CHAPTER III
GEOMORPHOLOGY
1) INTRODUCTION

Each land unit or a block has its own landforms and stream systems depending upon;

* Climate
* Rock formation
* Vegetation
* Man made features
* Precipitation
* Topography
* Drainage system

Owing to all these parameters any area or a basin develops its own physiological features. In the present chapter the author describes following features regarding geomorphology of HHB.

* Landform characters
* Land cover and Land use pattern
* Morphometric characters.
* Lineaments

2. LANDFORM CHARACTERS

The land form characters are primarily studied with the help of toposheet (48.I/13) and then by field study. The topographic features of HHB reveal vast plains in the central and south eastern parts of the basin. The north eastern parts and western parts exhibit hill ranges. Since there is difference in the nature of landform characters within the basin, the study is carried out under the following heads.

a) Hill ranges.
b) Physiographic units
c) Slope analysis
d) Landform profile and valley development
The contour lines and spot heights of toposheet (48-I/13) are shown in the Fig.6. The detailed study of these contours reveal that northeastern parts cover with prominent hillocks. The central part is covered with plains. Some isolated hills are found in the western and northwestern parts of the basin. The hill ranges in the north eastern parts trending north west to south east direction. These hill ranges are near Murgod, Kengeri, Rudrapur and Dundankop villages. The maximum elevation in this part is 780 meters above mean sea level. The isolated hill patches to the north west of Mutwad village trend north east to south west, the maximum elevation in this part is 760 meters above mean sea level. The weathered boulder patches near Mutwad slope are spread uniformly in the area, whereas hill ranges of northeastern part of the basin have varying slopes due west. The field study confirm these attitudes.

b) PHYSIOGRAPHIC UNITS

The various units could be considered based on geomorphic expressions, relief, slope factors, surface cover with soils and vegetation. Based on the surface cover aspects, the following physiographic units are recognised in the HHB.

* Denudation hills.
* Dissected pediments
* Pediplains
* Fluvial deposits

The DENUDATIONAL HILLS are relicts of natural dynamic processes of denudation and weathering. The geomorphic expression of denuded hills are largely controlled by the variation in lithological composition, distribution and spacing of joints and fractures. The denuded hills of quartzite have precipitous slopes with rugged surfaces (Photo 1). The quartzites are with scanty vegetation of low shrubs. The denuded hill patches of basalts have moderate to gentle slopes with boulders of basalts (Photo 2).
The DISSECTED PEDIMENT is eroded rock surface of considerable extent at the foot of mountain slope. The pediments often have only thin veneer of debris/soil. The thickness of debris may increase away from the pediment junction. In the HHB the dissected pediments are found near Muragod, Kengeri, Rudrapur and Dundankop villages. Here the rolled down rock fragments of quartzites are found. The thickness of dissected pediments have depth up to 10-15 mts. This is observed in open wells near Rudrapur village. The pediments found as slopes (Photo 3) and they continue as part of pediplain in the down slope direction. Adjacent to the denuded hills of basalts in the northwestern and northern part of the basin the land is covered by weathered basalts (Photo 4). These features are found in the slopes.

The PEDIPLAIN refers to the flat or gentle sloping surface, which is the end product of several pediments. The pediplain is covered with deep black soils ranging in thickness from 1.0 to 6.0 meters (Photo 5). The western part and most of the south central part is covered by black soil showing flat but gently sloping south east direction of HHB. The eastern part is covered with red soil with gentle slope towards west and later to south east (Photo 6).

The FLUVIAL sediments of catchment area, transported and deposited along the stream channel is noticed at one or two places, near east of Inchal village and also near Hosur village.

Besides, there are many isolated patches of moderate elevations within the basin. They are with basalts or phyllites and they have moderate slopes.

c) SLOPE ANALYSIS

The slope map of the HHB is developed using the toposheet and later confirmed by field survey. The slope map of the HHB thus prepared is given in Fig. 7.

The Fig. 7 reveals that nearly 60% of the area is covered by the plains with gentle slopes towards southeastern direction. The slope varies from 5° to 10°. This part of the area is covered by the litho units viz., phyllites and granitic gneisses.
The western and northern part of the HHB is covered with moderate slopes i.e., the slopes are with 20° to 25°. This part covers 35% of the HHB. The rock types exposed in this area are basalts.

A patch in the northeastern part of the HHB is covered with steep or precipitous slopes i.e., the slopes are with nearly 80°- 85°. This part covers only 5% of the HHB. The rock types exposed in this area are quartzites.

A small patch in the southeastern part of the HHB is covered by fluvial sediments with slope less than one degree. This part is confluence point of the Hosur halla with Malaprabha river.

d) LANDFORM PROFILE AND VALLEY DEVELOPMENT

The study of hill ranges, the physiographic units clearly reveal that HHB flows through dissected terrain in north western part and pediplains in the south eastern part. To know the varied landform the author has constructed seven cross sections along latitude and ten cross sections along longitude of the basin for every one minute interval. These cross sections are drawn utilising 1:50,000 scale toposheet, where the contour interval is 20 meters. All these cross sections are represented in figure 8 (along the latitude) and figure 9 (along the longitude).

The figure 8 represented the profile drawn with respect to latitudes. The study of these profiles indicate the number of hills in the north eastern parts of the basin and elevated landforms in the western part, a patch of hillock in the northern most part. The hills in the north eastern parts are with quarzites, while the hill in the northern and elevated lands on the western part of the basin are with basalts. The central and south eastern parts are covered by flat terrain, which is mostly covered by black soil and the eastern part covered with red soil. There are occasional exposer of basalts and phyllites, as mounds in the area. The author could identify the highly weathered formations in the northern and north - north eastern portions of the basin.
and also in the old abandoned deep open wells. The formations could be described as (weathered granitic gneiss) murrum.

The figure 9 represents the profile drawn with respect to longitudes. These profile indicate the channel development of HHB. The first and second order streams start from the western part, i.e., near Mutwad Village and start flowing towards southeast. It takes a sharp bend towards (as shown in 2nd, 3rd and 4th profiles) south - southeast direction. It takes another bend (as shown in the profile 6th) and start flowing towards north eastern direction. Further it has changed its course and flowing towards southeast. Further in the down stream direction (as shown in the profile 8th) it takes a sharp bend to the south and changes its course due southeast (as indicated in the profile 9th). Hosur - halla flows in moderately rough terrain and widens in the later reaches (profile 6th, 7th, 8th and 9th) may be because of back waters of Navilutirth reservoir of the river Malaprabha.

3. MORPHOMETRIC CHARACTERS

Morphometric analysis is the systematic description of the geometry of a drainage basin. The study comprises of linear (unidimensional) and aerial (two dimensional) and relief (three dimensional) aspects. The linear and aerial aspects are planimetric where as the relief aspect is the study of vertical irregularities in the basin.

Horton (1945) is the pioneer worker amongst the researchers who considered the detailed study of drainage basin as quantitative study. Later Smith (1950), Strahler (1952), Miller (1953), Schummm (1956), Chorley et al (1957), Faniran (1968), Gregory and Walling (1973), Gardiner (1975) and others have improved upon the Horton's (1945) method of studying the various parameters of drainage pattern/basin.

Drainage pattern is an important aid for identification of geologic, hydrogeologic and geomorphic phenomena. The 6 sub-basins of HHB are considered separately for the study of
the morphometric characters. These sub-basins are named as sub-basins I, II, III, IV, V and VIth basin which is a Hosur Hall Trunk sub-basin.

The general drainage pattern of HHB is dendritic (Fig. 10). However the geomorphological expression of rock types in the area showing characteristic difference in west, south western part and rest of the basin. Rao (1985) opined, that in first said part of the basin has relatively well developed drainage pattern and it implies that the area is with relatively low infiltration and relative impervious material while the absence of well developed drainage pattern in the later said area of basin is indicative of high infiltration and general perviousness.

The stream network of the HHB is transferred from the toposheet (48 I/13) on to a high density tracing paper. The different sub-basins are demarcated by a sharp boundary to study the various parameters of individual sub-basins (Fig. 10). The author describes the various parameters of morphometry with respect to;

a) Linear aspects
b) Aerial aspects; and
c) Relief aspects

a) LINEAR ASPECTS

Strahler's (1952) system is adopted in designating STREAM ORDERS of six sub-basins, and the same is shown in figure 11. The table gives the total number of streams and stream orders of 6 sub basins. It is observed that Hosur Hall trunk channel is of fifth order. The number of streams is not same in all sub-basins. This observation leads to recognition of bifurcation ratio \((R_b)\). Horton (1945) considered the bifurcation ratio as an index of relief and dissection. Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation from region to region or from environment to environment except where the powerful geologic control dominates. The theoretical minimum values of bifurcation ratio \((R_b)\) is 2. The ratio ranges from 3 to 5 for watersheds, where the geologic structures do not distort the drainage pattern. The
stream order \((u)\) and stream numbers as \((n_1, n_2, n_3, \ldots)\), bifurcation ratios \((R_b)\) and mean bifurcation ratios \((\overline{R_b})\) are given in the Table 7.

The mean bifurcation ratio \((\overline{R_b})\) can also be determined graphically i.e., by calculating regression coefficient \((b)\) (Morisawa 1959). The plots form a straight line and the slope of the straight line is the regression coefficient \((b)\). The antilogarithmic values of these values will give mean bifurcation ratio \((\overline{R_b})\) and are tabulated in the table 7. Thus determined mean bifurcation ratio and the mean bifurcation ratio calculated with the help of number of streams and stream order are nearly the same (Table 7).

Strahler (1957) has given three types of basin with values of bifurcation ratio.

* Longated basin with a bifurcation ratio value around 17.
* Rotund basin with a bifurcation ratio value around 2.25.
* Normal basin with a bifurcation ratio value somewhere between above two extremes i.e. the value is around 4.

The bifurcation ratios of all sub-basins range from 2.78 to 5. Thus the basins are normal basins.

Horton (1945) opines that "the number of stream segments of successively lower order in a given basin tend to geometric series beginning with a single segment of highest order and increasing with constant bifurcation ratio \((R_b)\) (THE LAW OF STREAM NUMBER). This law is proved to be consistent with all the sub-basin under consideration. The stream order \((u)\) is plotted on arithmetic scale and stream numbers \((N_u)\) plotted on logarithmic scale. The plotted points fall in a straight line. (Figure not presented).

The total number of streams of each order can be determined by Horton's (1945) formula. The total number of streams of each order thus calculated are given in the Table. From the table it is seen that actual number of streams are almost same to the calculated one (with the help of bifurcation ratio, \((R_b)\) and they are agreeable (Strahler 1952).
The STREAM LENGTHS of all the orders were measured with the help of chartometer. The chartometer values were converted into actual value keeping the scale of toposheet in view of stream (Lu) for different sub-basins are given in the Table 8.

Horton (1945) postulated the length ratio \((RL)\) i.e., the ratio of mean length \((L_u)\) of the segment of order \((u)\) to the mean length of the segment of next lower order \((L_{u-1})\). This ratio tends to be constant throughout the successive order of a watershed. The values of mean stream length \((L_u)\) and stream length ratio \((RL)\) of each order is given in the Table 8. It is observed from the Table 8 that mean stream length \((L_u)\) increases as the stream order \((u)\) increases and as such the mean stream length of any given order is greater than that of lower order and less than that of next higher order. The mean length ratio \((RL)\) is constant through the successive order. The mean length ratio \((RL)\) of different sub-basin are given in the Table 8.

The mean length ratio \((RL)\) can also be determined graphically i.e. by calculating the regression coefficient \((b)\) (Strahler, 1957). The regression coefficient is determined by plotting log of mean stream length \((\log L_u)\) against stream order \((u)\). The plots form a straight line and the slope of the straight line gives the regression coefficient "b". (Figure not presented). The antilog of these values is mean stream length \((L_u)\). Determined values are given in Table 9.

Horton (1945) postulated the LAW OF STREAM LENGTH which states that "the average lengths of the streams of the each of the different orders in a drainage basin tend closely to approximate a direct geometric series, in which the first term is the average length of streams of first order" The mean stream length based on this law can be obtained for different sub-basins under consideration, the mean stream length of each order is calculated according to Horton's (1945) formula and is given in the Table 10.

b) AERIAL ASPECTS:

The aerial aspects include the parameters like basin area, basin perimeter, basin length and basin shape are described in the following pages.
Horton (1945) inferred that the mean drainage Basin Areas of progressively higher order should increase in a geometric sequence as do stream lengths. The basin area of all the sub-basins have been measured graphically and the values are given in the Table 11.

The Basin Perimeter is the total length along the water divide of the basin, as projected on the horizontal plane of the map. The perimeter is a linear measure of the size of the basin and it is largely dependent on the texture of the topography. The basin perimeter of the sub-basin are given in Table 11.

The Basin Length is defined in different ways by many workers. For the present study, Gardiner's (1975) method is followed. He defined the basin length as the length of the line from a basin mouth to a point on the perimeter equal distant from the basin mouth in either direction around the perimeter. The lengths of different sub-basins are given in the Table 11.

The Basin Width is the longest intercept in the basin normal to basin length. Basin width of different sub-basins are listed in Table 11.

The Basin Shape of the drainage basin directly depends upon the stream discharge characters. As explained earlier long narrow basins with high bifurcation ratio would be expected to have sharp peaked discharges. The shape of the basin is defined by various workers and are described below.

Horton (1941) describes the basin of normal drainage basin as a pear shape ovoid. He regards this shape as one proof that drainage basins are formed largely by sheet erosion processes acting upon an initially inclined surface.

Horton (1932) quantitatively expressed the basin shape as Form Factor which is dimensionless ratio of the basin area, to the square of the basin length. The form factor calculated for the different sub-basins are given in the Table 11.

Miller (1953) used dimensionless Circularity Ratio and defined as ratio of the basin area to the area of the circle having the same perimeter as the basin. He found the
circularity ratio is remarkably uniform in the range of 0.6 to 0.7 in homogeneous geologic material to preserve geometrical symmetry. Utilising the Miller's (1953) formula circularity ratio for the different sub-basins are given in the Table 11.

Schumm (1956) used a term ELONGATION RATIO and defined it as the ratio of diameter of the circle with the same area of the basin to the basin length. This ratio runs between 0.6 to 1.0 over a wide variety of climatic and geologic types. Values near to 1.0 are typical regions of low relief, whereas the values in the range of 0.6 to 0.8 are generally associated with strong relief and steep ground slope. Utilising the Schumm's (1956) formula the basin elongation ratio for the different sub-basins are given in the Table 11.

Chorely et al (1957) have given a method of estimating the drainage basin shape. They defined the basin shape as the degree approach of actual basin form to the pure lemniscate form measured by LEMNISCATE RATIO, the ratio of perimeter of the basin. Making use of Chorely et al (1957) formula, the lemniscate ratio of the different sub-basins were calculated and are given in the Table 11.

The DRAINAGE NATURE of the basin is expressed as Drainage density. Density of first order streams, stream frequency, Frequency of first order streams, Drainage intensity. In the following paragraphs the author describes the definitions, and characters of the above said parameters in respect of drainage nature of the sub-basins under study.

The DRAINAGE DENSITY is important linear scale of land form elements in stream eroded topography. Horton (1932) has defined the drainage density as the total length of streams per unit within basin. The drainage density is expression of closeness of spacing of stream and is measured from toposheet with the help of chartometer. The factor controlling drainage density are the same as those that control the characteristic length, dimension of any group of first order basins. Low drainage density (Dd _ 0) is followed in the regions of highly resistant or highly
permeable subsoil material, under dense vegetative cover and where relief is low. High drainage density is followed in regions of weak or impermeable sub-surface materials, sparse vegetation and mountainous relief.

Smith (1950) has classified drainage density into 5 different textures as below:

<table>
<thead>
<tr>
<th>Drainage density (Dd) (Kms/Sq Kms)</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2</td>
<td>Very coarse</td>
</tr>
<tr>
<td>2 - 4</td>
<td>Coarse</td>
</tr>
<tr>
<td>4 - 6</td>
<td>Moderate</td>
</tr>
<tr>
<td>6 - 8</td>
<td>Fine</td>
</tr>
<tr>
<td>&gt; 8</td>
<td>Very fine</td>
</tr>
</tbody>
</table>

In the present study, the drainage density of different sub-basins according to Horton's (1932) formula are listed in the table 12.

Strahler (1957) has classified the drainage density values into four classes.

<table>
<thead>
<tr>
<th>Drainage density (Dd) Value</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>Coarse</td>
</tr>
<tr>
<td>5 - 13.7</td>
<td>Moderate</td>
</tr>
<tr>
<td>13.7 - 155.30</td>
<td>Fine</td>
</tr>
<tr>
<td>&gt; 155.30</td>
<td>Ultra fine</td>
</tr>
</tbody>
</table>
Schumm (1956) used the inverse of drainage density as a property termed as CONSTANT OF CHANNEL MAINTENANCE. This constant has a dimension of length and therefore increases in magnitude as the scale of land form units increase, specifically the constant 'C' represents the area in square kilometers necessary to develop and maintain one kilometer of drainage channel. It is therefore, the lower limiting area required for expansion of a drainage system in the given region. A watershed surface with an impervious and impermeable silt requires a smaller drainage area to maintain a permanent channel than does a watershed on porous sand. The constant of channel maintenance is thus a measure of the erodibility of land surface of a watershed. The constant of channel maintenance for different sub-basins are given in the Table 12.

The DRAINAGE DENSITY OF FIRST ORDER STREAMS is the ratio of the total length of first order streams in the basin to the area of entire basin. It helps in evaluating the relative drainage densities of different basins due to greater length from headward growth of the first order streams. The density of first order streams for different sub-basins of HHB are given in the Table 12.

Horton (1932) introduced the term STREAM FREQUENCY as the number of stream segments per unit area. Accordingly the stream frequency of the sub-basins of HHB are given in the Table 12.

Melton (1958) analysed in detail the relation between drainage density and stream frequency, both of which measure the texture of drainage net, but each of which treats a distinct aspect. He has given a universal relation

\[
\frac{F}{(Dd)^2} = 0.694
\]

where \( F \) = Stream frequency

\( Dd \) = Drainage density.
Substituting the value of drainage density and stream frequency for different sub-basins under study, the values calculated are given in Table 12.

Faniran (1968) defined the DRAINAGE INTENSITY as the ratio of stream frequency to the drainage density. The drainage intensity of different sub-basins of HHB are listed in the Table 12.

Horton (1945) used the term LENGTH OF OVERLAND FLOW to describe the length of water over the ground before it becomes concentrated in definite stream channels. This is quite synonymous with the length of sheet flow to a large degree. He opines that the length of overland flow is approximately equal to half the reciprocal of drainage density. The length of overland flow of different sub-basins under consideration are determined and listed in the Table 12.

Horton (1945) believes that the length of the overland flow is most important and independent of variable affecting both hydrologic and physiographic development of drainage basins. But the detailed study is beyond the scope of the present work.

c) RELIEF ASPECTS:

Relief aspects of the basin is expressed as channel gradient, channel cross section geometry, ground surface gradients, relief measures, ruggedness and geometry numbers and hypsometric analysis. The author in the present study has considered only channel gradient, relief measures and hypsometric analysis of different sub-basins.

The CHANNEL GRADIENT can be studied by longitudinal profiles. The longitudinal profiles of a stream channel may be shown graphically, by plotting of altitude along the ordinate and horizontal distance along abscissa. This study is performed considering a single channel profile. Altitudes stated in meters above mean sea level and distances in kilometers from stream head to stream mouth. These values obtained from topographic maps and are plotted in the Fig. 12. The single channel profiles of almost all streams under a wide range of climatic and
geologic conditions show upconcavity i.e. a persistent down decrease in gradient (Strahler 1964). Gilbert (1877) explained upconcavity as an effect of increasing stream discharge. His law of declivities states that declivity (gradient) bears an inverse relation to discharge because as discharge increases, channel cross section increases, reducing proportionately the frictional losses of the stream and enabling it to carry its bed load on a lesser slope. Yatsu (1955) has attributed upconcavity to decreasing calibre (diameter) of bed load particles down stream, using the reasoning that a lesser gradient surfaces for the transport or linear bed material.

The longitudinal profiles of 6 sub-basins under study satisfy the Gilbert (1877) and Yatsu (1955) law of declivity i.e., upconcavity.

The RELIEF MEASURE is the elevation difference between elevation points. Maximum relief within a region of given boundary is simply the elevation difference between highest and lowest points, maximum basin relief is the elevation difference between basin mouth and highest on the basin perimeter, usually stated in meters. Schumm (1956) measured basin relief along longest dimension of basin parallel to the principal drainage line. Maxwell (1960) measured relief along the basin diameter an axial line found by use of strictly defined criteria.

The maximum basin relief values for 6 basins are calculated according to Schumm (1956) and are given below.

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Basin relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>83</td>
</tr>
<tr>
<td>2</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>81</td>
</tr>
<tr>
<td>4</td>
<td>77</td>
</tr>
<tr>
<td>5</td>
<td>61</td>
</tr>
<tr>
<td>6</td>
<td>33</td>
</tr>
</tbody>
</table>
When basin relief is divided by horizontal distance on which it is measured, there results a dimensionless RELIEF RATIO (Schumm, 1956). Schumm (1956) has defined relief ratio as the ratio of maximum basin relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line. Melton (1958) used relative relief (Rhp) expressed in percentage as

\[ R_{hp} = \frac{100H}{5280P} \]

where \( H \) = Maximum basin relief in meters.

\( P \) = Basin perimeter in Kms.

The relief ratio for the 6 sub-basins under study are calculated according to Melton (1958) and are given below.

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Relative relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.47</td>
</tr>
<tr>
<td>2</td>
<td>9.19</td>
</tr>
<tr>
<td>3</td>
<td>10.13</td>
</tr>
<tr>
<td>4</td>
<td>7.78</td>
</tr>
<tr>
<td>5</td>
<td>8.71</td>
</tr>
<tr>
<td>6</td>
<td>3.55</td>
</tr>
</tbody>
</table>
HYPSOMETRIC (AREA-ALTITUDE) ANALYSIS

It is small part of the morphological analysis. It concerns the investigation of hypsometric properties of small drainage basins i.e., area-altitude relationships and the manner in which mass is distributed within a drainage basin.

Hypsometric analysis is the study of distribution of ground surface area or horizontal cross sectional area of the land mass with respect to elevation (Strahler 1952) and is used for calculation of hydrological information (Langbein et al 1947). The percentage hypsometric method used in the investigation relates the area enclosed between a given contour and the upper (headward) segment of the basin perimeter to the height of that contour above the basal plane. The hypsometric curve permits the comparison of forms of basins of different sizes and elevations. It expresses simply the manner in which the volume lying beneath the ground surface is distributed from base to top.

Strahler (1952) opines that the shape of hypsometric curve depends upon the stages of development of the basin. He categorised the different stages of development of the basin as follows (Fig. 13).

* Inequilibrium (Youthful) stages.
* Equilibrium (Mature) stage.
* Monadnock stage.

In the present study, drainage area and the corresponding height has been calculated from the topographic map. The relative area ratios \( a/A \) where \( a \) is the basin area lying above a given contour and \( A \) is the total basin area and relative height ratios \( h/H \) where \( h \) is the elevation of the contour above the base and \( H \) is the maximum height in the drainage basin above the base) are computed. The relative height ratios are plotted on ordinate and relative areas are plotted on abscissa.
Curve originates in the upper left hand corner of the square at 1.00 (x = 0, y = 1) and reach the lower right hand corner at 1.00 (x = 1, y = 0). The area lying below the curve was graphically measured and compared to the total area of the square enclosing the curve to give hypsometric integral. This value is 61.78% for HHB.

The hypsometric curve is nearly parallel and integral value 61.78% falls in the inequilibrium stage span (0.6 to 1.0) which are nearly matching with the reported values for youthful stage basin curves and integral values (Strahler 1952, Roohani and Gupta, 1988). Thus the HHB is in a youthful stage of development.

4. LAND COVER AND LAND USE PATTERN

The land cover is the actual field or geomorphological characters of an area. These characters include mainly the topography and drainage. In addition to these, the characters like climate, geology, vegetation (natural and artificial) and related factors are included.

In the previous sections the detailed landform and morphometric characters of HHB are explained. The HHB is a gentle southeasterly sloping basin. Based on satellite imagery, toposheets and field checks the land cover map of HHB is prepared and presented in Fig. 15. Thus HHB could be classified into four types of land cover patterns.

a) Waste lands
b) Built up land/residential areas
c) Agricultural land
d) Water bodies.
a) WASTE LAND

The waste land covers an area of 2.715 sq.Kms. Two types of waste lands are identified in the HHB and they are:

i) Land with barren rock or stony waste

ii) Land with or without shrub.

i) Land with barren rock or stony waste

This type of land covers a small part of HHB (Fig.15). In the northwestern part of the basin, the land is with weathered boulders of Cretaceous basalts (Photo 7). This land is unsuitable for agriculture. However some shrubs are seen. In the northeastern part of the basin the rocky lands show precipitous slopes. Here the land is covered with Proterozoic quartzites (Photo 1). There are no shrubs or any trees here.

ii) Land with or without shrub

In the northern part of the basin at some places the higher elevations are covered with shrubs and at place not covered with shrubs. Here the basalts are exposed. Photo 8 shows phyllitic outcrops. Thus there is no cultivation in such areas.

b) BUILT UP LAND/RESIDENTIAL AREAS

The built up land area covers an area of 4.037 Sq.Kms. There are no industries or any big towns in the HHB area. However there are eleven large and small villages. The population of these villages varies from 10,000 to 25,000 (1991, Census). All the villages are with houses built up of either masonry or mud/stone. All the villages are interconnected by all season motorable roads.
c) AGRICULTURAL LAND

Most of the area in the HHB is covered by the agricultural land (140.698 Sq.Kms). This area is normally flat with gentle slope towards southeastern side. The cultivation is normally found along, 3rd, 4th, 5th and 6th order streams. In this area there is availability of thick soil. The farmers have taken good advantage of this plain area and have cultivated for jawar, wheat, maize and other crops. This cultivated land forms the part of central and southern part of the basin.

Thus, from the foregoing discussion and Fig. 15 it could be said that large part of the HHB is available for cultivation.

d) WATER BODIES

There are five tanks in the HHB. Two of these lie close to the outcrops of quartzites in the eastern part of the basin. One lake lies in the western part of the basin where basalts are occurring. All these 3 tanks are smaller in dimension and store little water. There are two more tanks in the central part of basin. These two tanks are larger in dimension and good quantity of water is stored in these lakes. The agricultural fields in the down stream direction utilize the water collected in these lakes immediately after monsoon. All the lakes of HHB go dry before March i.e. before commencement of summer season. There is lot of silting in these lakes. Thus there is little use of these lakes in the HHB presently.

5. LINEAMENTS

Sharma (1985) opines that the lineaments represent surfacial reflections of subsurface structural features like fault zone, fracture (joints) zones, fold axes, linear igneous intrusions. Lineaments are potential locations for infiltration and groundwater percolations. The lineaments in the low lying areas are the zones of natural recharge. The satellite imagery study helps to
identify lineaments easily. The satellite imagery (IRS) is used for identification and location of lineaments.

Fig. 16 shows the major and minor lineaments in HHB. The lineaments are classified based upon their directions as E-W, NE-SW and NW-SE. The table below gives the details about the lineaments.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Trends of lineaments</th>
<th>Total number of lineaments</th>
<th>Total length of lineaments in Kms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NE - SW</td>
<td>15</td>
<td>29.50</td>
</tr>
<tr>
<td>2</td>
<td>NW - SE</td>
<td>14</td>
<td>27.80</td>
</tr>
<tr>
<td>3</td>
<td>E - W</td>
<td>4</td>
<td>5.96</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>63.26</td>
</tr>
</tbody>
</table>

The lineaments are more in number in the NE-SW directions (15) and are more pronounced. Next prominent lineaments are NW-SE direction lineaments and are 14 in number. Next to this there are 4 lineaments in E-W direction. Most of the lineaments cut across each other.

In the field stream channels are found along some of the major lineaments near village Harugop, Gontmar, Murkumbi, Hirekop and Hosur. This data i.e. the lineaments study is utilized for describing the groundwater potential areas elsewhere in the thesis.