CHAPTER -4

GEOMORPHIC SURFACES

An important ingredient of tectonogeomorphic studies is the identification and characterization of geomorphic surfaces developed in response to geological processes over a period of time. Reconstruction of long term development of landscape is based on the morphostratigraphic relationship and interpretation of these surfaces. Further categorizations of surfaces as constructional or erosional enables recognition of reasonably well constrained phases of erosion and deposition in the evolution of landscape. Accordingly, a major emphasis is given for the recognition, description and interpretation of various geomorphic surfaces while carrying out the present study.

RECOGNITION OF GEOMORPHIC SURFACES

As the present study is mainly field based, the various geomorphic surfaces were mapped in the field through extensive field surveys, and topographical data. Satellite images (IRS-FCC'S) on 1:250,000 scales were used for delineating the mega-geomorphic set up of the Kim basin. A critical analysis of the Survey of India Topographical maps on 1;50,000 scale helped in recognizing the relief features and primary information on the occurrence of geomorphic surfaces. Based on the above observations, strategy for field mapping was derived. Orientation of field traverses were finalized based on the data generated from the visual interpretation of satellite imageries and topographical maps. The various geomorphic surfaces were mapped on 1:50,000 scales. Recognition of geomorphic surfaces in the field is mainly based on elevation differences. Continuous traces of a surface are mapped on the basis of similarity of their elevations. In general, these erosional surfaces have a discontinuous fragmented occurrence while the depositional surfaces have a more continuous occurrence. As a consequence, the depositional surfaces are easier to map and correlate. Moreover, they also allow for fairly accurate, determination of their age, while this is rather difficult in case of erosional surfaces. The various geomorphic surfaces occurring in the Kim basin have been mapped in the field and their mode of occurrence, morphologic characteristics and their relationship with the structural elements have been determined. The surfaces were mapped in all the three morphostructural domains. This was followed by stratigraphic and sedimentological studies of sediments comprising the depositional surfaces and assign relative ages to the erosional and depositional surfaces.

The oldest surface encountered in the study area is a relict erosional surface developed over the exposures of Tertiary rocks. The surface is gently undulating and its occurrence is limited to the topographic highs which correspond to structural highs seen in Tertiary rocks. Away from the structural highs it passes below the alluvial deposits.

The surface is distinctly identified in the field owing to its higher elevation in relation to the surrounding areas. The elevation difference is 15 to 20 m. The surface marks a phase of post-depositional deformation and erosion of the Tertiary rocks. This phase appears to be a prolonged period as evidenced by extreme deformation seen in the Tertiary rocks and is considered to be of Post-Pliocene age.

The second surface observed in the area is that of the flat undissected alluvial plain It occurs at a lower level than the erosional surface seen over the Tertiary rocks. The occurrence of alluvial plain is found to correlate with the synclinal lows. The continental sediments indicate a depositional phase which followed the prolonged phase of erosion of Tertiary rocks. Based on the tentative age of 34$\pm$ 5 Ka obtained by OSL on the sediments of the depositional surface and the long erosional interval preceding it suggests that the surface was formed by fluvial deposition during Late Pleistocene. Along the river valleys, the alluvial surface is deeply dissected and appears as a distinct erosional surface. The surface represents post-depositional i.e. Early Holocene erosional activity over the Late Pleistocene sediments. The youngest surface is a low incised terrace occurring within the river valleys and is inferred to be Middle to Late Holocene based on a tentative OSL age of ~2 Ka obtained on sediments comprising the upper part of the sequence. As mentioned above, four geomorphic surfaces have been mapped in the Kim river basin (Figs. 4.1, 4.2). These have been termed as:

1. Early Pleistocene Erosional Surface (EPES)
2. Late Pleistocene Depositional Surface (LPDS)
3. Early Holocene Erosional Surface (EHES)
4. Late Holocene Depositional Surface (LHDS)

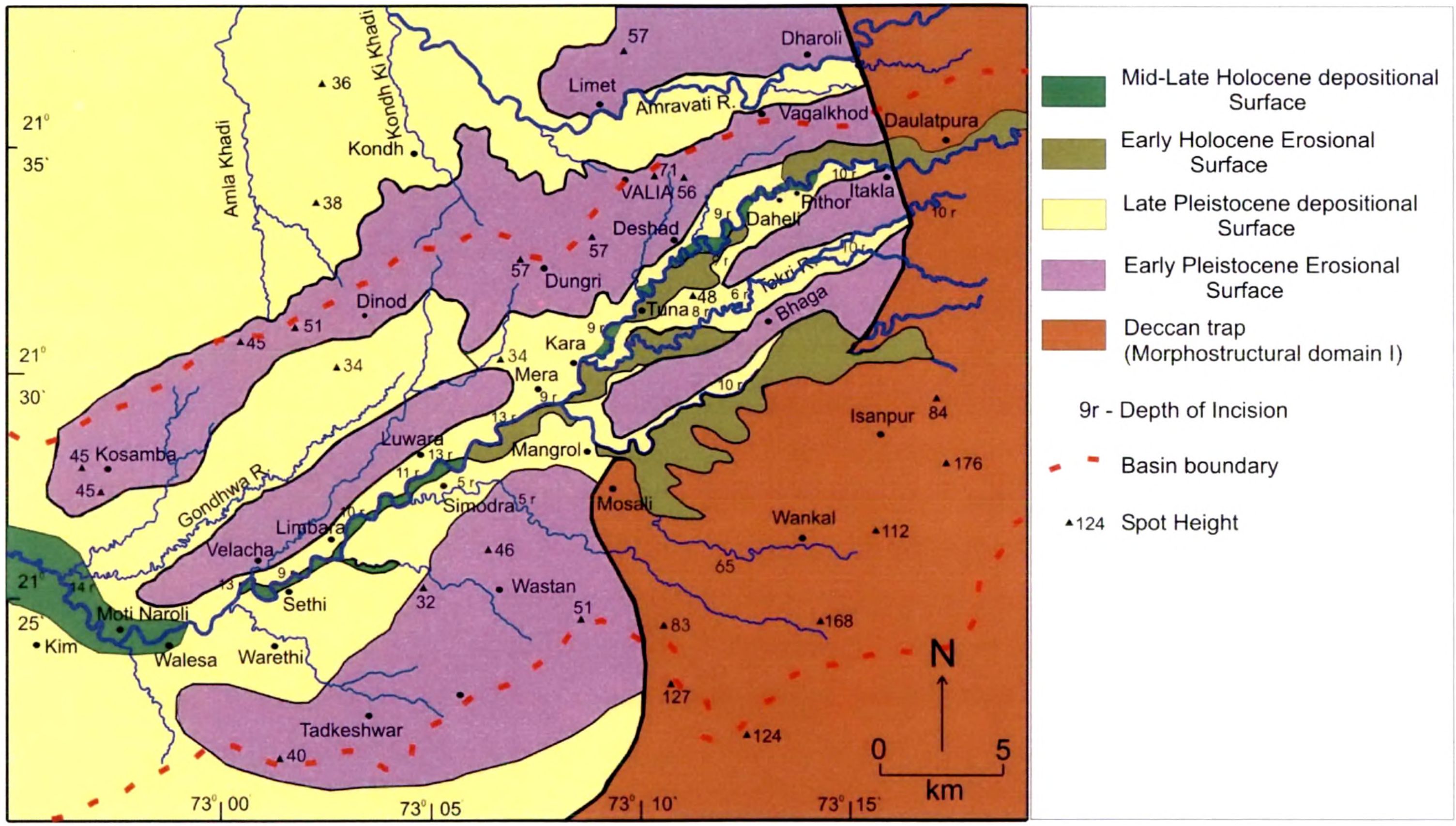

Fig. 4.1 Geomorphic map of morphostructural domain-II in the Kim river basin.

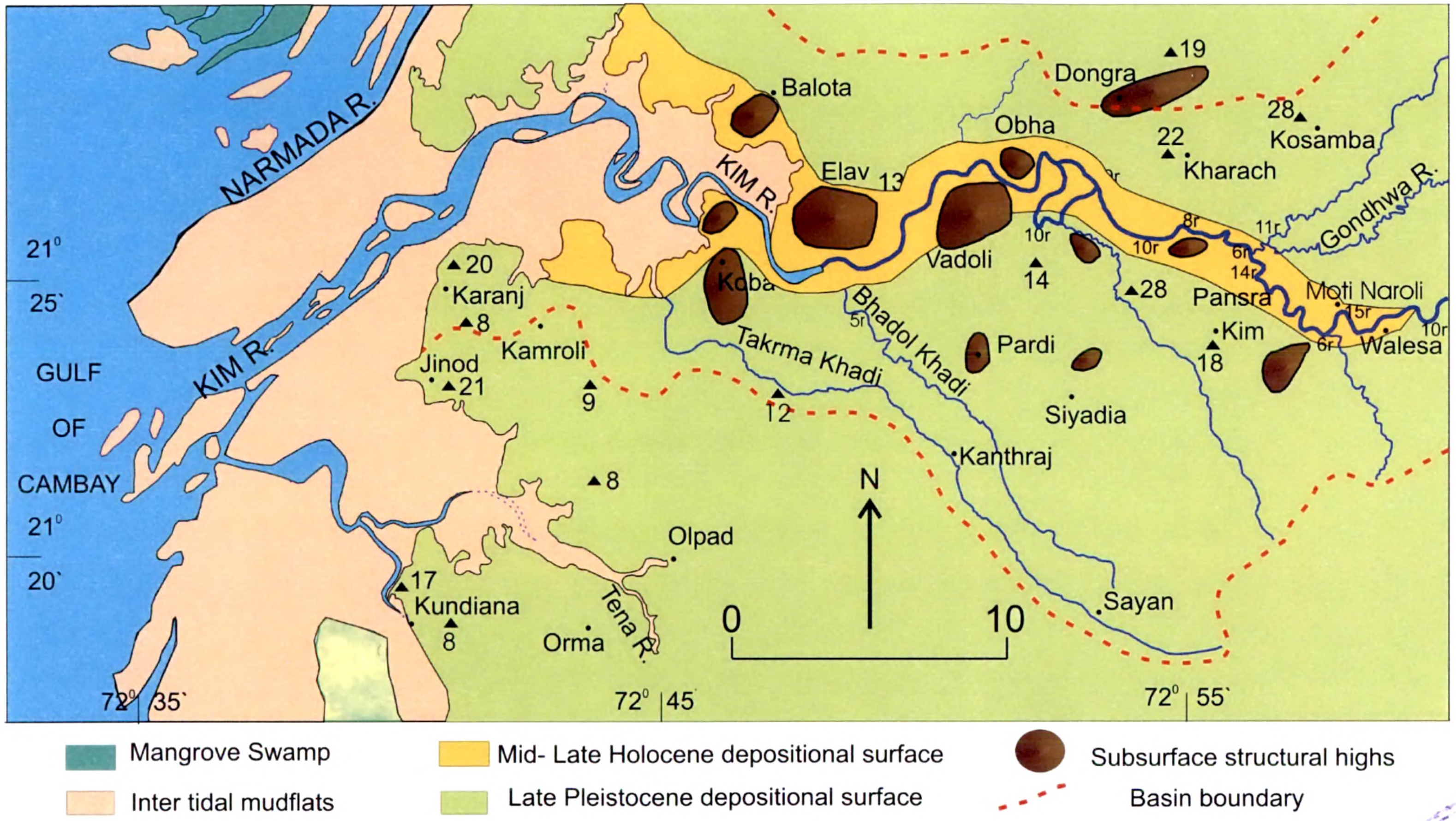

Fig. 4.2 Geomorphic map of morphostructural domain-III in the Kim river.

As shown above, two erosional surfaces and two depositional surfaces are found in the Kim basin (Fig. 4.1, 4.2). The morphologic characteristics of each of these surfaces are described in the following pages.

EARLY PLEISTOCENE EROSIONAL SURFACE (EPES)

The Early Pleistocene Erosional Surface (EPES) occurs exclusively within the Morphostructural domain– II (Fig. 4.1). This is the oldest geomorphic surface occurring in the Kim river basin and is developed over the deformed Tertiary rocks in the central part of the Kim river basin. The Early Pleistocene Erosional Surface (EPES) occurs as ENE-WSW trending discontinuous patches with intervening alluvium. The surface occupies topographic highs (Fig. 4.3) which correspond to tectonic highs within the Tertiary rocks. The surface shows a gentle inclination towards WSW. The maximum elevation of the surface is ~80 m in the east near the Rajpardi Fault which drops down to ~40 m in the downstream direction. Beyond this, the EPES disappears below the alluvial plain in the lower part of the Kim basin.

Fig. 4.3 Panoramic view of structural high in the form of Early Pleistocene Erosional Surface (EPES) in morphostructural domain-II at Valia.

The EPES is a gently hummocky surface (Fig. 3.9) and is not of so spectacular occurrence in the field owing to its discontinuous nature. However, it shows an excellent one to one correspondence with the structural highs. The surface is covered by a thin veneer of soil which, testifies to its long period of subaerial exposure to weathering processes (Fig. 4.4). At places, the soil cover has been stripped off and Tertiary rocks are

Fig. 4.4 Close view of the highly weathered surface of the Early Pleistocene Erosional Surface at Valia.

exposed on the surface forming a uneven rocky surface (Fig. 4.5). Morphologically, each patch of the EPES displays an undulating surface which rises about 10-15 m above the surrounding area. The break in the topography is rather abrupt and hence the EPES is readily recognizable in the field (Fig. 4.6). Another distinction is the absence of agriculture on these high surfaces while the lower surfaces around are extensively used for agriculture by the local population. The EPES are linear topographically high surfaces and trend in E-W and ENE-WSW directions which continue uninterrupted for several kilometers (Fig. 4.2). However, the width of the surfaces range from a few hundred meters to a couple of kilometers. This is attributed to the E-W and ENE-WSW trending anticlinal highs over which the EPES has developed (Fig. 4.6).

The largest exposure of the EPES is located in the area around Kosamba. It

Fig. 4.5 View of the undulating rocky surface (Early Pleistocene Erosional Surface) devoid of soil cover in morphostructural domain-II near Vagadkhol.

extends in the ENE-WSW direction for more than 10 km while the width is around 3 km. The crestal part of it exposes the rocks which are belonging to the Babaguru Formation. The entire exposure of the EPES at this place is covered by a cherry red coloured soil similar to that seen at Valia (Fig. 4.4). The EPES at this place coincides with the Kosamba and the Dinod anticlines which also mark the drainage divide of the Narmada River in the north and the Kim basin to the south (Fig. 4.6). The northwestern part of the Kosamba anticline is buried under a cover of alluvium. The subsurface studies have shown the presence of the Kosamba and Dinod Faults at the southern end of these highs

(Agarwal, 1984) while the DSS profile shows the Kosamba Fault as a crustal scale structural feature (Kaila et al., 1981). Due to the presence of these faults the southern edge of the occurrence of the EPES in this area is represented by a sharp topographic break (Fig. 4.6). The northern side slope is gentler and grades below the alluvial sediments.

Fig. 4.6 Photograph showing a prominent geomorphic high developed over Dinod anticline.

To the NE of the above occurrence lies another extensive patch of the EPES. The village Dungri is located at the crestal part in the middle of the EPES at this place. The fossiliferous coquina limestone is present below a thin film of residual soil. This occurrence of the EPES marks the Dungri anticline. At this place the EPES marks the drainage divide of the Amravati basin to the north and the Kim basin to the south (Fig.

4.2). Here, the EPES shows an elongate appearance in the ENE-WSW to E-W trends. The length of this occurrence is about 12-15 km while the width is about 3 km. Other remnants of the EPES occur further east of the above described highs with no known apparent structural features. Similarly the EPES has also been mapped to the south of the Kim river which are located between the Tokri and Bhaga rivers where structural highs are not reported (Fig. 4.2). However, the presence of the outcrops of the Tertiary rocks indicates that these also represent the Early Pleistocene Erosional Surface (EPES) in the Kim basin. These also show an ENE-WSW trend running several kilometers. This suggests that they may also be the manifestations of the subtle structural highs formed in the Tertiary rocks.

The occurrence of the EPES is not unique to the Kim basin. These occur discontinuously all along the terrain of outcropping Tertiary rocks south of the Narmada river. Some of the high relief EPES are characterized by the presence of radial drainages. Further, many of the lower order streams crossing or originating from these remnants of the erosional surfaces show incision of the order of 4 -5 m indicating the youngest phase of uplift in the Kim basin. These streams expose rocks belonging to various formations of Tertiary age.

The occurrence of EPES in the Kim river basin marks a significant and prolonged phase of tectonically controlled erosion of the deformed Tertiary rocks. The erosional phase closely followed a phase of severe deformation due to N-S directed compressive stresses during the initiation of the basin inversion. The deformation produced ENE-WSW trending topographic highs along the anticlines and lows along the synclines. The crustal shortening associated with this deformation was partly adjusted by the development of the reverse 'thrust' faults in the southern limbs of the anticlines. The deformation took place during Late Pliocene to Middle Pleistocene which resulted in the basin being exposed to erosion. The erosion was tectonically controlled as revealed by the close relation between the topographic relief of the EPES with the structural elements. Much of the EPES lies buried below the alluvial sediments which form the Late Pleistocene Depositional Surface (LPDS).

LATE PLEISTOCENE DEPOSITIONAL SURFACE (LPDS)

The Late Pleistocene Depositional Surface (LPDS) comprises the flat constructional surface developed over the Late Pleistocene alluvial sediments (Fig. 4.2, 4.3). The LPDS occurs in the morphostructural domains I, II and III. The surface occurs 10-15 m above the present river level due to incision (Fig. 4.7). In morphostructural domain-I, it shows a very limited occurrence in the river valleys only. Well developed occurrences of LPDS are noted near Punjabnagri, Daulatpura and Pansim in morphostructural domain-I.

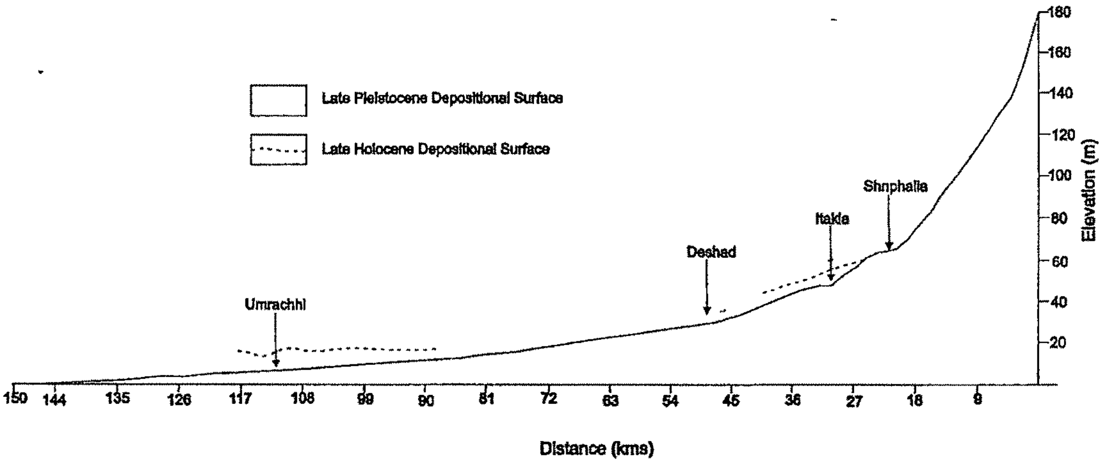

Fig. 4.7 Longitudinal profile of the Kim river with two depositional surfaces.

At Daulatpura, the LPDS surface rests directly over the trappean rocks. The LPDS in this domain is almost a flat surface that hardly exceeds a few tens of meters in width (Fig. 4.8). Away from the river valley it abuts against the trappean basaltic flows. The LPDS typically occurs at a height of 10-12 m above the river level (Fig. 4.9). At places the surface shows a paired occurrence while at

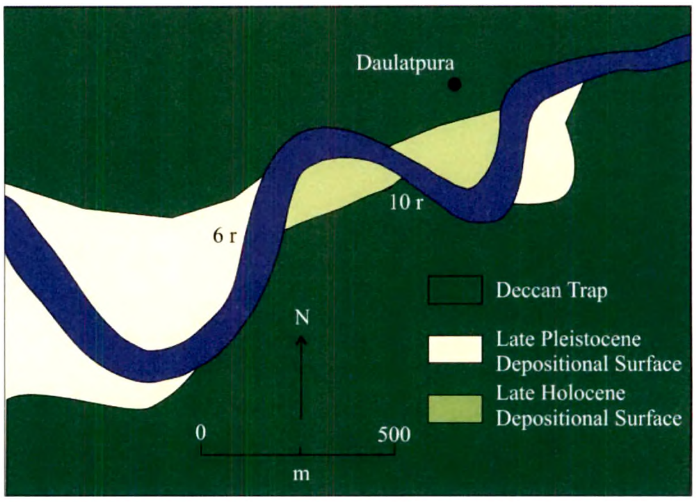

Fig. 4.8 Geomorphic map of the area around Daulatpura in morphostructural domain-I.

Fig. 4.9 Photograph showing two depositional surfaces at Daulatpura. The Late Pleistocene Depositional Surface (LPDS)at higher elevation while the lower terrace is the Late Holocene Depositional Surface (LHDS).

some places it is unpaired. However, in morphostructural domain-I this surface is not continuous but it occurs consistently at the same elevation.

At Punjabnagri in the morphostructural domain-I where both the depositional surfaces are exposed in the form of terrace (Fig. 4.10). The sediments of both the depositional surfaces rest on the trappean rock which is basement rock of the area (Fig. 4.11). The geomorphic map (Fig. 4.10) shows that LHDS surface is paired while LPDS surface is unpaired. Here, the Kim river has incised upto 10-12 m into the trappean rocks along its left bank.

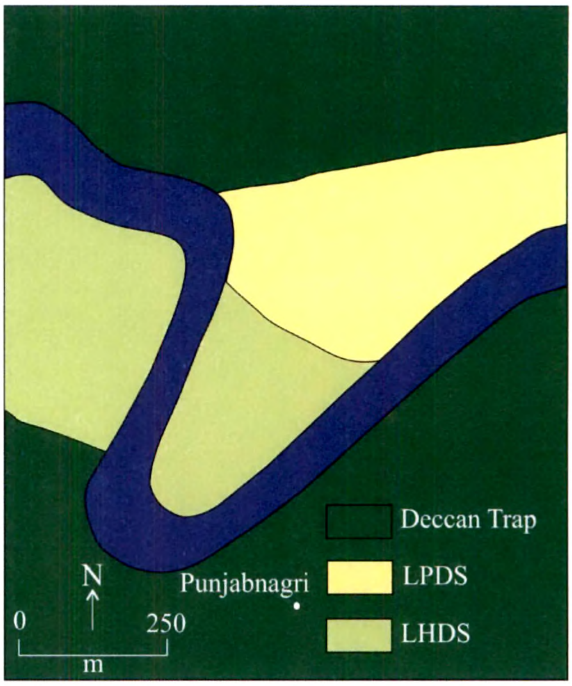

Fig. 4.10 Geomorphic map of a part of Kim river near Pujabnagri showing the two depositional surfaces.

At Pansim, in morphostructural domain-I, both the depositional surfaces are unpaired and overlie the basement rocks. The geomorphic map (Fig. 4.12) shows the Kim river has two unpaired surfaces. The LPDS surface occurring on the left bank is much extensive than LHDS surface (Fig. 4.13). At downstream end the surfaces of the Kim river descends by about 3 m because of the presence of a knickpoint expressed as a water

Fig. 4.11 Photograph showing the two depositional surfaces at Punjabnagri. The Late Pleistocene Depositional Surface (LPDS) is at higher elevation and lower one is Late Holocene Depositional Surface (LHDS).

fall. Downstream of the knickpoint, incised cliff exposes rock occur on either banks of the river.

At Itakla the Kim river enters in the morphostrucutral domain–II. The basement rocks consisting of trappean and Tertiary rocks show sharp contact which marks the Rajpardi Fault (Fig. 4.14). Here, both the depositional surfaces overlie the Tertiary rocks. Here, there is presence of boundary fault in the form of reverse fault. Both the depositional surfaces shows gravelly and sandy facies. Downstream of the surfaces the channel takes an abrupt turn

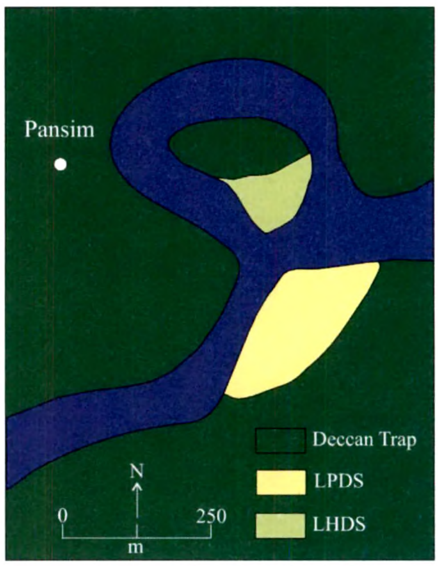

Fig. 4.12 Geomorphic map of the area around Pansim in morphostructural domain I.

Fig. 4.13 Upstream view of Kim river showing the two depositional surfaces overlying trappean rocks at Pansim. On the right is the Late Pleistocene Depositional Surface (LPDS) while to the right is the Late Holocene Depositional Surface (LHDS).

trend E-W and follows a E-W trending fault seen in the Tertiary rocks exposed in the river bed (Figs. 3. 17, 4.14).

In the central part of the Kim basin i.e. morphostructural domain-II, the LPDS occurs in patches within the topographic lows, while the topographic highs are occupied

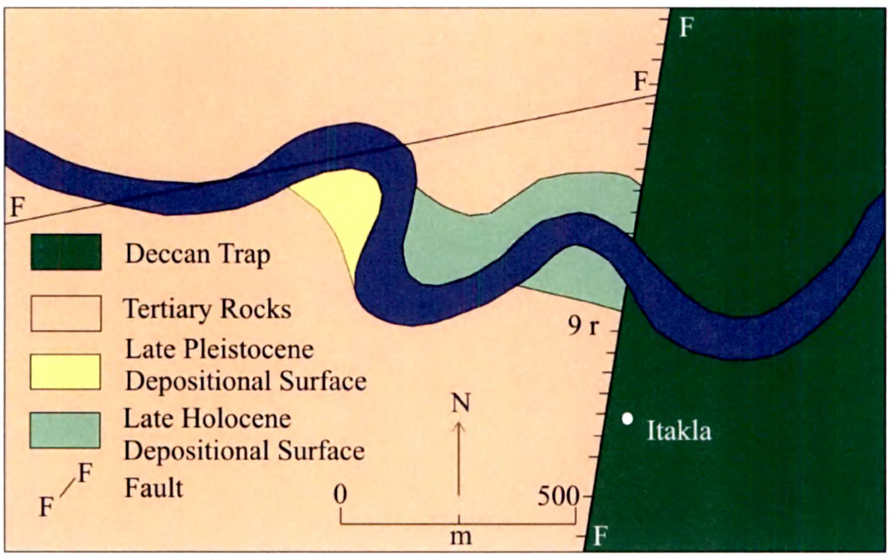

Fig. 4.14 Geomorphic map of the area around Itakla.

by the EPES as described earlier (Fig. 4.1). In morphostructural domain-II, the deposition was confined within the topographic lows created during Late Pleistocene. The formation of this is the result of a major aggradational phase in Kim river basin. This LPDS surface is in morphostructural domain-II occurs as a flat surface typically corresponding to the morphology of the alluvial plain. At places, this surface terminates abruptly against the EPES surface (Fig. 4.6). The sharp contact of these two surfaces is seen in the area around Dungri, Dinod and Kosamba anticlinal area where they terminate against the EPES surface (Fig. 4.6).

The Kim River has incised the LPDS by about 10-15 m all along its course (Fig. 4.15). The alluvial sediments forming LPDS unconformably overlie the deformed Tertiary rocks. The sediments are well exposed in the vertical cliff sections, the details of which are given in the next chapter. The fluvial sediments forming the LPDS represent a

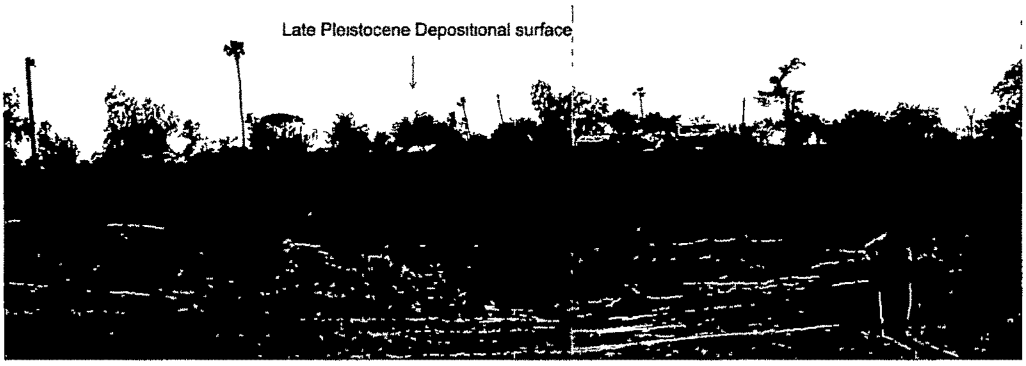

Fig. 4.15 Photograph showing a part of the large entrenched meander at Deshad. Note the incision of the Late Pleistocene Depositional Surface (PPDS).

depositional phase which followed the prolonged phase of intensive tectonically controlled erosion. This indicates the waning intensity of tectonic activity during the Late Pleistocene.

This LPDS surface comprises gravel facies of different depositional environments. Here, gravels are overlain by thick deposits of pedogenised clay showing vertic characters. Due to pedogenesis the clays do not show any depositional features and consist of calcretes which are nodular in shape. This pedogenised clay is overlain by cross-stratified gravel. At some places, the LPDS surface is eroded and highly dissected upto 10-15 m. In the morphostructural domain-III, this surface is seen as vast plains which is used for agricultural purpose.

EARLY HOLOCENE EROSIONAL SURFACE (EHES)

The Early Holocene Erosional Surface (EHES) occurs dominantly in the morphostructural domain I and II. This surface developed due to post depositional erosional activity over the Late Pleistocene Depositional Surface (LPDS). The surface comprise deep ravines and is confined in a narrow belt along the various river valleys (Fig. 4.2).

In morphostructural domain-I, this EHES surface is well exposed in the form of deep gullies. In this domain-I, this EHES surface covers a wide zone in the form of güllies in this surface. Away from the river valley, it abuts against the trappean basaltic rocks. This EHES surface occurs at a height of 10-12 m in the form of river cliff of LPDS surface. In morphostructural domain-I, this EHES surface occurs on both sides of the river. In morphostructural domain-III, this EHES surface shows a very limited occurrence.

In general, the ENES extremely dissected and gullied erosional surface which is well developed in Morphostructural domain I and II of Kim river basin. The surface marks a phase of fluvial erosion, which post-dates the alluvial deposits forming the Late Pleistocene Depositional surface (LPDS). At several places in the Kim basin, the LPDS shows deep gullies and ravines upto 8-12 m deep along the courses of the various rivers (Fig. 4.16). The dissection of LPDS in morphostructural domain I and II points to contemporaneous phase of erosional activity. In morphostrucutral domain-I, well developed ravines in the alluvial deposits are seen around Pujnabnagri, Pansim and Daulatpura. The gullies are found to gradually become deeper as they approach the river channel. The gullies range from few tens of meters to a couple of hundred meters in length. Various smaller gullies converge to form a major gully giving an extremely

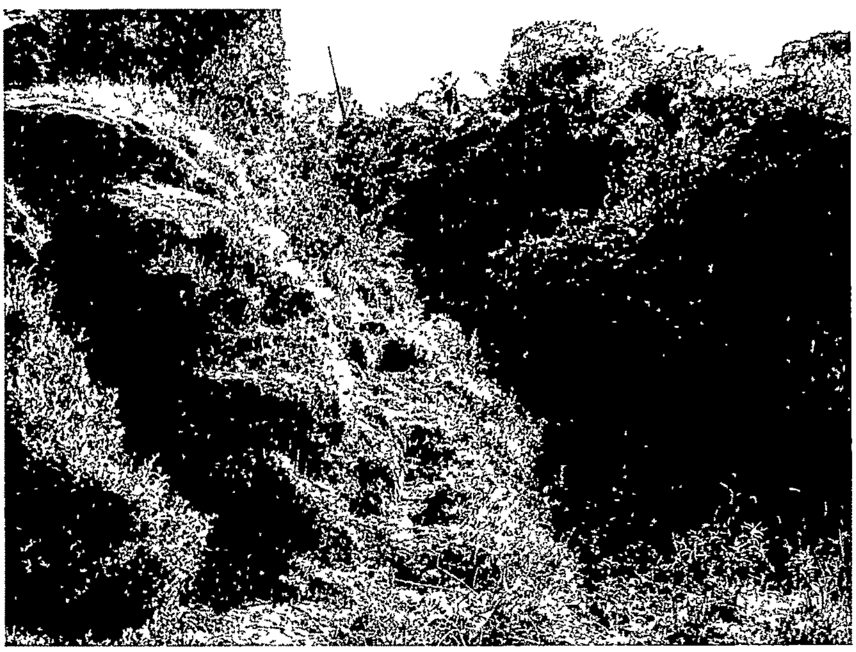

Fig. 4.16 Photograph showing gullied landscape in Late Pleistocene Depositional Surface at Velachha.

dissected aspect to the landscape. Several gullies are found to begin within the trappean rock (Fig. 4.17), which further continues into the alluvial deposits comprising the LPDS. This suggests that the gullied erosional landscape developed over the trappean basement rock in the vicinity of the stream courses were during the same erosional phase that was responsible for the incision of the LPDS. An important geomorphic evidence to constrain the time of this erosional phase is provided by the Late Holocene Depositional Surface (LHDS) which are not affected by the ravines or gullies. Further the ravines are not seen to extend from the Late Pleistocene Depositional Surface (LPDS) to the Late Holocene Depositional Surface (LHDS). The erosional phase therefore post-dates the deposition of LPDS but pre-dates the LHDS. This morpho-stratigraphic relationship among the surface is the same all over the Kim river basin. In morphostructural domain-II the ravines, gullies are well developed around Velachha, Sinada, Gondhu and at several other places.

Fig. 4.17 Photograph showing view of gullied landscape developed over trappean rocks in morphostructural domain-I at Pansim.

The study therefore infers that the incision and erosion of the Late Pleistocene Depositional Surface took during Early Holocene. It is also suggested that the incision and erosion was induced by tectonic uplift of the area. A correlatable phase of tectonically induced fluvial erosional phase has been reported from the nearby Lower Narmada valley (Chamyal et al., 2002) and Mahi and Sabarmati basins further north (Maurya et al., 2000). The formation of the Early Holocene Erosional Surface in the Kim river basin suggest a new phase of tectonic uplift of the area related to the inversion of the Tertiary sedimentary basin.

LATE HOLOCENE DEPOSITIONAL SURFACE (LHDS)

The Late Holocene Depositional Surface (LHDS) is a low valley fill surface which occurs about ~5 m above the river bed. This surface is well exposed and developed morphostructural domain-III followed by domain-II and finally by domain-I. The deposition of the sediments of the LHDS correlates with the Mid-Late Holocene high sea. The fluvial sediments are mostly sands and silts with the coarser fractions dominating in the upstream reaches.

The Late Holocene Depositional Surface (LHDS) is represented by a flat undissected terrace surface that typically occurs about 4-8 m above river level (Fig. 4.18, 4.19). This surface is seen to be well developed in all the three morphostructural domains of the Kim river basin. The sediments comprising the LHDS belong to two distinct depositional environments – fluvial and tidal-estuarine. These fluvially formed LHDS surfaces are found in all the three morphostructural domains whereas the tidal-estuarine LHDS occur in the estuarine reaches only. In morphostructural domain I and II, the LHDS occurs as a typical inset valley fill terrace that truncates against the LPDS or EHES away from the river. In morphostructural domain-I, the LHDS abut either against

Fig. 4.18 Photograph showing generalised view of the Late Holocene Depositional Surface (LHDS) at Itakla. Note the stratification in the sediments that make up the surface.

Fig. 4.19 Photograph of the Late Holocene depositional surface and associated sediments at Pithor.

the LPDS or EHES or the trappean country rocks. At Punjabnagri the LHDS occurs on the right bank of a deeply entrenched meander on the channel of Kim river. Further away it abuts against the LPDS shown an abrupt rise in elevation. On the left bank, the trappean rocks are exposed in the vertical cliff of about 12 m high. At Pansim, the LPDS overlies the trappean basement and occurs on the right bank of the river channel (Fig. 4.13). The left bank at this place exposes the Late Pleistocene sediments. At Daulatpura, the LHDS occurs as a paired surface and on the left bank abuts against the dissected Late Pleistocene alluvial sediments (Fig. 4.7). The LHDS on the right bank abuts against the trappean rocks. At all the above mentioned places in morphostructural domain-I, the LHDS occur on the inner bends of tight entrenched meanders. However, they show a clear incision of 4-8 m and are comprised mostly of fine sands and silts.

In morphostructural domain-II, the LHDS is seen to be well developed at Itakla (Fig. 4.18), Singla, Pithor (Fig. 4.19), Gondhu and Kara. Further downstream in the estuarine zone in morphostructural domain-III, the LHDS form continuous cliffy exposures all along the channel of Kim river, which it almost imperceptibly merges into the LPDS on either sides of the river. A distinct increase in the incision of the LHDS is observed in this domain as correspond to morphostructural domain-I (Fig. 4.7). Here, the LHDS is incised by about 5-10 m. Lithologically the LHDS in morphostructural domain-II consists of coarse gravelly deposits which is in complete contrast with the fine silts and sands of the LHDS in morphostructural domain-I. In morphostructural domain-III, the LHDS is seen to comprise typical estuarine facies. The LHDS in Kim river basin points to a Mid to Late Holocene phase of aggradation after the erosional phase of Early Holocene.