CHAPTER - VI

LANDSCAPE EVOLUTION

GENERAL CONSIDERATIONS

CONTROLLING FACTORS

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LANDFORMS

GENERAL CONSIDERATIONS

In the foregoing pages, the author has critically analysed the various landscape characteristics of the study area, and has attempted to bring out the terrain diversity in terms of various geomorphic parameters. Obviously the landscape evolution as reflected in the present day geomorphology and the landforms, point to a protracted history, extending back to millions of years since the close of the Coretaceous period. In the course of last 60 million years, the area has undergone a variety of geological changes - faulting, volcanism and sea-level changes. All these have manifested themselves in the terrain diversity of the present day. Volcanic lava flows of the Deccan Trap, sedimentary rocks of the Cretaceous and Tertiary systems and the residual, fluvial and marine sediments of the Quaternary period, all these have been subsequently carved into erosional and depositional landforms, finally combining to give rise to the present day topography. The fascinating diversity of the landscape as encountered in the study area, ideally reveals a succession of depositional and erosional events, each having been brought about by sub-aerial and subterranean processes. It is therefore worthwhile to discuss, at this point, some of major factors and processes of landscape evolution, and also to describe the resulting landforms as encountered in the different physiographic units.

CONTROLLING FACTORS

The factors that have controlled the landscape evolution, comprise mainly (1) geological and (2) Climatic. As has already been made out in the various preceding chapters of this thesis, the physiographic divisions of the study area are characterised by their distinct geological features, over which have been superimposed diverse sets of climatic controls. The author proposes to briefly highlight the salient features of the controls exercised by these two factors in different parts of the area.

Geological Control

Lithological and structural aspects of the geological control, could be spelt out as under :

1. Lithological

The response of the rocks belonging to the geological formations of different ages, to the processes of erosion, has been essentially controlled by the lithology of the constituent rocks.

2. Structural

The structural characters of the various rocks, including stratification, fold styles and dimensions, faulting and jointing, all these have played an effective role in sculpturing the landscape.

Climatic Control

The effects of climatic factors, viz. temperature, rainfall and wind, show strikingly varied manifestations. Although, in a relative sense, the study area constitutes only a small portion of the Mainland Gujarat, it shows marked variation in the climatic factors, and this variation in turn, is reflected in the terrain evolution diversity. The overall meterological conditions of the area constitute a sub-tropical moist climate, which is significantly characterised by irregularities in rise and fall of temperatures and the uncertainty of the rain; the heavy or low rainfall, either of short period, or of the long duration or even of long intervals too.

In a general way, normally the study area from west to east, shows maximum temperatures between 40°C to 54°C (Summer), the minimum temperature range being between 7°C to 13°C (Winter), and it receives rainfall between 1200 mm to 2200 mm. But when examined in detail, the effects of altitude, nearness or otherwise from the coastline and variation in the rainfall pattern, have combined to give rise to several micro-climatic zones, and these zones have affected the rocks differently. This micro-climatic variation, prevailing within the study area is further described below :

1. Temperature : The temperature variation normally depend on the (i) altitude and (ii) distance from the sea, and the hilly terrains in the east, which rises to heights as much as 882 m, should normally show some effect of altitude. But this lowering of temperature is nowhere recorded. Possibly, this phenomenon might be playing effective role, at the various higher summit points, but for which no recorded observations are available. Barring this, on a regional basis the temperature variation during various seasons from coastline to hilly terrain more or less remain comparable, as will be seen from the following Table below :

Table VI - 1 Regional Temperature Variation.

	Summer	Rainy	Winter
I. Hilly Terrain			
Stations : Dediapada, Sagbara, Rajpipla, Kawant & Chhota Udaipur.	D 46°-54°C N 28°-34°C	D 45°-48°C N 25°-30°C	D 18°-25°-C N 7°-11°-C
II. Uplands & Coastal Plains			
Stations : Netrang, Jhagadia, Dabhoi.	D 44°-48°C N 25°-30°C	D 38°-44°C N 20°-24°C	D 16°-13°C N 9°-13°C
III. Coastline			
Stations : Bharuch & Ankleshwar	D 40°-42°C N 18°-24°C	D 38°-40°C N 20°-22°C	D 18°-20°C N 9°-12°C

(Data are average temperatures stations)

Obviously, it can be inferred that the role of temperature might not be considered as effective as one would expect it to be.

2. Rainfall : Though the total annual rainfall does not show any significant variation in the different parts of the study area, it however in combination with other metereological and geological factors, does show variable denudational or erosional effects. The annual rainfall varies between 1200 to 2200 mm and is confined to the four monsoon months from July to October, the total rainy days ranging between 45 to 70 days. In a general way, the amount of rainfall comparatively tends to increase from west to east. The monsoonal winds from the sea, enter the study area from the W and SW and when the hills of eastern trappean terrain obstruct them, the area receives heavy rain. Thus, the number of rain days is more and the intensity of rain also tends to be more towards the east. Normally July and August are the months of heavy rain, and almost 60 to 70% of the total rainfall, is received within a period of 40 to 45 days during these months. The month of September also receives heavy showers and with this month, 90% rain of the year is received in 58 to 64 days. The rainfall is not uniform; it is rather irregular and sometimes is torrentially heavy confined to a short duration. It is commonly observed that the area may not receive rain in the months of July and August, but the

September and October may be unusually wet. Similarly, the first two months could be usually wet to be followed by dry September and October months. The three zones from east to west tend to show following rainfall characteristics.

i. Eastern hilly terrain : 1500 - 2200 mm in 60 to 75 days, relatively heavy rainfall, tropical monsoon rain, irregular, torrential and uncertain; cause heavy runoff, frequently floods in tributaries and main rivers; brings about effective erosion and some transportation.

ii. Uplands and coastal plains : 1600-2000 mm in 55 to 60 days relatively steady yet irregular and uncertain; not uniform; brings about erosion and deposition; local floods etc.

iii. Coastline : 1200 - 1700 mm in 45 - 50 days, rainfall is comparatively steady and casually associated with the sea-storm; mainly deposition durigg floods, except along the coast where some coastal erosion due to sea waves.

3. Humidity : It is but natural to expect a higher values for relative humidity in the coastal areas as compared to those of the hilly terrains of the east, also these values tend to vary from summers to winter through rainy season. These factors appear to have played rather a very insignificant role in the sculpturing the landscape, except, in aiding the erosive processes through chemical 'in situ' weathering.

4. Winds : The role of winds is worth mentioning. During monsoon months, the southwesterly winds are responsible for causing heavy rainfall, especially in the hilly terrains. The monthly winter winds have been observed to provide some local shifting of unconsolidated sand etc. along the hill slopes and river beds.

OPERATING PROCESSES

The various controlling factors, having manifested themselves into numerous denudational and depositional phenomena, operating in the different parts of the study area and provide a fairly well defined picture of landscape evolution. It is not at all an easy proposition to describe the complex evolutionary history of the terrain because of considerable gaps in the available information in terms of space and time, effective during Quaternary period. The author has however, attempted to provide a picture of the landscape evolution, by discussing the following dominant processes responsible :

1. Weathering
2. Fluvial action
3. Coastal processes

Of the above three processes, weathering is most effective in the hilly terrain, somewhat less effective in the uplands while its effectiveness in the coastal plains is minimum. Fluvial processes appear to be quite effective almost all over the area, but in the hilly terrain these cause erosion while in the other two zones, the fluvial action is erosional as well as depositional. The coastal processes obviously restricted to the coastline, are both erosional and depositional.

1. <u>Weathering</u> : The term weathering has been used to indicate the effects of atmosphere on the rocks, and to include both mechanical disintegration and chemical decomposition. The various factors which control the weathering are :

1. Temperature and rainfall
2. Rock types,
3. Joints and fractures
4. Vegetation

All these factors have played their due roles individually as well as collectively, but the extents to which each has been effective vary from place to place. It is however, not always possible to specify precisely the nature of weathering, whether it is only disintegration or decomposition, and distinctive analyses of weathered and eroded material are also not very easy.

The major climatic variations like temperature and rainfall affect the rate and extent of weathering. The temperature changes comprising repeated processes of heating and coolings mainly control the mechanical weathering, and it is observed that the different rock types, viz.

Plate VI 1 Round top low altitude ridge, showing effects of weathering and erosion (Locality : Right bank of river Terav, near village Zampa).

Plate VI 2 Round top basaltic hill showing distintegration along joints and accumulation of scree material (Locality : The left Bank of river Terav near village Sada and Bej).

Plate VI 3 Weathering and erosion of basalt along sub-horizontal joints (Locality : Cliffy bank of Mohan khadi near village Thava).

Plate VI 4 Rocky and cliffy bank of the river Terav (Locality : Near village Zampa).

basalt, sandstone, shale and limestone have reacted differently to the temperature changes. The extensive jointing and fracturing of the trappean terrain has facilitated the mechanical disintegration; the block separation is the initial phenomenon, followed by widespread exfoliation along minor joints and cracks developed on the blocks, and finally ending up into surfaces of spheriodal weathering or disintegration of the entire mass into weathered angular pieces. (Plate VI 1,2,3).

So far as chemical weathering is concerned, its effect is widespread in the basaltic terrain. The minèralogical compositions of the constituent rocks, viz. feldspars and pyroxenes which are silicates of calcium, sodium, aluminium and of iron and magnesium, are most susceptible to chemical changes brought about by atmospheric moisture as well as rain and river waters. The presence of dissolved Co_2 in water augments to this process of chemical break up. The distruction of the original minerals into a variety of clays, calcium carbonate and released iron-oxides, ultimately end up into a considerable softening of the basalt and the subsequent removal of the chemically derived products. The process of Chemical weathering is facilitated by the cracks and joints. With break of monsoon, the action of chemical weathering in the trappean terrain starts. The water enters through cracks and joints and reaches to considerable depths. As the water seeps through the edges and corners of the rocks are chemically affected. The weathered material becomes soft and increases in volume, this further exerts strain on the solid mass. A long continued process of chemical weathering causes a gradual rounding of the corners and convert the rock mass into numerous spheroidal boulders. As the process penetrates deep down, the weathered material is scaled off into concentric layers.

It is further observed that in the rainy season, due to heavy showers the water table of the area rises and it is possible that some chemical changes are brought about by groundwater also. The final product of the chemical weathering is easily identified in the field, though it is commonly mixed with mechanically derived angular fragments. These angular fragments also undergo chemical weathering and tend to get subrounded. The chemical products occur in the form of '<u>in-situ</u>' residual coarse soil within which occur numerous ball-like bounders and cobbles of exfoliated basalt.

The total effect of mechanical and chemical weathering is reflected in the step-like rugged topography of the basaltic terrain, the entire landscape characterised by successive plateau surfaces dotted with hills an d separated from one another and those of differing altitudes by steep cliffy slopes. The products of weathering thus derived, either remain untransported forming a cover of residual soil over the flat topped hills and plateaux, or they accumulate at the base of the cliffs and slopes as scree material. Finer products are carried towards uplands and coastal plains.

Obviously, the undulating landscape of the trappean uplands, which typically represents a denuded basaltic terrain, in a way point to the ultimate result that would be generated by the culmination of the processes seen operating to-day on the high altitude basalts. The trappean uplands are thus the end product wherein processes of mechanical and chemical weathering have been functioning in union with transportation and deposition of the waste material by fluvial action. The fine sand, silt and clays, that originate in the trappean hills are either deposited on the uplands and alluvial plains or dumped into the sea as estuarine mud.

The processes of weathering in the terrain comprised by low altitude alluvial plains to the north of Narmada and the Tertiary uplands (south of Narmada), are quite different from those discussed above. The original configuration and altitudes of these physiographic units were quite distinct right from the very beginning, and the weathering processes have also acted somewhat differently over them. Except for the sporadic hills of basalts and dyke ridges, these areas comprise sedimentary rocks of low dips and made up of sandstones, shales, marls and limestones etc. The mechanical weathering in sandstones, marls and shales, is much less striking as compared to traps. In massive finegrained sanstones, exfoliation and mechanical breaking up is quite well marked, but in thinly bedded sandstones, the parting plaines, mainly bedding, provide the split planes. In the case of shales the fossility of the rock facilitates mechanical breaking up; the total mass breaking up into heaps of angular fragments.

The chemical weathering is confined to the breaking up of feldspars into clays, leaching of limestones and disintegration of ferruginous sandstones by the hydrolysis of iron bearing matrix/cement. As a result, the sedimentaries, in totality produce a vast bulk of sand, silt and clay, which are transported to various distances by the action of rain and river water. The weathering process ultimately causes a smoothening of the topography, giving rise to a sort of rolling landscape through which fault controlled hills of sedimentaries as well as of trap and dolerite project out.

The landscape of the alluvial plains and the Tertiary uplands, ideally reflects a combination of the processes of weathering followed or accompanied by deposition.

2. FLUVIAL ACTION

Fluvial action responsible for the landscape evolution is mostly restricted to the erosional and depositional processes of the twelve main rivers. Almost all rivers originating in the hilly terrains of the east, during their seaward journey have sculptured the area into a variety of landforms. Normally, starting from the altitudes above 300 m, it is observed that in almost all cases the 1st, 2nd, 3rd and 4th order streams mostly cause erosion and transportation of sediments, while the trunk streams (5th order onwards) are the sites of both erosion and deposition.. The processes of sculpturing by the action of rivers, no doubt, have been influenced by the factors of geology (lithology and structure), and taking all these into consideration, it has been observed that the fluvial action is characterised by well marked differences in the following three parts of the area :

1. Terrain north of the Narmada.
2. Terrain south of Narmada and east of Karjan
3. Terrain south of Narmada and west of Karjan.

1. Terrain North of Narmada

The action of the various rivers (Heran, Aswan, Men, Ruwel and Narmada) draining this part of the area, happens to comprise erosional as well as depositional.

Roughly, 55% and 45% are the proportions of the terrain, distinctly showing the erosional and erosional-cum-depositional work of the streams respectively.

Originating in the hills, the low order channels not only derive sediments by vertical erosion, but the erosion of hill slopes, soil and mass-wasting also provide load to the streams. On emerging over the low gradient terrain, the intensity of vertical cutting is considerably inhibited, while lateral erosion and cutting of the banks increases. The total detritus carried by the rivers at this stage is both the transported load as well as one generated locally during the local flow. Some of the coarser material is dropped along the channel bottoms and/or meander curves, while the finer particles are carried further downstream. The only depositional features encountered along the plains, are the gravel and pebble beds, and sporadic flood plains.

The Heran river and its two main tributaries Kara and Rami, illustrate ideally the differences in the erosional pattern within the hilly terrain. Their courses are remarkably straight. While the Heran Nadi (the upper course of the main river) has denuded the relatively low altitude hills of Phulmal and Panwad (400-500 m) excavating a relatively wide valley, the Kara and Rami nadis flowing through Kawant and Ambadungar (500-700 m) are observed to have carved narrow deep valleys. West of Panwad and Kawant, the confluence of all these streams forms the Heran river, which flows westward across the alluvial plains.

2.2 Terrain south of Narmada and East of Karjan

The landscape of this trappean hilly terrain, is by and large controlled by the action of fluvial processes, manifested in the form of NW flowing rivers like Devganga and Karjan and their numerous tributaries. The rainfall being significantly high, during the monsoon months the surface run off as well as the rapidly flowing streamlets bring about considerable erosion. As the surface and slopes of the terrain is controlled by highly jointed horizontally layered lava flows, the resulting land features provide an aggregate of dissected plateaux of all dimensions with intervening steep sloped narrow valleys and Khadis. It is quite obvious that the joint and fractures pattern have controlled the fluvial processes, and the course of the streams of various orders, are seen to be mostly straight if they follow a major joint or are zig-zag if they flow through intersecting joints. Most of the hilly (low order) streams are emphemeral, while the higher order streams (5th, 6th, 7th & 8th) are perennial. But all these bring about erosion of the trappean surface by vertical cutting and transportation of the rock debris derived by the surface wash as well as stream erosion. Except accumulation of gravelly and coarse sandy material at such spots on the successive plateau levels, where the stream velocities show temporary breaks, nowhere significant depositional processes are seen to be operative, except where the perennial streams impinge upon the uplands. The Karjan and Terav rivers, flowing over uplands are observed to deposit a large portion of their suspended load in the form of gravel and pebble beds and islands along their courses. Due to lack of slope and augmented supply of water during monsoon period, these rivers are also observed to widen their courses by lateral erosion. (Plate VI 4, 5, 6).

3. Terrain south of Narmada and West of Karjan

This portion of the study area, includes trappean hills, uplands and coastal plains, and as such shows several diverse effects of fluvial action. The landscape, spanning from the hills of basalt in the east upto the actual coastline in the west, consists of a wide variety of erosional and depositional features. The fluvial action in the extreme trappean hilly area is almost identical to that described for the terrain east of Karjan. It is only when the various streams emerge over the uplands that they cut down their erosional intensity, and the fluvial processes here show combined effects of erosion as well as deposition. Drained by the three major NW flowing tributaries of Narmada, Amaravati, Kaveri and Madhuvati, and the west flowing independent consequent river Kim, this part of the terrain is characterised by a rather subdued landscape with undulating to gently rolling topography, where the various streams perform both erosion and deposition. While flowing within the uplands, erosion is confined along the river courses only, especially where smaller tributaries meet them. A significant phenomenon of erosion - deposition is observed in the streams that flow over the Tertiary uplands. As has already been alluded to in the earlier chapter on drainage, the various rivers streams that flow westward follow almost gradientless structural low's (of the underlying Tertiary sedimentary rocks), give rise to numerous meanders, where both the processes of erosion and deposition operating simultaneously on the opposite banks are observed. A well-defined entrenchment of 3 to 10 m of such meandering stream courses, attributed to neotectionism, points to the vertical cutting action of these streams. On going towards the coastal plains, the meanders become more pronounced but the entrenchment progressively decreases, the process of deposition becoming almost exclusively operative. The landscape related to the fluvial action along the coastal plains thus comprises alluvial plains, meanders and flood plains.

3. COASTAL PROCESSES

The role of coastal processes is restricted to the neighbourhood of the actual shoreline and the effective agents responsible for sculpturing the coastline, are essentially related to the marine processes; viz. waves and tides. The wind action and the nature of the near offshore substrate control the intensity and effectiveness of the wave action (Surf), while the heights upto which the tidal water rise control depositional features, especially along the estuaries and backshore lagoons. The action of waves, aided by longshore drifts and currents, has given rise to well defined beaches along the shoreline. Due to strong wind action, sands have been lifted up and dumped above the berm line to give rise to longitudinal sand dune ridges. Accumulation of tidal muds along the river mouths and other such sheltered spots, are seen to be the characteristic depositional features that are related to the interference of fluvial and marine processes. The river Narmada has however developed big mouth bar of Alia bet. The Kim river mouth is marked by extensive mudflat through which the river flows for several kilometers before meeting the sea.

During stormy conditions when strong winds generate breakers, it is commonly observed that along the coast, some erosion is also brought about and occasionally along the shoreline, one comes across the effects of the attack of high energy waves on the coastal dunes, giving rise to well marked cliffy bermline.

LANDFORMS

The fascinating diversity of the landscape as encountered in the study area, ideally reveals a succession of depositional and erosional events, each having been brought about by subaerial and subterranean processes, and the resulting landforms as are encountered in the different physiographic units, are given in two accompanying tables (Table VI 1 (i) and VI 1 (ii).

TABLE VI 2 (i)

THE LAND FORMS

EROSIONAL LANDFORMS

No.	Land Form	Physiographic Division, Unit and submit	Note
HILLY TERRAIN			
1.	High altitude ridges and steep sloped conical hills. (Relief altitude : between 500 to 880 m).	Div. 1 and 2.	Rectangular flat topped ridges have conical hills rising 20 to 30 m above the ridge top. Tops and slopes of the ridges have thin weathered soil cover, and scattered boulders.
2.	Plateaux	Div.2 I & II (i) (iii)	These are Dissected plateau; having thin soil cover of residual weathered material. Agricultural fields and other grounds show trap fragments of different sizes, strewn all over.
3.	Low altitude ridges and conical hills.	Div. 1 I (i), (iv), (v). Div. 2 II (ii), (iii), (iv).	Flat topped conical hills with gentle slope, Residual soil cover and hill slopes have scree channels, with accumulation of weathered and erosional material.
4.	Cliffs and Escarpments. (Plate VI 7)	Div. 2 I & II	The high altitude ridges and plateaux slopes show cliffs between 500 to 800 m altitude. Weathered cavities and rill-channels are observed on the cliffs and escapements.
5.	Waterfalls (Plate VI 8)	Div. 1 I. Div. 2 I & II.	Several khadis and rivers like Devganga, Terav, Karjan and Narmada show waterfalls in trappean terrain, drops of water 3 to 15 m.

No.	Land Form	Physiographic Division, Unit and submit	Note
6.	Spurs and Secondary ridges	Div. 2 I & II	From high altitude ridges and plateaux, the spurs are formed and extend towards low altitude, observed as parallel secondary ridges running towards the valleys of the rivers Devganga, Terav, Karjan and Narmada.
7.	Intermontance stream or valleys (Khadis)	Div.1I, Div.2I & II	Khadis comprise such valleys between the high altitude ridges and hills. Criss-cross dissection is widely responsible for the formation of such land features.
8.	Meander or Zig-zag course with bends or loops.	Div.2 I & II	The river Terav, Karjan and some Khadis (Bogla, Kalinadi, Som etc.) have formed bends or loops by their so called meanders. Nice loops or bends are observed in the river Terav near villages Gadi and Bogaj.
	UPLANDS		
9.	Low altitude Ridges (200 to 300 m altitude)	Div.3 units I, II & III	Broad Flat topped, rectangular shaped or linear or parallel. The conical or sharp summit hills rising 20-30 m over the top of the ridges.
10.	Conical hills	Div.3	Linear conical hills (Dykes) are of irregular shapes and sizes. These hills have sharp summits or round tops and gentle slopes.

No.	Land Form	Physiographic Division, Unit and sub Unit.	Note
11.	Undulating uplands	Div. 3	
12.	Broad shallow depressions or broad valleys or Gullies (Plate VI 9)	Div. 3	Rivers Karjan, Kim, Amaravati and Kaveri have dissected the uplands, depressions are carved of order 5 to 10 m deep and are 200 to 300 m broad.
13.	Meanders and entrench meanders & Alluvial Cliffy banks or rivers. (Plate VI 10)	Div. 3	Neotectonism/structural control 5th, 6th order streams or main rivers are observed deep seated or incised. The cliffy banks are 7 to 15 m high (Sand, silt and clay)
	THE PLAINS		
	The types (i) Alluvial Plains (ii) Coastal Plains (iii) Flood Plains.	Div.4 I, II & III	
14	Hills (on alluvial and coastal plains) show height between 60 to 150 m	Div.1 II, Div.4 I & II	These hills are of trap (karali & Phenai Mata) Bagh bed (Bhadarwa hills) and Tertiary (hills on Kadvali uplands). Parallel - linear, clusters or group of hills have sharp summits conical or round summits. Low altitude hills have gentle slopes.

No.	Land Form	Physiographic Division, Unit and Sub Unit	Note
15.	Meanders and alluvial cliffy banks (3 to 5m)	Div. 1 II	Rivers Heran, Aswan and Men are showing meanders; these are becoming broad towards west. Erosion and deposition are simultaneous. Alluvial cliffy banks are observed as depositional feature (Floods are significantly effecting the meanders and cliffy banks).
16.	Entrenched meanders and cliffy banks.	Div.4 I, II.	Neotectonism impact is observed in the meanders showing entrechment of 3 to 10 m deep and 4th, 5th, 6th order streams and main tributaries of Narmada are showing entrenchment.
17.	Flood plains of Narmada, Meanders of Narmada, Terraces of Narmada.	Narmada River Basin	Saucer shaped flood plains are very broad and wide. Three meander curves are broad and wide (Cliffy banks and Terraces are the features of flood plains.
	<u>THE COASTLINE</u>		
18.	Eustarine mouth and Bars	Div.4 III	Funnel shaped eustarine mouth of Narmada has big bars - Alia bet (sand silt and clay) show swampy marsh - mangrove. Even river Kim has also form eustarine mouth near the sea.

No.	Land Form	Physiographic Division, Unit and Sub Unit	Note
19.	Creeks	Div.4 III	Amol Creek and Wand Creek. Small streams flowing in the sea have cut the coastline (deep 3 to 5 m).
20.	Cliffy Shorelines	Div.4 III	Sanddunes are eroded/ cut by strong waves or storms and the shorelines cliffs are formed.

TABLE VI 2 (ii)

THE LAND FORMS

DEPOSITIONAL LAND FORMS

No.	Land Form	Physiographic Division Unit and Sub Unit	Note
	HILLY TERRAIN		
21.	Hill and valley slopes, rock fall and creep of sediments.	Div.1 I	The slopes of ridges, hills and valleys (of rivers Devganga, Terav, Karjan and Heran) are observed to show rockfall (Boulders & stones) and creep of debris (Gravels & stones).
22.	Flood plains (main rivers or tributaries have formed local flood plains)	Div.1 I, Div.2 I, II	The broad banks of the river show the depositional work caused during floods, deposition of debris. Even foot-hill zones of the river and khadi confluence portion shows the deposition of sediments or debris.
23.	Meanders, bend and loop curves have deposition of debris.	Div.3 I & II	Zig-zag or meander course rivers. River banks and curved sides (or sides of bend or loop) show the deposition of sand, clay, gravels and pebbles.
24.	Rocky and/or alluvial cliffy banks.	Div.2 I & II and Div.3 I II	Valley sides and Khadi sides are eroded or cut by the streams and form cliffs. And the sides are showing the depositio of material like clay, sand and silt.

No.	Land Form	Physiographic Division Unit and Sub Units	Note
	UPLANDS		
25.	Zig-zag course of Khadis and rivers Sluggish meander channels, and cliffy banks.	Div. 3 I & II	Khadis, Streams and rivers initial courses are forming zig zag narrow curves, while the lower course form the meanders and curves. As well as river and stream banks are showing the deposition of coarser and fine material, becoming meanders towards the lower course of the streams. The curves and banks are showing deposition of coarser and fine material.
26.	Flood plains	Div. 3 I & II	Wide banks, meander curves and the zone of confluence are the sites of deposition of coarser and fine debris especially sand, clay and silt, this forms the flood plains. Rivers Karjan, Terav, Devganga, Men, Amaravati have formed local flood plains.
27.	The braided river channels and the bars or islands in the rivers' courses. (Plate VI 11)	Div. 1 II, Div. 2 I and Div. 3 I, II.	On the uplands, erosional and depositional work of rivers are simultaneous. Streams cut the banks; separate the courses and these form two or three channels in the rivers course termed as braided channels/streams. The sides of the channels and river banks are showing deposition of gravels, pebbles, sand and silt. Rivers Terav, Karjan, Aswan, Men and Amaravati are showing this type of landform.

No.	Land Form	Physiographic Division unit and Sub Units.	Note
	ALLUVIAL PLAINS AND COASTAL PLAINS		
28.	Meanders and alluvial cliffy banks.	Div. 1 II.	Meander curves are becoming broad, deep cutting of the order 2 to 7 m produce the alluvial cliffy banks.
29.	Entranched meanders and cliffy banks. (Coastal plains)	Div. 4 I, II.	Meanders and even small curves of sub-tributaries and streams are observed to have deepcutting in the structural 'Lows'.
30.	Narmada Meanders and terraces (Plate VI 12).	Narmada river basin (southern bank)	Three meander curves are assymetrical and show structural control. The curve sides have deposition of sand, fine clay and/or silt. Terraces are observed to have deposition of pebbles small gravels and sand.
31.	Point bars and alluvial islands in the river Narmada.	Narmada river basin.	Narmada river course is seen to have islands, Govali, Kabirwad and Aliabet. These Quaternary alluvium deposits are also seems to have effects of sea-level changes, neotectonism and of floods.
32.	Funnel shaped estuarine mouth of Narmada. Estuarine mouth bars or islands, Small estuarine mouth in river Kim. (Plate VI 13 & 14)	Div. 4 III.	In the Gulf of Khambhat, river Narmada has formed estarine mouth, this has mud and sand deposits along the banks in form of bars and big bar in form of an island known as Aliabet - observed to have swampy marsh and mangrove.

No.	Land Form	Physiographic Division Unit and Sub Unit	Note
	COASTLINE		
33.	Sand dunes and ridges	Div.4 III	Sea waves, high tides & storms deposits the sand above the 'berm line', these dunes and ridges are longitudinal marine deposits.
34.	Mudflats	Div.4 III	In the mouth of the river and along the coast or shore the mud deposits are largely observed like raised land forms. The deposition of mud is the inter-action of both sea waves and river action.
35.	Beaches	Div.4 III	The action of waves, aided by long shore drifts and currents; have given rise to well defined beaches along the shorelines ; mud, sand and silt deposits.