map of average slope. The slope have every where been defined in relation to the dips, massiveness and resistance of the associated rock types. Where rocks are dipping and of structurally weak compositions are exposed slopes reced or decrease most rapidly. For example, in the Vindhyan country where soft formation occur, viz. shale are underlaid by resistant rock as sandstone the steep slopes have developed. In addition to the structure the relief is also a controlling factor in determining the degree of slope. Where the relief is maximum the action of weathering and erosion will be more and slopes develope easily. It is clearly noticed in the south-western and south-eastern part of the basin, especially on the Bijawar hills and the Panna range. Thus, it is clear that the slope
is intimately connected with the variation and lithology in the region under study.

As mentioned above, the regional slope of the basin is the results of the fluvial geomorphic cycle of erosion. The analysis of slope has not only revealed some important geomorphic facts of the basin but has also provided rational grounds to believe that the basin has a multi-cycle conditions.

**Superimposed and Simple Profiles**

The superimposed profile was drawn from north-west to south-east not only for the area but for some adjacent areas also (Fig. 16). The simple profiles were drawn in the south to north direction for the region under study. These simple and superimposed profiles of the region are analysed to understand the broad characteristics of the geomorphic features. The analysis of the profiles show that the surface of the region is considerably undulating. The profiles indicate that the surface of the north eastern part of the basin is mostly near flat and the greater part of the region is more or less undulating. If one moves from south-western to north-eastern direction one finds gradually decreasing height. But in the Vindhyan scarp we have found abrupt descent in the southern part of the basin. In the Bijawar hills abrupt descent is also seen in the south-western part. The region exhibits a remarkable concentration of relief in its south-western part, where the relief is found more than 1500'. While in the north-eastern part of the basin relief
is comparatively low and does not increase more than 750'.

The simple profiles drawn astride the Ken in the Panna–Bijawar hilly track reveal that there are well defined scarps (Fig. 29). The highest scarp has developed from 1080' to 1500' elevation in Kaimur sandstone rocks. This is followed by a region of comparatively undulating surface. Coming towards south there is a second scarp between 1650' to 1749' which has essentially developed on Rewa sandstone. Although not very continuous and well defined, the region of the second undulating surface could be seen in the cross-profiles. It is further followed by a third scarp between 1000' to 1500' on the western side of the Ken. It has developed on the Bijawars but in the east it could be identified even in the Vindhyan. This scarp leads to the Chhatarpur upland. Since these scarps are intensively dissected producing a confused mass of hilly country they may not be clearly traced on the contour map but could easily be identified on landsat imagery of the region. These have also been identified in the simple cross-profile.

The superimposed profiles also show the various erosion surfaces which are discussed in foregoing section in detail. From the superimposed profiles it is clear that the area has an irregular and undulating profile due to interruptions in the geomorphic cycle of erosion in the region under study.
Longitudinal Profiles

Longitudinal profiles were drawn for all the main streams of the region. In upper part of the basin the longitudinal profiles (Fig. 17) make it evident that the rivers are good examples of rejuvenated streams. The upper basin of the Ken and its tributaries, therefore provide the index for the morphogenetic complexity in the area. All of the main streams show however two breaks in their curve, one of them is at the 1000' - 1100' and the other one is at 600' - 700'. Here the longitudinal profiles show different erosion surfaces. At the height of 1000' - 1100' the longitudinal profile indicates water falls, due to very steep descents. In the upper basin a number of waterfalls have developed which indicate youthful stage in the cycle of erosion. Being non-perennial rivers in this part of the basin, the water-falls can be seen only in the rainy season, except the Pandwa falls at Panna.

In the middle part of the basin, the longitudinal profile make it evident that the river has reaches the late youth to early mature stage. This point of view is based on the smooth longitudinal profile in this part (Fig. 17). The smooth profile section really represents an area of homogeneous rocks. The broad picture of the longitudinal profiles in the middle part is almost similar but some irregularities are rather more peculiar which are the indications of the work done by rivers.
CROSS-PROFILES OF KEN RIVER
UPPER PART TO LOWER PART RESPECTIVELY

IN FEET
1500
1400
1300
1200
1100
1000
900
S.W.

IN FEET
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
E.

IN FEET
700
600
500
400
300
200
100
0
W.

IN FEET
700
600
500
400
300
200
100
0
E.

VERTICAL SCALE EXAGGERATED BY 264 TIMES

MILE

FIG 1
In the lower part of the basin the longitudinal profiles of all the rivers are very smooth, due to the near flat plain area. This smoothness of the profiles is also the indication of the mature stage of cycle of erosion in the lower part.

**Cross - Profiles**

Cross-profiles of the Ken river were drawn from the beginning of the basin to the lower part of the basin. In the upper part, two profiles (Fig. 19) have been drawn one of them is at south-western to north-eastern direction and the other is at south to north direction. Where the cross-profiles are narrow, deep and have a 'V' shape with steep gradient. Apart from field study evolution of the valley side slopes and height and width of the channel have also been analysed by the cross-profile. At the point, where the Ken enters into the region (79° 55' E 24° 30' N) the valley walls rise like steep walls from bottom upwards. This peculiar feature may also be seen in the gorges of the Barana and Bane rivers. There is much more active weathering and erosion in the upper part than in the lower part.

In the middle part of the basin, the cross-profiles are open and shallow (Fig. 19). The study of the cross-profiles in this part is generally asymmetrical. The development of asymmetry in cross-profiles of valleys is often due to the local topography in the region under study.
The right hand bank of the valley is too open than the left hand side. This unusual profile develops due to boulders or 'tors' in the valley of Ken. In the lower part of the basin cross-profiles are found in symmetrical and open shape due to the near flat plain. Thus the cross-section of valleys is really the expression of the arrangement of the rocks and the age of valley. The intensity of valley widening is dependent on weathering, development of gullies and mass-wasting which are the main geomorphic processes.

Present Cycle of Erosion in the Lower Ken Basin

It is clear that rivers, and all landscape features, are continuously changing. The valleys and related landforms pass through a series of well characterised stages recognized to as youth, maturity and old age. All these stages which are included in this evolutionary development of landscapes is called the 'normal cycle of erosion.' For the better understanding of cycle of erosion, it is divided into three stages as below.

The late youth to early mature stages: In the upper part of the region under study, all the streams as well as their tributaries show an appreciable tendency of eroding power. In the valleys of the bigger rivers the conditions are indicative of the youthful stage. For example, steep sloping valleys of Burana, Barana, Mirhasan, Saimri in cross-profiles indicate the youth stage. It may be observed that in the river valleys very steep slopes are found, and gorges are an indication of the fact that
intense vertical cutting has been done by these rivers. The descent is of 300' in short distance of 23 miles in the Ken river which drains the southern escarpment. Such a descent also indicates that along this zone the rivers have still to work sufficiently to attain the graded condition.

The development of various landforms show that the upper part of the basin is in the late youth. Sharp ridges separated by narrow valleys from the water divides and steep slopes are the main characteristics of the youthful stage. From the map of slope (Fig. 15) it is noticed that in the upper basin there are zones where the average slope is 5° and above. It is evident that the upper part still has considerable local relief. There are two more peculiar features which clearly show the youthful conditions in this part. 1. The drainage texture is fine about 5 streams per sq. mile, than on the lower part of the basin, where less than 2 streams are found per sq. mile. 2. The occurrences of rapids and water-falls do indicate the youthful conditions of the region. It is noticed that there are four water falls of 30' - 160' height on the left wall and another four of 140' to 170' height on the right wall of the gorge of Ken in the upper part of the basin.

As noticed above that the upper part of the basin has attained late youth in the cycle of erosion. By field observation and map study the region seems to have early maturity, but there is unconformity between the streams
and topography. The rivers are most sensitive to any change, which is the indication of rejuvenation, after the establishment of the mature topographic condition in this part of the region. It may be assumed that the post Deccan Trap cycle was interrupted thrice following the subsequent phases of upheaval in the upper Eocene, middle Miocene and lower Pleistocene periods. The rejuvenation gave new erosive power to the rivers and they seem to have gone back to the early mature stage.

We have already described the main characteristics of the late youthful to early mature condition in the upper part of the basin. They may be summarized as follows:

(1) In this part rapids, waterfalls and gorges are marked characteristic features.

(2) A number of small tributaries and gullies are extending themselves by headward erosion.

(3) Narrow cross-profiles with a 'V' shape and at places with asymmetrical shape.

(4) There are no flood plains except in the major rivers.

(5) A very steep descent has been found in the longitudinal profiles.

(6) It is noticed that the valleys have extended themselves and region have maximum relief.

(7) The drainage system has developed in fully conditions and any lakes or waterfalls that existed in youth have eliminated.
(8) Flood plains are found on the major streams.
(9) It is also seen that the master streams have a profile of equilibrium.
(10) The latter are increasingly widened by lateral erosion and meanders are a characteristic feature.

Mature to Old Age: In the middle part of the basin, the gradient of stream is regular and have developed a profile of equilibrium. The cross-profiles of master streams have too open covered with river deposits. In Ken such deposits are particularly large where the river leaves the highland and comes to the valley of the Urmal and Kutni nadi. In the mature stage there are maximum height above the valley floors and the valleys have reached their maximum width in the region. The river has a little erosive power which indicates that the river is in its late mature stage.

In this part some peculiar feature has developed which indicates the mature stage of middle part of the region. These are big pinkish boulders or tors and quartz-reefs or dykes of great topographical interest. Another feature in the middle part of the basin which indicates the mature condition is the presence of moderate slope as well as moderate drainage texture i.e. 3° and less than 3 streams respectively. It is also noticed that the small tributaries are still developing, and astride some rivers.

As mentioned above, the flat-topped hills of smooth skyline probably represent the surface of the ancient
peneplain. But rivers of this part have sufficient erosive power which is the indication of the juvenile character of the streams. Such a condition is found in all the rivers which drain the middle part of the basin, especially in the Urmal nadi.

When one traverses across the Chhatarpur upland down to the alluvial plain south of Jamuna river, one can observed the typical characteristics of a peneplain, the end product of the cycle of erosion. The Bundelkhand gneiss country is a very old land mass and never in its history has been submerged under the sea. Hence all through its geological history it is being sculptured by agents of erosion and weathering. In this region there are gentle undulations and this subdued topography is only dotted by 'tors' and intrusive hills. 'Tors' is a typical landform of gneissic country and could be seen in similar other areas of unclassified granites and gneisses in India. The gentle sometimes imperceptible slopes of barren rock surface and at other places with thin vaneer of soil is the general landscape.

As one moves northwards the country rock slowly is buried under the alluvium. This area again has developed due to the sluggish stream action when they start depositing their load rather than carrying it further downwards. This again could be taken as a characteristics of old age.
Due to the less gradient of streams, longitudinal profiles are very smooth and cross-profile are too open, in the lower part of the basin. The extensive gently sloping valleys of Ken, Kail and Chandrawali nadi in the cross-profile indicate the late mature to old stage condition. In this part power to transport debris decreases and extensive sand deposits are found on the banks and bottom of the streams.

The Rejuvenation: However, this extensive peneplain of the Lower Ken basin could not remain standstill and has been rejuvenated in the recent geological past. Due to this the fluvial erosion was intensified and the intrusions in the Bundelkhand gneiss now stand high above the general land of the peneplain as long ridges. These could be seen all over the peneplain.

Besides, there are other signs of rejuvenation as well. The incised meanders are most significant features of the lower part of the basin. Blache (1939) and Cole (1930) have suggested that incised meanders were inherited from a previous erosion cycle and are second cycle features evidence of rejuvenation.

The incised meanders are most significant features of the lower part of the basin. These could be seen in Ken and Chandrawali rivers. The banks of Ken are 9' to 60' high and of Chandrawali 10' to 50', ravines are developed by flood plain cutting. These are especially seen in the
Chandrawali and Ken river basins in Banda and Charkhari tahsils. Regarding the course of the Ken in this section it may be assumed that before the recent upliftment the Ken had attained mature stage and was meandering freely over the flood plain. But after the last upliftment the Ken has been rejuvenated resulting in the incision of meanders and the development of the ravines. Singh L.R. and Singh R.P. (1961) have already accepted this statement, in the study of Chambal ravines. Thus, extensive region north of Panna- Bijawar range may be taken as a good example of the uplifted peneplain.

As mentioned above, the main characteristics of mature to old stage of the rivers, along the lower part of the region; they are summarized as follows:

(1) Valleys are extremely open and gently sloping both laterally and longitudinally.

(2) Flood plains are developed in the master streams as well as in minor streams.

(3) It is also noticed that over flood plains streams flow in broadly meandering courses.

(4) Local relief has been reduced in height and the water partings of small streams are also low.

(5) Dury (1966) has suggested that "For if a trunk river becomes graded by landscape maturity, it is entirely possible for the vertical distance between source and mouth to be still the same then as in the preceding
stage of landscape youth".

But it has already been accepted by numerous geomorphologists that for the perfect development of a peneplain it is essential that the area should not be uplifted. The region under study is uplifted by recent movements and rivers have got erosive power again, and the landscape reveals the multicyclic character.

**Interruptions in Cycle of Erosion**

As mentioned in the previous section, before the recent upliftment, the Ken had attained the mature stage and was meandering freely over the flood plain. But evidences are that the whole basin was uplifted and the rivers show signs of rejuvenation and active erosion all through their courses. Detailed discussion of rejuvenation will be given in the erosion surfaces. Pascoe has also (1919) suggested that the great changes in the chief drainage lines of north India since late Tertiary times. Thus the region shows signs of rejuvenation such as the ravines, rocky surface and the deep gorges and waterfalls.

**Development of Ravines:** The ravines are the peculiar features of the lower part of the region which are produced by flood plain cutting. The ravines may be taken as a indication of the rejuvenation of streams in the region under study. Sharma, H.S. (1968) has stated that "The genesis of the ravines can be attributed to some other reason, such as the lowering of the local base level of
erosion caused by uplift of the region . Ahmad, E. (1968) has also accepted this statement and suggested that "It is very likely that this excessive and spectacular gully erosion is due to regional uplift which might be extant. The axis of uplift might be along a line passing midway between Banda and Hamirpur on the east and Hathras and Gwalior on the west". Indeed, it may be said that such ravines are peculiar features of the lower part and show minor disturbances in a late geological age. It is noticed that the shape, size and pattern of the ravines are mostly related to soil characteristics. Where the soil is underlain by fine grained clays ravines are deep and narrow in size due to the resistant soil. But where the soil is usually non-resistant the size of ravines become very large. The study of ravines in the field and also in maps show that they have developed on both sides of the rivers, descending the flood plain, and produced the bad land in Banda-Charkhari tahsils.

Regarding the channel of the Ken and Chandrawali nadi in this section it may be assumed that before the recent upliftment the rivers had attained mature stage and formed the flood plain. But the last upliftment the rivers have regained erosive power and have incised where they were at the time of upliftment.

Deep Gorges and Water falls: Deep gorges and water falls are the most peculiar features of the region which indicate rejuvenation of the region. According to Wadia (1961)
"Indeed, it may be said that such falls are more characteristics of penesular than of extra-penesular India and bear evidence to some disturbances in a late geological age". Vaidhyanathan (1967) has also suggested that the rejuvenation of rivers resulting in gorges, piracies, wind gaps and waterfalls are attributed to minor cyntagencies paralleling the major axis. Such deep gorges and waterfalls have developed in the upper part of the region especially in the Burana nadi and Seo nadi. Detailed description of gorges and waterfalls has been given in the previous chapter related to drainage analysis. The waterfalls have developed due to the differential and headward erosion in the region. At northern escarpment where the streams crosses upper Bhander sandstone and fall over the Jhiri shales waterfall have been formed. Some waterfalls are developed due to the differential erosion between Ken and its tributaries. Another peculiar feature of the part is the gorge, which is correlated with waterfalls. The development of waterfalls in the streams of the Ken system and their following gorges have been correlated with the advancement of fluvial erosion upstream in the Ken and its tributaries. The observation in the field survey such as gorges have been seen especially at Majhagawan in Panna (Plate 25).

From the shape and size of these gorges, is clear that they are the results of rejuvenation of the region. Broadly speaking such erosion power of the rivers in this part of the region is due to the juvenile character of the
streams, after the recent upliftment of the region. In other words, it may be said that the gorges and waterfalls are the indication of mature but near youthful condition of the rivers of the region.

Rocks surface: Rock surface of the rivers is main characteristic of the rejuvenation of the region. Drainage on the peneplain is already well established, so that the streams are merely rejuvenated and cut valley into their old shallow courses. In the same way while streams cut their bottom so rocky surface has been exposed everywhere. Such rocky surfaces were seen in the Ken and Urmal river near Malehra, during the field study of the region. Extremly intense erosion and large scale transportation of debris are the result of recent upliftment of the region. It is noticed that rivers of the region are too active excavation their rocky beds.

As mentioned above that the ravines, deep gorges and waterfall and expanses of rocky surfaces are the main characteristics of rejuvenation of the region under study. The longitudinal profiles also show a marked change of slope which has already been discussed in the previous section.

Uplifted Peneplain

As described in the previous chapter that the Lower Ken basin ever since its inception had remained a stable mass and had withstood for long the effects of erosion and
massif was peneplaned at least once in its long history. Worcester (1961) has suggested that "Uplifted peneplain which have suffered varying amounts of dissection during and subsequent to the uplift have been widely recognized". It is believed that after a period of time much longer than was needed for maturity to be reached, the topography is reduced to a low irregular surface and is said to have reached the peneplanation. But once formed a peneplain is usually rejuvenated again by the geological disturbances or crustal movement.

The peneplain, the end of Davis's cycle of subaerial erosion, has already been briefly discussed. Davis himself has accepted that it is not likely that any part of the earth's crust has been sufficiently stable for a long time to allow for the formation of a perfect peneplain, but there is the possibility of finding examples of what may be termed partial peneplains. According to Thornbury, W.D. (1969) "Probably the strongest argument of the validity of peneplain is the fact that in many areas the topographic features have characteristics and relationships that are most logically interpreted by assuming the existence of low relief erosion surfaces which have been uplifted and dissected". It may be discussed theoretically by a number of criteria which are found in the region.

Accordance of summit levels: From the study of one inch topographical sheets and the field study it is clear that the region was peneplaned at least once in its long history.
Explanation of this statement should be made with the realization that peneplain was not completely flat due to the slopes both laterally towards the main axial of streams. It is noticed that accordance of summit levels can be produced in various way, but at least this test must be met while the possibility of peneplanation is considered. This surface which are usually no more than a few miles wide are separated from each other (Plate 10).

Topographic unconformities: As mentioned in above section that the rivers of this part have a sufficient erosive as well as transportation power which are indications of the uplifted peneplain of the region. Sparks, B.W. (1972) has stated that "It (Ken) has valleys are equally spaced, cut down to approximately the same depth and flanked by slopes of the same angle, the accordant summit levels might be interpreted as a feature without significance". It is clearly that the upland interstream areas with old age characteristics which have cut valleys with juvenile features and sharp ridges in the cross-profiles of the upland topography. Such examples are found in the Urmal and the Ken rivers in the Bundelkhand upland.

Truncation of rocks of varying hardness: This is the most peculiar feature of the uplifted peneplain in the region. Thornbury (1969) has suggested that "The most crucial test can be applied to an erosion surface thought to be a former peneplain is that its low relief surface truncate strata of
varying resistance to weathering and erosion. It is very clearly seen in the northern plain and middle part of the basin that its greater part, the older rocks are concealed by the alluvium of the Gangetic plain and the two different resistant rock found in the same height. Such as unconformable conditions is also found in the south-western part of the region.

**Presence of weathered rock debris in a thick zone:** In the northern part of the basin a zone of ground deposit has been found which represents the level of the ancient plain, is an indication of advanced weathering on erosion surfaces. This extensive erosion surface may be seen in the middle western part of the region. This thick debris zone consists of laterite or other soils such as chert and quartz which are related to the insoluble materials. It has been badly cut up by river action and sub-aerial erosion due to the recent upliftment of the region.

**Presence of Old alluvium:** It is believed that the peneplain are not formed by the lateral stream erosion but by down wasting of inter stream tracts. Thus the alluvium is not found so much extensively remnants on peneplain, but it is found only on a narrow strip on the former flood plains. Such alluvium has been found towards the surface is undulating and stream with fine and partial material especially in Banda district. Soils are thin and coarse, mostly sandy or 'bajari' hence infertile. This zone is also badly cut by the river action and the ravine land has been produced
in large areas. Thus these remnants of former alluvium is the most characteristic of the uplifted peneplain in the region under study.

As noticed above it may be concluded that the presence of this unconformity with the topography in the region may be considered as the characteristic of a uplifted peneplain. It is believed that before the recent upliftment the region had attained old stage and subjected for long the weathering and denudation. But the whole basin was uplifted in the recent period and the region shows signs of uplifted peneplain. Thus the present discussion as a whole of the fluvial geomorphic cycle helps to show the geomorphic features in the Lower Ken basin.

**Erosion Surfaces**

The previous analysis makes it evident that the Lower Ken basin has been rejuvenated in the recent geological past. Therefore the cycle of erosion has been interrupted due to which rivers have intensified their erosive activity. The remnants of the previous cycles could be seen as erosion surfaces in the region.

The erosion surfaces are important features in the study of the geomorphology of the Lower Ken basin. The study of erosion surfaces helps in understanding the geomorphological history of the region. The erosion surfaces in the region are outcome of the running water and weathering. In the study the erosion surfaces have been correlated with
the geological ages in an order of their development.

Various geologists have suggested the intermittent upliftment of the Himalayas. Wadia (1961) has stated that "There appear to have been three important phases of the upheaval of this mountain system. The first of these was past nummulitic culminating in the oligocene... It was apparently followed by a movement of greater intensity about the middle of the Miocene. The most important phase elevated the central part of the range together with the outlying zone of Sivaliks into the vast range of mountains which have been reduced by denudation to form the present Himalayas. The last stage was mainly of past. Pliocene age later than the deposition of the greater past of the Siwaliks and did not cease till after the middle of the Pleistocene". Mithal (1968) also believed the upliftment of the Himalayas from Cretaceous to Pleistocene in continuation. Kumar and Rai (1972) have argued that intermittent uplift and interruptions in cycle of erosion of Deccan Foreland may be correlated to the Himalayan orogeny. They say "Regarding the cause of this rejuvenation, Dunn (1938) while analysing the causes of earthquakes in north Bihar has explained the mechanism of subsidence of the Indo-Gangetic trough and rising of the Himalaya and the Deccan Foreland". The authors further say "Once we take this premise that alongwith the Himalayan orogeny the Chota Nagpur plateau and the Aravalli have been involved in the diastrophic action, there is no reason to ignore such a possibility for the central highland. For the
whole foreland in front of the Himalayas should have acted as one unit.

Choubey (1967), Dube (1968) Dutta (1968), Pandey (1972) and Subramaniam (1975) have worked in adjacent areas of the Lower Ken basin. These authors have also identified the erosion surfaces in their respective areas of study. From the evidence of field observation and analysis of altrimetric frequency curve, longitudinal profiles and other morphometric analysis of the region the conclusions regarding erosion surfaces has given in preceding section in detail.

The most important features of the south-eastern and south-western part of the region are sharp ridges and free face scarps which indicate the peculiar history of the regions. The rivers of this part are fully guided by the underlying rock structure. The presence of deep gorges in all the streams and the presence of residual hills at different heights covered with laterite indicate the rejuvenation of the region. The development of waterfalls even along the small streams indicate the rejuvenation of the old surface.

Other conspicuous features of the region are the pinkish boulders or 'Tors' and quartz-reefs or dykes which help in understanding the erosion surfaces at different levels. These 'Tors' and dykes are the results of continuous erosion. According to Small, R.J. (1970) "Strictly speaking of course, all parts of the land surface that are not directly
depositional in origin are surfaces of erosion. Thus the
dip and scarp slopes of a cuesta; although owing their form
in large measure to the influence of geological structure
are 'surfaces' produced by weathering and erosion". The
northern part of the basin, therefore, has been reduced
to a peneplain. It has already been discussed in the
previous chapter that the Bundelkhand upland was peneplained
at least once in its long history and is a beautiful example
of uplifted peneplain. The geomorphic features and the
rivers of the Bundelkhand upland show signs of rejuvenation.
It is also noticed that the rivers of the Lower part of the
region even now are very active and have erosive power.
Due to the river action extensive ravine land developed
which is another indication of the juvenile character of
the streams. From the study of the geomorphic features and
courses of the streams it may be said that even now the
major tributaries of Ken have not attained a mature stage
and are actively cutting their beds, due to the upliftment
of the region in the recent past.

Methods of Study: There are various morphometric techni-
ques which have been used for identification of erosion
surfaces in the region under study. For the understanding
of the erosion surfaces an extensive field work has also
been undertaken to collect the field evidences. Relevant
literature on the geology of the region has also been
collected and the ages of erosion surfaces are determined
relatively and not in absolute terms. Some morphometric
techniques are discussed in detail which are also to help to understand the erosion surfaces in the region.

**Superimposed Profiles:** The superimposed profile was drawn from the quarter inches topographical sheets not only for the study area but for some adjacent areas also (Fig. 16). The broad characteristics of the erosion surfaces of the region are beautifully displayed in the superimposed profile. From the study of the profile is clear that the remnants of the exumed Vindhyans surface is found at the height of 1750' and above. Another erosion surface may be seen at the height of 1300' to 1450' which is extensively seen in the region. The profile also exhibit another extensive erosion platform at the height of 1000' to 1200'. While the lowest erosion surfaces has been found at the height 650' to 900'. Such similar results has also been found in the simple profiles of the region (Fig. 16).

**Altrimetric frequency curve:** For the identification of the erosion surfaces an altrimetric frequency curve was also drawn (Fig. 19). The maximum frequency occurs at the height of 750' to 1000' while above 1250' the frequency decreases. At the height of 1500' and above the frequency is found only 5. It is noticed that the maximum height is found both on the Vindhyans and Bijawars hills which indicates an erosion surface. These various descends of the altrimetric frequency curve show different levels of the erosion surfaces.
Longitudinal Profiles: Longitudinal profiles were drawn for all the main streams on the one inch to a mile topographical sheets of the region under study. The longitudinal profiles of the main streams shows that there are no major knick points in the profile (Fig. 13). But there are some marked descends which indicate the break in the profile. All the main streams show however three breaks in their curve one at the height of 1000' to 1100' in the Saimri and Ken river. The Mutni and the Kail have two breaks; one at the height of 700' and the second at 600'. In the Ken river the third break is at the height of 500' to 600'. These breaks of the main streams are of help to understand the erosion surfaces in the region under study.

Area height curves: From the one inch to four miles topographical sheets the actual area between two selected contours, have been measured by a planimeter, not only for the study area but for some adjacent area also. In this manner the points are plotted against the vertical height scale to the area between each successive pair of contours. The area height curve indicates clearly that a major part of the region is concentrated in the zone where the altitude ranges from 500' to 750' out of total area of slightly more than 2368 square miles within these zones. The height from 1000' to 1250' comprises more than 1632 square miles, of the region which is the next extensive erosion surface. From the curve it is clear that the areas rising more than
1250' is hardly 208 square miles of the total area and shows the next erosion surfaces of the region. These breaks of the area height curve are indicative of the various upliftments of the region is different periods.

Identification of the erosion surfaces: The analysis of the various morphometric techniques such as superimposed profiles, longitudinal profiles altrimetric frequency curve and area height curve and field study give evidence to the presence of different erosion surfaces in the region. Presence of several erosion surfaces indicates that the upliftment was intermittent. Since this region is a part of the Himalayan foreland, it seems during the orogenic activity it could not escape its impact and has been uplifted with each orogenic phase. This has been described in detail by Dunn (1942). These erosion surfaces may be correlated with the Himalayan orogeny. Hence, keeping this viewpoint the suitable names for erosion surface has been given and are described in detail which are as follows:

The Cretaceous erosion surface (1750' and above)
The Mid-Miocene surface (1300' - 1550')
The Pleistocene erosion surface (1000' - 1250')
The Recent erosion surface (650' - 900').

The Cretaceous erosion surfaces (1750' and above): The Vindhyans and Bijawar hills and ridges which occur to the south-west and south-east of the region reach an elevation of 1750' and above. The maximum elevation on the top of
the Vindhyan formations in the region is 1828' on the ridge near Sukuha village. As noticed in the previous section at the close of the Cretaceous period the mature topography of the Vindhyan was completely buried beneath the lava. As soon as the lava cooled down the surface came under the effects of erosional agents. And after removing the cover the exhumed Vindhyan surface has been exposed. Thus the highest summits of the Vindhyan are the remnants of the oldest erosion surface in the region. The elevation and extent of the pre-Cretaceous erosion surface is more towards south-east and has been discussed by Choubey (1967), Dube (1968), Rai (1969) and Subramanayan (1975). Choubey found some evidence of a pre-Cretaceous erosion surface on 1450' to 1750' in the Katangi region. While Rai also has recognized this surface at the height of 1900' and above in the Sonar-Bearma basin i.e. the upper Ken basin. Subramanayan has observed this surface at the height of 1900 to 2050' around Sagar and called it the Rewa surface due to its formation on the upper Rewa quartzites.

From the analysis of the different morphometric techniques such as altrimetric frequency curve and longitudinal profiles and field observations it is clear that the exhumed Vindhyan surface is the oldest surface. Some field evidence suggest that the Cretaceous surface was uplifted and rift faulted along the Narmada-Son line before the erruption of Trap. West (1962) has suggested that ...

"It thus appears that the Narmada-Son line may have been a
line of weakness from early times, with areas to the north and south moving up and down relatively to each other along this line". It is clear that the rejuvenation of the Vindhyans has also been effected in the region under study. Thus the region may be correlated to the Bhander surface of Rewa Plateau (Dube, 1968) at the height of 1800' to 2000' and late Cretaceous surface of the Sonar-Bearma Basin (Rai, 1969) at the height of 1900' and above. But the Cretaceous erosion surface has been found at the height of 1750' and above in the region under study, for this region is located much downwards in the drainage basin.

This exhumed surface was uplifted in the later period and the valleys must have been deepend and widened by the streams. Along the margin of the inter-fluvial ridges, the stream must have produced deep cuts. In this manner the scarp must have retreated from the river banks differentially, especially where the rocks appear jointed and cross-bedded. From the study of the courses of streams it is clear that the cycle did not reach beyond maturity in the hilly tracts of the region.

The middle Miocene surface (1300 - 1550'): From the study of altrimetric frequency curve, superimposed profiles and the longitudinal profiles it is clear that another extensive erosion surface has developed at the height of 1300' to 1550' in the Panna range. It is interesting to note in this connection that the remnants of the late Eocene erosion surface, which was developed on the Deccan Trap (Rai, 1969)
was not left in the region under study and has been completely washed away. The absence of the late Eocene surface in the region may be explained by the fact that this region comes on the margin of the Deccan Trap. Keeping this fact in view we considered in this region a Mid-Miocene surface at the height of 1300' to 1550'.

Interruptions of the pre-Cretaceous cycle initiated the Mid-Miocene cycle of erosion in the Lower Ken basin. Wadia (1938) has stated that in the late Cretaceous or Oligocene the first phase of the Himalayas orogeny took place which it seems has affected the stability of the peninsular India especially on the northern marginal areas.

From the study of morphometric techniques and field observations it is clear that the region must have been uplifted and rivers of the region were rejuvenated. The presence of waterfalls in the tributaries of the Ken and deep gorges of Ken and its tributaries, suggest that there has been upliftment in the recent period. It may be inferred that before the beginning of the Mid-Miocene uplift the cycle of erosion might have reached the mature stage, as on the Cretaceous surface thick deposits of the laterite are found. It would be relevant to mention here that the Mid-Miocene surface of the region and the adjacent areas may be correlated with the Panna surface Dube (1968) of the Rewa Plateau, at the height of 1250' to 1550' (400-500 mts.) and sub-basaltic erosion surface (Choubey, 1967) of the Sagar-Damoh plateau at the height of 1450' to 1750'.
The Pleistocene erosion surface (1000' to 1250') : The study of the superimposed profiles clearly show a third erosion surface at the height of the 1000' to 1250' which is an extensive surface. This surface is found north of Panna and Bijawar range and is well-developed around Chhatarpur. Chaterjee, S.P. (1962) has designated it as Chhatarpur upland (Plate 29, N.W.A.O.) and has recognized it as an erosion surface. It is believed that the interruption of the Mid-Miocene cycle initiated the Pleistocene cycle of erosion by which the alluvium deposits in the lower part were laid down upon the Mid-Miocene surface. A large number of dykes and quartz-reefs rise above the general surface of the upland showing its erosion in a later period.

A.M. Heron (1938) in the paper on the physiography of Rajasthan has discussed the geomorphology of Aravalli range, which according to him was peneplained during the Mesozoic and subsequently uplifted. ... He also suggested two other peneplains, one of Tertiary age to the east of the Aravalli range developed on softer rocks and the other of Pleistocene age developed on the older alluvium. Geomorphological studies of Krishnan (1953) and Dunn (1938) have revealed that the Peninsular India was disturbed by epeirogenetic movements. Due to this disturbance the cycle of erosion have been interrupted. It may be mentioned here that this erosion surface of the region may be correlated with the Pleistocene surface of the Chambal valley (Sharma, 1969) at the height of 180 to 305 metres. It is noticed
that the southern part of this surface is less eroded and is characterized by the presence of many granitic hills, while the northern portion is more eroded. It becomes clear from the above discussion that there are extensive areas of uniform physical features in the Chhatarpur upland.

**The Recent Erosion surface (650' to 900')**: The study reveals that the recent surface has developed on the northern part of the Bundelkhand gneisses, due to the interruption of the Pleistocene cycle. It is also believed that the recent surface has been developed by the destruction of the northern part of the Pleistocene surface during the recent period, and its formation is under process at the present. The recent erosion surface is developing at the height of 650' to 900'. The southern part of the recent surfaces is generally undulating, elsewhere the plain is more or less level. The local relief on this surface has been found and the height reaches 971' at Tihari Pahar and 872' at Kalashwar Pahar. In the extensive southern portion of the recent surface the structure is granitic and the rocks do not lie a very deep from the surface. It is observed that in the northern part of this surface the thickness of the alluvium is increased.

On the northern alluvial plain of this surface is developing the bad land which is the indication of the recent upheaval of the region. Sharma, H.S. (1967) has suggested that "From 1050' to 1250' the curve flatness gradually which suggests recent rejuvenation in the valley. It is also evident from the observation of deep ravines along the rivers
valleys". It is clear from the field observation that in the northern plain, rivers are vigorously engaged in downcutting to attain the base level. It may be mentioned here that this erosion surface may be correlated with the Trans Yamuna surface (Dube, 1968) of the Rewa Plateau at the height of 100 to 150 metres, and 300 metres stage surface (Dutt, G.K. 1968) of the Lower Son Valley.


These fluvial geomorphic processes and erosion surfaces of the Lower Ken basin bring us to the conclusion that the basin has multicycle landscape due to intermittent uplift in different periods. Thus it is logical to turn to a discussion of actual landscape and to see the way in which they have been interpreted in terms of landforms or terrain. For this purpose identification and analysis of landforms of the Lower Ken basin have been discussed in the foregoing chapter in detail. The fluvial geomorphic processes have left their imprints on the basin, and to some extent they are responsible for the height of the region as well as for the present geomorphic character.
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