CHAPTER - IV

G E O M O R P H I C   A S P E C T S

GEOMORPHIC SUBDIVISIONS

CONTROLLING FACTORS

LANDFORMS

GEOMORPHIC ASPECTS

GEOMORPHIC SUBDIVISIONS

The study area is broadly divisible into three geomorphic zones trending NNE-SSW, quite distinct from one another. They are (I) Coastal plains, (II) Uplands, and (III) Trappean Highlands.

Two major regional faults appear to be responsible for this landscape variation. A, NNE-SSW fault delineates the Uplands from the Trappean Highlands. This fault has been reported by ONGC (Babu, 1984; Rao, 1987) Similarly in the eastern parts of the highlands, the well pronounced escarpment also points to a regional fault. Even the subdivisions of the Trappean Highlands are based on a sequence of E-W faults. These tectonic aspects are discussed in Chapter VI.

I. COASTAL PLAINS

About 80 km wide in the north gradually narrowing down southward to few km, the coastal plains are made up of exclusively unconsolidated Quaternary sediments, fluvial as well as marine. Marine sediments are confined to the coastline and comprise sand and mud accumulation occurring as dunes, beaches and tidal mudflats. Late Quaternary sea-level fluctuations have given rise to more than one generations of coastal sediments (Merh, 1986). Further inland, the sediments are mostly alluvial brought down by the various rivers, and these form featureless agricultural plains, showing distinct terracing along the major river mouths. The coastal marine deposits are seen resting over alluvium, the latter at all places overlie Deccan Trap with varying thickness, almost 100 m in the north gradually thinning to a few meters towards south.

II. UPLANDS

These comprise a transitional zone between coastal plains on one side and the highlands on the other. In a general way the Uplands fall within the altitudes 50 and 100 m. The eastern limit of the Uplands is better delineated by the line which marks an identifiable break in the topography by the sudden rise of the hilly terrain. The Uplands show essentially a low relief and lesser ruggedness, and are seen as an undulating surface with rolling topography dotted with small ridges, hills and mounds, for the most part rocky, but covered with a thin veneer of residual or transported sediments. The zone between the Uplands and the highlands to the east is characterised by local accumulations of alluvium and colluvium. Practically the entire upland zone is made up of Deccan Trap. Within the limits of the study area, the width of the upland zone for the most part varies approximately between 30 to 5 km. Northward, it tends to broaden, but to the south it thins out, with rocky hills occurring quite close to the coast.

III. TRAPPEAN HIGHLANDS

Trappean Highlands, by far, are the most important and dominant geomorphic features. These rise rather suddenly above the Uplands, into a rugged terrain occupying more than half of the study area. Constituating the northern fringe of the Western Ghats, the Trappean Highlands, provide a very unique landscape. Rising from west to east, in a rather step-like fashion, the highlands also show a progressive rise in the height from north to south as well. Combinations of the factors of horizontality of lava flows, response of varying lithologies to erosional processes, trends and intensity of large as well as small-scale fractures, all these have imparted much landscape diversity to the highlands in its different parts. On the basis of this diversity in the overall landscape, the Trappean Highlands, could be sub-divided into four major blocks from north to south as under (Fig.IV.1).

1. Umarpada - Vyara block (III A)
2. Ahwa - Waghai block (III B)
3. Dharampur - Surgana block (III C)
4. Mandva - Kaprada block (III D)

Umarpada - Vyara Block (III A)

Of all the four blocks, this block is comparatively less rugged. Though the hills are flat topped and valleys are shallow wide, but these are of smaller dimensions as compared to those in the south. Elevationwise, a major part shows the average altitude between 150 to 300 m, though a few isolated hills rise up to 450 m. A major fault along the river Tapi cuts across this block such that the portion to the south of the river around

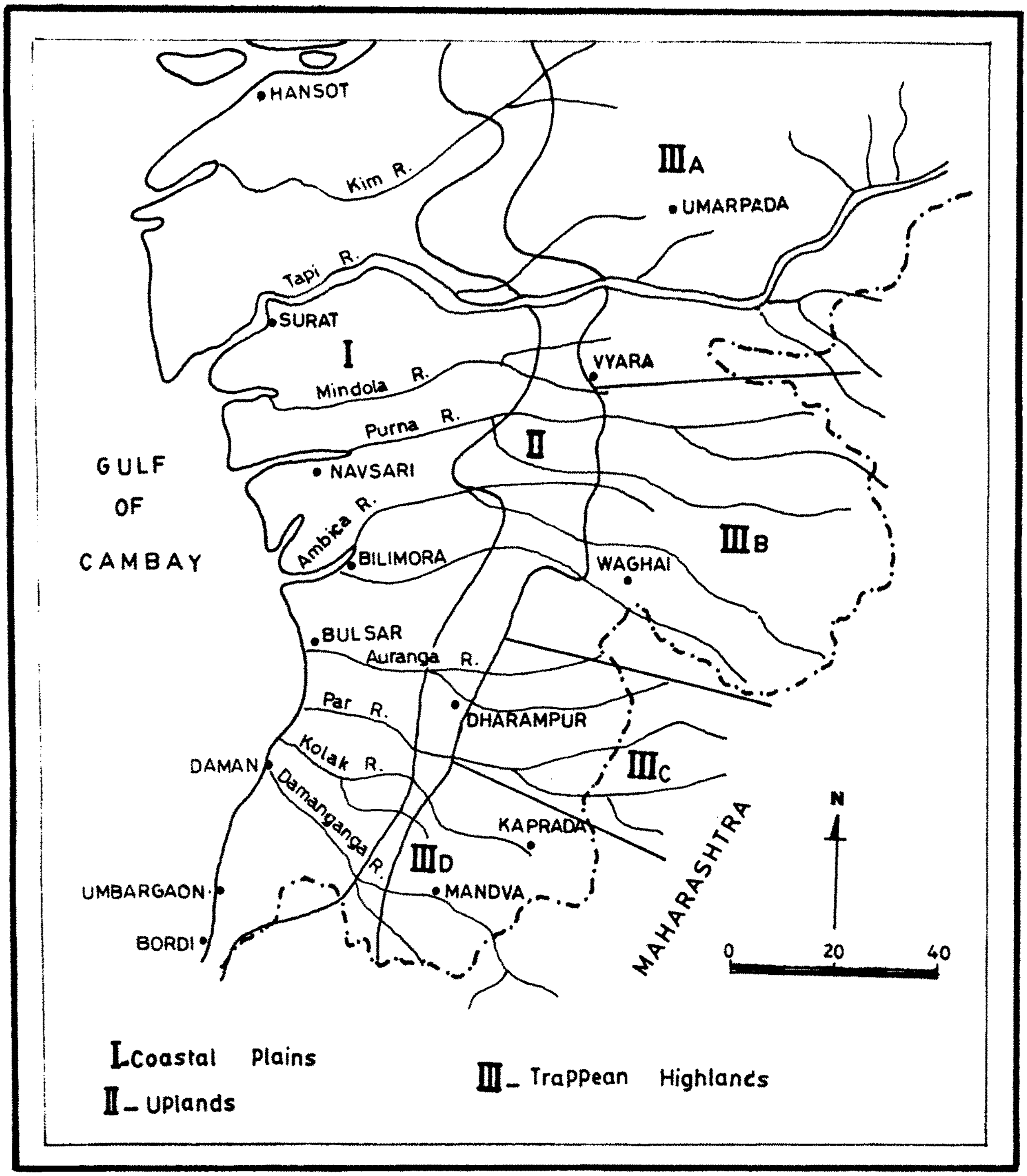

Fig:IV.1 GEOMORPHIC SUBDIVISIONS OF THE STUDY AREA

Vyara averages 100 - 150 m only in altitudes. Higher altitudes are restricted to sporadic hills and to the eastern fringe. The block is considerably dissected by a fracture pattern comprising NNE-SSW and ENE-WSW trending lineaments, though the topography on the whole shows only a subdued influence of these fractures on the landscape.

Ahwa - Waghai Block (III B)

Altitudewise, this block is dominated by hills and ridges which are higher than those in the north. The height variation ranges from 100 m to 600 m, the latter marking the base of the Great Escarpment in the east. A fault along the river Purna, marks the northern limit of this block. Although the hills and ridges, rising to various heights do not show any well-defined trends, but they do exhibit a distinct N-S to NNE-SSW linearity especially in the eastern half. Hills are generally flat topped. The southern limit of this block, is marked by the cliffs of the Great Escarpment, such that the hills rise abruptly to 1000 m or more. A number of west flowing streams, all originating in the escarpment, flow down to the sea. Of these Purna and Ambica are the two prominent ones. NNE-SSW and WSW-ENE fractures are abundantly observed on the satellite imagery as well as in the field (Plates IV.1 & IV.2). The NNE-SSW fractures are more numerous and are quite closely spaced in the eastern part, the intensity and closeness of these fractures are the two main causes for the configuration and trends of hills and ridges.

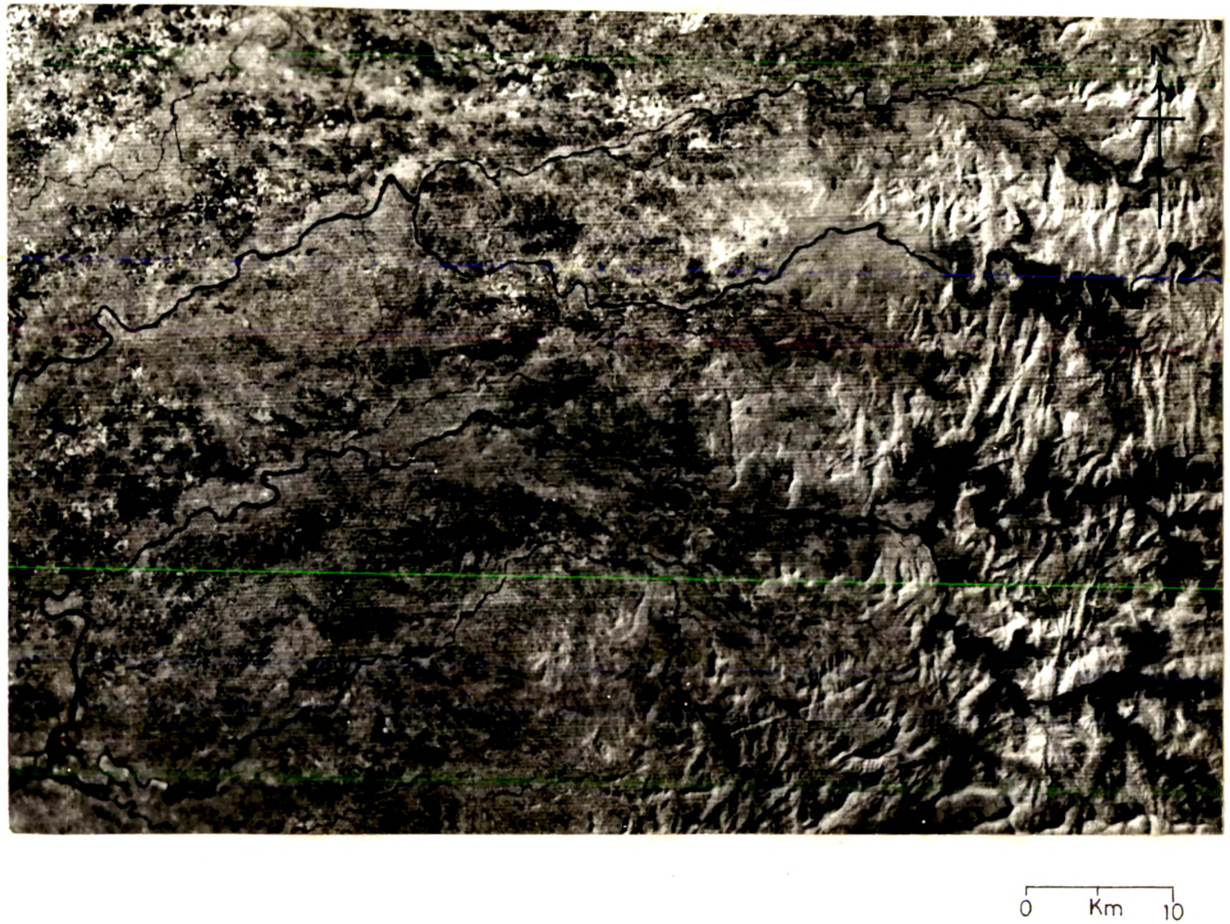

PLATE IV.1 Satellite Imagery (Landsat) of terrain around Purna and Ambica rivers.

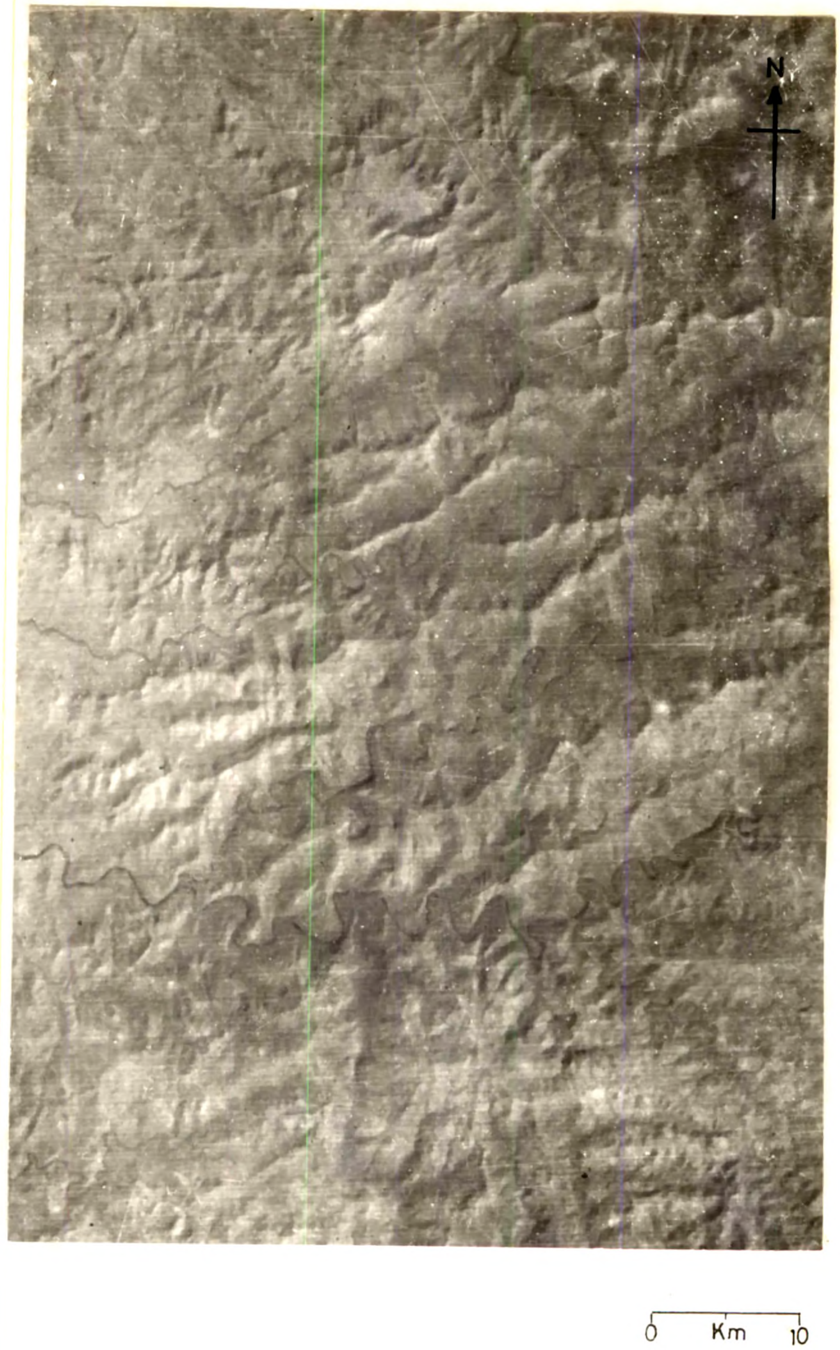

PLATE IV.2 Satellite Imagery (Landsat) of the Southern part of the area.

Dharampur - Surgana Block (III C)

The rivers, Auranga and Par, broadly delimit this block to the north and south. This part of the hilly terrain is most interesting. Topographically it is highly rugged, made up of E-W oriented narrow ridges, that rise to altitudes as high as 700 m. The hill ranges show distinct parallelism and the entire landscape is characterised by narrow flat topped ridges quite often with steep flanks and intervened by V-shaped valleys. The ridges and valleys appear to be products of ENE-WSW to E-W, such that the hill ranges as well as valley sections at many places form steep cliffs. The density of these faults and fractures is maximum in this block. NNE-SSW fractures are also present, superimposed over the former. On account of this superimposition, at many places, the E-W ridges show lateral shifting as well as 'serration' of eastern and western flanks, characterised by a number of entrant valleys and spurs.

Mandva - Kaprada Block (III D)

The southernmost portion of the highlands that lies within the limits of the study area, is topographically different from the previous blocks in the sense that the linearity of the E-W trending ridges is less pronounced. From the point of view of altitude of hills and ridges it is almost at the same elevation, but the trends of the hills and ridges are almost N-S. It has been observed on the lineament map (cf. Chapter VI) that there is predominance of NNE-SSW fractures, and this is reflected in the topographic features. The ENE-WSW faults/fractures are much less pronounced, and there are no major streams flowing in this direction. The courses of the two rivers Kolak and Damanganga when flowing within this hilly terrain are seen to have been considerably influenced by NNE-SSW fractures, in their different segments.

CONTROLLING FACTORS

GENERAL CONSIDERATIONS

As early as the beginning of 20th Century, Davis (1909), categorised the major controlling factors as (1) geomorphic processes, (2) geological structure including lithology and (3) various stages to represent the successive changes in configuration of the landscape with increasing time. The above three factors can be described as under :

The geomorphic processes are further classified as endogenetic and exogenetic. Endogenetic processes include volcanism and diastrophism, while weathering, mass wasting, erosion and deposition by wind, water and ice comprise exogenetic processes. Obviously, the climate and fluvial processes dominate and contribute significantly to the sculpturing and changing the landscape through erosion and deposition. The processes at work in weathering and eroding the rocks are closely related to the factor of climate. Rock weathering is accomplished physically and chemically. Mass exfoliation of rocks due to cyclic heating and cooling of the rocks in regions of considerable diurnal range of temperature is another important process. Spheroidal weathering is the most common manifestation of this. The chemical weathering through hydration, hydrolysis, oxidation, carbonation and solution is more significant. The biochemical refinement of the weathered complex into a soil profile is the most remarkable natural process. Differential weathering bears testimony to the extreme sensitivity of the process even to subtle changes in the rock properties.

Movement of rock material under the influence of gravity, (weathering product down the slope; sliding of rock-mass along joint, bedding, foliation, etc.) falls within the category of mass wasting. According to Sharpe (1938), there are four major classes of mass wasting, dominated by (i) slow flowage (ii) rapid flowage (iii) landslides and (iv) subsidence. The causes that bring about such mass movements generally comprise overloading, over-steepening of slopes, removal of the support by natural agencies. Seismic activity or heavy rainfall can also trigger rock mass movement.

The factor of climate is equally important. The amount, frequency and intensity of rainfall directly affects the process of denudation. Humidity and temperature variations and directions and velocity of winds are also potent agents. Climate also plays a somewhat indirect role through the control exercised by vegetation. The climatic factor influences the kind and distribution of vegetal cover which in turn significantly influences the process of landscape evolution, by providing a protective cover from rain splash, surface wash and gravity action (mass wasting of the underlying rock bodies and soils). Vegetal cover is necessary for the stability of slopes. Vegetation also provides CO_2 and organic acids for enhancing the chemical weathering. Lack of vegetation causes rapid soil erosion and sheetwash and bare rocks are subjected to mechanical weathering. Roots of small plants and bushes bind the soil together and prevent erosion but roots of larger plants and trees help in widening the fracture plannes in the rocks and causing mechanical separation. The angularity and sharpness in landforms and slopes in arid and semi-arid regions in contrast to smooth rolling topography in humid regions is partly due to scarcity of vegetation.

Budel (1948) has very rightly emphasized that under a certiain set of climatic conditions, particular geomorphic process will predominate imparting to the landscapes of the region characteristics that will be distinctly different from these of the landscape developed under different climatic conditions. Of the five morphogenetic zones proposed by him (Budel, 1963) the study area would fall within his sub-tropical zone of pediment and valley formation.

Geological structure, include structural characteristics related to the formation (deposition) stage viz. stratification, bedded flow, igneous intrusive shapes etc, and those brought about or superimposed later on by stresses generated due to cooling, compaction and tectonism. The term structure also includes the physical and chemical properties of rocks, dependent textural arrangement etc. It has to be noted that these internal structural characteristics are eqully vital in responding to the processes of weathering erosion and deformation.

The various stages of landscape evolution consist of successive changes in the surface configuration with passage of time. Traditionally, a geomorphologist would speak of relative time only and compare the development of landscape in terms of the relative stages of erosional evolution. But it is now realised that there are several factors that could interfere with the 'uniformity' of landscape changes, viz. tectonism, and changes in the agents of erosion and deposition and their intensities (Bloom, 1979). According to this author, practically the entire subarial landscape has evolved in the late Cenozoic Era, a time of great tectonic activity and climatic changes on the earth.

SOUTH GUJARAT LANDSCAPE EVOLUTION

The landscape diversity of South Gujarat essentially points to the role of degradational and aggradational processes operating over a terrain made up of near-horizontal basaltic rocks of varying composition and texture, which have been cut by a several sets of faults and fractures of all dimensions. In imparting geomorphic differences, at all scales, no doubt, the erosional and depositional processes related to a high rainfall have significantly influenced the geomorphic differences at all scales but the factor of tectonism, has played a dominant role.

As already stated, the three major sub-divisions, viz. Coastal plains, Uplands and Trappean Highlands, point to the existence of regional NNE-SSW faults. The actual coastline too marks a fault zone belonging to the West Coast Fault System (Biswas,1982). The boundary between the Uplands and the Highlands, is also a fault, which has been recorded by numerous workers of ONGC (Babu, 1984; Rao, 1987). Again the sudden and almost vertical rise of the order of 1200 m along the eastern limit of the South Gujarat highlands, is also due to a regional fault, that forms the northern portion of the Great Escarpment of Ollier & Power (1985). The step-like increase in average altitude from N to S, is also a manifestation of a number of E-W parallel faults which are related to the Narmada-Tapi graben (cf.Chapter VI). Numerous smaller faults related to the two above major tectonic directions, have in turn contributed to the diversity of landforms. Various streams flowing along these fractures have carved out erosional valleys in their upper courses while giving rise to depositional landforms in their lower reaches. The phenomenon of mass wasting is also, to a considerable extent dependent on the depth, intensity and orientation of the fractures and joints. Heavy rainfall has aided to the process of landscape sculpturing, augmenting to physical and chemical weathering, mechanical erosion, transport of debris and deposition in areas of low gradient.

Horizontality of the successive lava flows, has played an important role in sculpturing the landscape. The profusion of flat-topped hills and ridges as well as existence of vast flat areas of different elevations typically reflect the control exercised by the horizontality of flows. Another factor which has contributed to differential weathering is that of the thicknesses of various layers and their lithology. The Deccan Trap rock layers of the study area, consist of several petrographic types, each characterized by its own thickness, texture and mineralogy. The response of each variety to the processes of mechanical and chemical weathering, aided by the factor of jointing and gradient (low or high), has obviously been variable, the net result pointing to a fantastically striking landscape.

The various factors and processes enumerated above has given rise to a wide variety of landforms, each characterised by their own shapes, sizes, slope characteristics and genesis.

The landscape evolution and genesis of various landforms, have been brought about mainly by the processes of erosion and deposition through the agencies of rain, river and gravity. Rain and resultant stream action have been mainly responsible for the disintegration and decomposition of rocks and the transport and subsequent deposition of the debris. Considerable movement of debris is attributed to gravity sliding and talus accumulation as colluvium.

The factors and processes in the coastal area are somewhat different. The landscape here is essentially a product of erosional and depositional action of sea and rivers related to the fluctuating strandline.

LANDFORMS

The landforms are the basic elements in any landscape and a geomorphic analysis involves the study of the geometry of the landforms and their attributes, considering the landscape as a relatively static form at the time of observation and the processes that strive to modify them. Howard & Spock (1940) has defined a landform as "any element of the landscape, characterised by a distinctive surface expression, internal structure or both and sufficiently conspicuous to be included in a physiographic description". The definition, though quite subjective, reasonably describes the basic terrain elements, assemblages of whom go to make up the total landscape. Landforms could be constructional (depositional) or destructional (erosional) and are the products of complex series of reactions that take place when rocks are exposed to water and air, and the landforms represent the result of constructive and destructive processes acting on structures (Bloom, 1979).

For the purposes of landform studies and description, the study area is divisible into two categories, viz. coastal plains and hilly terrain. For describing the landforms of the coastal plains, the present author has relied on the terminologies used by earlier workers (Vashi & Ganapathi, 1982; Joothun et.al, 1982; Patel et al, 1982). But for the hilly terrain, he has prepared geomorphic maps for three selected areas highlighting the landforms based on toposheet and field check and using the symbols proposed by Vestappen & Vanzuidham (1968), and Mieczyslaw - Klimaszawski (1982).

COASTAL PLAIN LANDFORMS

The landscape of the coastal areas has been the product of the depositional and erosional activities of the sea and the rivers, that flow into it. The various landforms are related to, and appear to have been controlled by, a fluctuating strandline (regression, transgression and regression) during the Late Quaternary time (Merh, 1987). The rise and fall of sea level is reflected in the depositional and erosional features and the present author has briefly described the various landforms as follows (Fig.IV.2) :

Alluvial Landforms

1. Alluvial plains (Older Alluvium)
2. Flood plains (Newer Alluvium)
3. Relict older alluvium within mudflats
4. Erosional cliffs
5. Islands and point bars
6. River mouth bars

Coastal Marine Landforms

1. Beaches
2. Coastal dune ridges (Present day, unconsolidated)
3. Coastal dune ridges (Older, consolidated)
4. Tidal creeks and estuarine river mouths
5. Mudflats (Present day)
6. Raised mudflats (Older)
7. Estuarine river mouths
8. River mouth bars

Alluvial plains, which comprise the dominant landform nearer the coast represent older alluvium, considered by most workers (Krishnan, 1982; Vashi & Ganapathi, 1982) as of Middle to Late Pleistocene. Flood plains are restricted to the flanks of the river valleys, and form low terraces. They are the products of the present day flooding of the rivers. They are more common in the central portion of the area between Navsari and Billimora. Relict patches of older alluvium provide another interesting landform; these occur as alluvial islands within the present day mudflats. They point to the submergence of an older alluvial topography by the Holocene transgression of sea. Erosional cliffs of alluvium rise a few meters above the mudflats and are indicators of a period of erosion of the older alluvium during the last transgressive sea. Islands and Point bars are the typical depositional features observed in river Tapi, River mouth bars are quite common in several rivers and indicate a depositional phenomenon pointing to the low energy of the inflowing streams, perhaps related to the choking phenomenon due to rise of sea level.

Marine landforms are indicative of two strandline positions. Those related to a higher strandline (Flandrian) are older coastal dune ridges, considerably consolidated and several meters inland from the present day high water line. Raised mudflats which are now above the tidal influence, also indicate their origin during the high sea level of the past. The features related to the existing sea level are; (i) sandy beaches, (ii) coastal dune ridges and (iii) tidalflats. Sandy beaches are seen extending almost all along the coast, the beach is flanked landward by dune ridges of unconsolidated sand. These ridges rise about 2 to 5 m, above the berm line. Mudflats are another dominant depositional feature, occupying large areas of the inter- tidal zone; at most places, the mudflats lie behind the beach dune complex, the tidal waters having entered through creeks and river mouths. Wherever the coastline is cut by river mouths, small estuaries have developed. These are essentially made up of tidal muds and silts, quite often with overlooking alluvial cliffs. Some of these, especially those in the northern part, contain mouth bars.

HILLY TERRAIN LANDFORMS

Landform within the Trappean Highlands belong mostly to the erosional category, but some depositional ones are also present. The important landforms are as under :

1. Linear ridges
2. Irregular hills
3. Plateaus
4. Mesas, Buttes and Cuestas
5. Conical hills
6. Valleys
7. Pediments

Linear ridges : These are essentially fracture controlled flat-topped ridges of varying dimensions and constitute a dominant landform. The ridges trend both E-W and N-S directions, the former are more abundant in the southern part, whereas the latter are common in the northern part (Plate IV.1). Their extension is quite variable ranging from a few hundred meters to several kilometers. They are characterised by steep slopes, quite often cliffy. Their flat tops are dotted with small projections. The flatness of the top is a reflection of the horizontality and lithology of the lava flows. Some of the ridges show a progressive stepping down in their altitudes along their two ends, a phenomenon related to their being differentially eroded along the two lineament directions.

One good example of the E-W ridge is seen to the north of Man river near Ganva village. Here the linear ridge extends for about 8 km in E-W direction at an elevation of 450 m. (Plate IV.3) N-S trending ridges are ideally seen on both the banks of Bardi Nadi, (a tributary of Purna), the ridges extend for several

PLATE IV.3 E-W linear region with escarpments and also colluvial fans at the base (view looking north from Wilson hill).

PLATE IV.4 View of a ENE-WSW trending Mesa on Surgana-Saputara road.

km. The ridges have been cut across by an E-W flowing tributary of Bardi Nadi. (Fig. IV.3)

Irregular hills : These are quite common at elevations between 400 and 600 m. They represent an originally horizontal plateau, dissected in such a manner that the linearity (E-W or N-S) has been obliterated on account of the interference of the two fracture directions. Of course, some of these do show a tendency toward E-W or N-S elongation. A diagnostic feature of such hills is the random and curved crestal trends (Fig.IV. 4 & 5).

Plateaus : Large areas to the north of Tapi river, are made up of plateaus. These form flat elevated tablelands measuring several sq.km in area and marked by steeply sloping flanks. The flat top surfaces are dotted with isolated small hills and mounds. Plateaus of smaller dimensions are also present but they are more common to the south of Tapi. The latter are at elevations between 400 to 500 m, whereas the more extensive plateaus north of Tapi show lesser elevations, ranging between 250 to 400 m.

The tops of plateaus are covered with a thin veneer of residual soil, some local alluvial and colluvial accumulations.

Mesas, Buttes and Cuestas : These landforms of comparatively smaller dimensions, are characteristic of the Trappean Highland topography, and typically comprise erosional relicts of ridges. The terminology is used for describing structurally controlled scarps and ridges (Bloom 1979). If the more resistant unit is horizontal and caps a broad flat topped hill, the hill is called a Mesa. If the diameter of the cap rock is less than the height of the hill above the surrounding terrain, the term Butte is more often applied. If the resistant bed dips gently, an asymmetric Cuesta results with a steep escarpment and a gentle dip slope.

In the study area, near-horizontal layers of varying resistance, have quite often given rise to Mesas, Buttes and Cuestas. Obviously, they represent eroded remnants of fault controlled scarps with flat topped hard capping. These are more common in the eastern portions. A typical example of Mesa is seen near the Hatgad village at an elevation of 1028 m, on the Surgana - Saputara road. The mesa trends ENE-WSW (Plate IV.4). Buttes which are seen as almost vertical columns on the top of hills, appear to point to their origin due to presence of vertical joints. Quite a few occurrences of Buttes are recorded in the Great Escarpment at elevation of 1000 to 1200 m. A good example is seen, just south of Mavchipada village (Plate IV.5). Cuestas are another dominant erosional landforms of the hilly terrain in the study area. The flows dip gently towards the east, showing very steep slope westward. These landforms are seen near the Vanar village at elevation of 1000 - 1100 m. (Plate IV.6).

Conical hills : These erosional features are typical of such areas where the topmost lava flows are soft and more prone to

PLATE IV.5 View of a Butte looking southward. Location : Warse village.

PLATE IV.6 View of a Cuesta looking northward near Vanar village.

weathering, or the overlying hard top has been eroded away. These hills show a pointed top, with steep slopes. The conical hills also represent detached and eroded extremites of linear ridges. A good example of this landform is seen to the east of the village Vadgavan (Plate IV.7). Here the hill rise 400 m above the ground level, showing a total altitude of 1000 m or above.

Valleys : In general, most of the valleys are formed due to jointing and fracturing and have developed along these weak zones. Streams flow along these structural lineaments and are sites of active erosion (Fig. IV.3). Two types of valleys are encountered. One comprises broad flat bottomed valleys, occupying intervening areas between linear ridges, mostly E-W. They are seen to be filled up with a thin veneer of alluvium. They represent a landform, wherein the rivers flow along structural depressions. The second type of valleys show N-S trend as well, are restricted to more rugged terrain, and are V-shaped (Plate IV.8).

Pediments : Within the hilly areas at various plateau levels, occur pediments, which fringe the rising slopes. The pediments are of two categories, colluvial and alluvial. Colluvial pediments, represent accumulation of mass - wasting, slid down by action of gravity or runoff. While the alluvial pediments, point to local accumulation of fluvial sediments at various

PLATE IV.7 View of typical Conical hills looking eastward.
Location : Garkhadi village.

PLATE IV.8 View of narrow and broad valleys looking northward
Location : Wilson hill.

altitudes in such flat areas where the velccity of streams suddenly breaks.

SLOPE STUDIES

A landscape, has to be visualized as composed of slopes of different categories. Thus, slopes form an important geomorphic element of a landscape. Slope studies comprise the form, gradient and their genesis. According to Small (1970), there are two approaches to slope studies-the "slope evolution approach" and the "form process" approach. In the former, an attempt is made to trace how the slope has evolved, often assuming an initial form like a cliff and trying to work out how it declines subsequently. This approach is a highly complicated process. On the other hand, it is more reasonable to study the form of the slopes objectively in the field and try to establish the relationship between the processes and the forms. However the 'form-process' approach has to be employed, keeping in mind the warnings counted by Small (1970) that (i) the processes operate too slowly to be assessed quantitatively, (ii) not all the processes may influence the slope form, (iii) the present day slopes may not be the product of the present day processes.

The South Gujarat landscape provides very fascinating slope features, and to study them, one has to evolve a strategy which incorporates elements of both the two approaches mentioned above. The slope studies by the present author, therefore have taken into account the evolutionary as well as form approaches. No doubt, the processes of erosion and deposition have played significant roles in giving rise to the present day slope variety, but, it needs to be pointed out that the two major factors that have contributed to the development of slopes of various categories and their areas and altitudinal variations, are (i) those of horizontality of trappean rocks of variable lithology and (ii) the trends and intersections of fractures of different dimensions.

The present author has classified the entire terrain into smaller units each with their own distinct slope categories. Broadly speaking, the slopes show correlation with the overall geological and topographical setup. In details, however, the horizontality or very low dips of the lava flows and variable response of different lithological types to weathering agencies, contribute to slope diversity. Tectonic factor has no doubt played a significant role.

The present author has prepared slope maps on two scales. The slopes for the entire area are shown on 1 : 250,000 scale (Fig. IV.6) Detailed slope maps for a few selected area have been proposed on 1 : 50,000 scale based on the Wentworth (1930) method of average slope determination. Slopes of three selected areas showing percentage wise coverage of various slope categories for (i) extremely rugged mid-eastern portion (Toposheets No. 46 H/13 & H/14), (ii) southern hilly terrain (Toposheet No. 46 H/7) and (iii) northern Uplands (Toposheet No.

H/9), give an idea of the close relationship existing between horizontality of lava flows and erosion along the two main tectonic lineament directions (Fig. IV. 7, 8 & 9).

The studies indicate following slope characteristics :-

1 - Gentle to very gentle slopes occupy the table-lands or plateaus at various altitudes which are the reflections of the near - horizontality of flows. They are characteristics of Uplands and Coastal plains.

2 - Moderate to gentle slopes are confined to softer Trappean rocks.

3 - Very steep to almost vertical slopes are restricted to hilly terrain only and are indicative of hard lithology and fracture control.

4 - Wide variation in slope values within short distances are typically indicative of the influence of tectonic factor.