CHAPTER II

GEOMORPHOLOGY OF THE AREA

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GEOMORPHOLOGY OF THE AREA

2. **Introduction**

Geomorphology is a science of land forms. Worcester (1957) defines the subject as "the interpretative description of the relief features of the earth surface, which describes the surface of the earth, explains the origin of it and interprets its history". In brief it can be said that geomorphology deals with the origin and classification of the irregularities of the surface of the earth. Hence, geomorphology involves the study of geology including both the litho-types and the structural features, as well as the study of exogenic forces which bring out these changes on the earth's surface.

The present chapter, accordingly, deals with:

1. Description of the relief features, slope and stability studies with reference to the geology of the area.

2. Study of the scenery of land forms and the processes involved in their development and
(iii) Study of the development and the type of drainage in the area, its relationship with the geology and structure, and erosional surfaces formed by these processes, in order to bring out the stage of development of the cycle of erosion.

Hammond (1954) has mentioned that "in any landform context, the main aspects of the landform features which provide different characteristics and which can be studied from a topographic map, are area, (surface arrangements), altitude, relief and volume (vertical dimensions), profile (vertical arrangement of the surface), texture (horizontal dimension), and slope. Morphometric methods give quantitative information about the landforms."

Pal (1972) has classified the morphometric methods into two major heads, comprising analytical methods (graphic, arithmetical and cartographic), statistical and dimensional analysis comprising statistical indices, drainage network relationship.

Present work deals with certain methods which are found suitable for the presentation and solution of the problem. They are:

1. **Graphical Method**:

   Serial profiles—mainly projected and superimposed profiles have been prepared (Monkhouse, 1948) in order to
get the cross-section view of the land surface at 1 km. interval. This reveals the flat topped hills and stepped topography, characteristic of trap area.

Superimposed profiles (Trueman, 1938) have been prepared to work out the erosional surface.

(ii) **Cartographic Method:**

Slope and stability maps have been prepared after Smith (1935). Slope angles have been calculated after Wentworth (1930). This study was undertaken to determine the area of high and low stability, since various buildings of the University as well as the residential colony are built on the Patharia hill.

(iii) **Statistical Indices:**

Parameters like drainage density (Horton, 1945), drainage frequency and drainage texture are discussed.

Drainage frequency is a useful tool to study the drainage texture. It also affects the run-off pattern of the basin, and hence the rate of erosion.

Drainage density is related to the relative relief and being an indicator of stream spacing, infers the rock character. "The value ranges from 3-30 for moderate type of rocks in humid areas, from 50-1300 in arid areas and bad land topography", (Pal, 1972).
Drainage texture is defined as a product of drainage density and drainage frequency. The scale is described as 4.00 and below coarse, 4.00 - 10.00 intermediate, above 10 below 50 fine, above 50 ultrafine.

Bifurcation ratio and stream length ratios have been calculated for the drainage of Patharia for correlation purposes.

2.1 Geomorphic Features of Deccan Trap

Deccan Trap basalts are the products of volcanic activity of Cretaceous - Eocene period. Successive eruptions with certain time gap have resulted into a layered sequence of basaltic flows.

Basalts are massive, fine to medium grained rocks with vesicular and jointed top. Some of the flows are characterised by zeolite and laterite top. Weathering of these traps finally results into impervious, black cotton soil constituting plain country. This soil swells after absorbing water and helps thick vegetational growth. From a distance, trap country can be identified by conical hills, flat topped hills, plane areas and stepped topography.

Top of the horizontal flows may form the top of a Deccan Trap range. At places, the ranges show stepped nature. Each step represents a flow. Conical hill resembling a volcanic crater is the last stage "pedeplanation".
2.2 **Slope and Stability Study**

To plot about the data on land, topographic map is an absolute necessity. The topographic map used is on the scale of 1:25000 with a contour interval of 30 metres.

The method adopted to carry out the slope analysis is by the method of crossing contours in each grid divided by the contour interval and multiplied by the slope factor given by Wentworth (1930). The slopes so determined vary from 0° to 30°. These values are plotted in the respective grids and contours are drawn at 5° interval to obtain the slope map. The generalised slope map is shown in figure 2.1. This map is a special type of topographic map that summarises the continuously variable slope information shown on the standard topographic map. Categories of slope can be chosen to meet the various needs and the map divided into units with the same slope characteristics. Such a map is necessarily generalised because except at very large scales, there usually are local slopes that do not fall within the assigned categories. The slope map for the area (Patharia hill) has been prepared on the lines adopted by Debrovelny and Schmoll (1968) for preparing a slope map of Anchorage area of Alaska.

The principle reason for making a slope map is to identify areas having the same range of slope angle, because the slope angle is a major factor in estimating the slope
FIG. 2-1 AVERAGE SLOPE, PATHARIA HILL
stability. Landslides occur mainly on steep slopes and along steep topographic discontinuities. They do not occur in areas of low relief, that are far from breaks in topography. Identification of steep slopes is the first step in the process of isolating areas where landslides are more likely to occur.

From slope map, stability map of various slopes has been prepared and presented in figure 2.2. The map is derived essentially from the slope map and the geological map. The primary criteria for determining the instability is the degree of slope. Areas of steep and very steep slopes will be the chief sites of instability. However, the degree of instability depends considerably on the geological materials underlying the slope. Thus, by combining the elements of the two maps (slope map, and geological map), the slope stability map can be prepared showing varying degrees of stability. Generally the area of low and moderate slopes are lumped together as having high stability.

Slope stability map presented in figure 2.2 clearly shows:

(1) Those areas which are unsuited for most development because of slope stability problems,
FIG. 22 AVERAGE SLOPE OF STABILITY, PATHARIA HILL
(ii) Those areas in which slope stability present problems that must be considered in planning,

(iii) Those areas which are relatively free of slope stability problem.

2.3 **Drainage Morphometry**

Study of drainage not only reflects light upon the factors controlling its development, but also helps in understanding the stage of development of the erosional work. Study of drainage involves the study of drainage pattern and drainage texture.

Geology, structure, climate, topographic relief and the altitude of the area control the development of the drainage of the area. Local relief and the development of the drainage system are independent.

Thornbury (1954) defines the drainage pattern as "referring to the particular plan or design which the individual stream course collectively form". "The same has been described as the study of the special arrangement of the stream", by Miller (1961).

Drainage morphometry has been carried out, as most of the streams on Patharia hill are ephemeral, remaining dry most of the time in the year. They are active only during
monsoons and the rocks of Patharia hill are not hospitable to water percolation and infiltration, owing to their impermeable nature. Hence, the hill forms the watershed area and major bulk of water is lost as run-off. Therefore an attempt has been made to study the drainage morphometry comprising the determination of the streams, drainage frequency and density in order to explore the possibility of conserving the run-off at suitable sites, so that they may contribute to the ground water levels in the re-charge area.

2.4 **Drainage Pattern on Patharia Hill**

The trappean area represents the succession of four horizontal flows. The rock is fine to medium grained with irregular joints and porous top. No relevant structural features are present in these rocks. The streams have developed in all directions along the slope and hence, the dendritic pattern is the characteristic feature of the area. This type of pattern is developed from all sides radiating away in all directions. This pattern can be defined as the "radial dendritic type".

Drainage texture means the relative spacings of drainage lines (Thornbury, 1954). This includes the study of both drainage density and drainage frequency (Horton, 1945). Horton defines the drainage density as the "total length of streams in a given basin divided by the area of drainage"
basin" and the drainage frequency as the "total number of streams in a drainage basin divided by the total area of the drainage basin". Similar to the method applied to the slope and stability maps, the area has been divided into several grids of one square kilometer and drainage density and frequencies for each square has been calculated. Later on isopleths have been drawn by using iso-drainage density and iso-drainage frequency lines for the area. These are shown in figure Nos. 2.3 & 2.4.

Study of the drainage morphometry brings out the following facts:

(i) Drainage frequency over the Deccan Trap varies from 1 to 8 streams per square kilometer.

(ii) Drainage density over the Deccan Trap is of the order of 1.13 to more than 2.84 kms. per km².

(iii) In the case of traps the factors like the compactness and the fine grained nature of the rock, imperviousness of the weathering product, restricted shallower depth of porous horizon due to the presence of vesicles, zeolites or joints do not permit surface water to percolate to greater depths. This results into high amount of run-off over the trap country causing more amount of erosion. Hence, this gives rise to high drainage density and high drainage frequency resulting into high relief.
FIG. 2.3 DRAINAGE DENSITY, PATHARIA HILL
FIG. 2.4 DRAINAGE FREQUENCY, PATHARIA HILL
(iv) Order of stream deals with the age and position of a stream in a river basin. Stream order of the highest number indicates the main river. Whereas the first order deals with the first stream in the head-water region. As the stream of the similar order number meets in their course, they result into a stream of next higher number. Present studies reveal that there are in all two order of streams in the hill.

Table 2.1 shows the number of streams in each order, their total length and mean length in kms.

<table>
<thead>
<tr>
<th>Order number</th>
<th>No. of streams</th>
<th>Total length of streams (in kms.)</th>
<th>Mean length of stream in kms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Order</td>
<td>17</td>
<td>5.48</td>
<td>0.32</td>
</tr>
<tr>
<td>2nd Order</td>
<td>8</td>
<td>3.04</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Close study of the above table brings out the fact that there is an inverse relationship between the number and the order of streams.

The study of the topographic map of the Patharia hill shows that the local relief varies from 530 to 620 metres indicating a high degree of unevenness of topography. High
drainage density, high drainage frequency, presence of vertical cliffs, rarely active downward erosion by the streams indicate that the area is under active vertical erosion. Boulders and pebbles in the stream valley, absence of any depositional feature also suggest that the streams are in their youthful stage of development.

2.5 Study of Erosion Surface

Deccan Traps interspersed with valleys constitute the scenery around Patharia hill. The high elevation of trap hills is in contradiction to the contention of West and Choubey (1964), who have described the scenery around Saugor. During the geological past, however, it is evident that the Vindhyan have been covered by trap, and the present Vindhyan outcrops are the consequence of post-trappean erosional work, resulting in palaeo or exhumed Vindhyan, occurring as inliers amidst Deccan Traps.

Erosional surface studies have been carried out by first mapping the geology of the area, and then several east-west topographic profiles were prepared at one km. interval. This is shown in figure 2.5. These profiles have been superposed one over the other and the prominent break in the profile has been studied with respect to the geology of the area.
The superimposed profiles (Figure 2.5), clearly point to a prominent break at the elevation of 548 metres, which brings out the fact that mostly the Vindhyan hills have their tops at this level in Saugor district. From this, it can be stated that during the geological past this level had been a level of erosion for the agencies of erosion. Marked break in the longitudinal profile at this level, hence represents an erosional surface. This erosion surface closely corresponds to "Cretaceous peneplain" level described by Choubey (1967) and also to the "Etch Plain", described by Wayland (1934). The interesting point to be noted about the erosion surface, is that it is confined to and controlled by the top of the basaltic flows.

2.6 Rate of Erosion

The existing topography is but a sample of the geological past. The traps of Patharia hill have undergone an extensive and continuous erosion during the geological past which is still continuing. Hence, erosional studies involving the determination of the rate of erosion has been carried out to assess the amount of material removed within the last 65 million years. A first attempt of this type had been made by Gandhe (1970) on the traps of Barkoti Kalan, Saugor District. He however, had not calculated the rate of erosion in terms of geological time. He has determined as
FIG. 2.5 SUPERPOSED PROFILES DEPICTING EROSIONAL SURFACE
to how much material had been removed from 1 sq. mile area with an attitude of 400'.

The rate of erosion in the present studies has been calculated as follows:

From the superimposed profiles, the erosion surface, which occurs prominently in the area has been established. Areas lying between this contour to the highest present elevation contour has been determined and the volume computed by taking half the contour interval as the thickness. Area between the contours has been determined with the help of planimeter. Specific gravity of the basalt was next determined, which gave an average value of 3.0. By multiplying the volume and specific gravity, total mass of material removed has been calculated.

Since, the erosion surface determined from superimposed profiles correspond to Cretaceous - Eocene peneplane, and traps are found beneath the erosion surface the boundary is taken as Palaeocene (65 million years) and the amount of material removed, computed upto the present day is represented in figure 2.6.

The rate of erosion and the amount of material has been calculated for every 10 million years, the actual calculation of the material removed in Patharia hill is shown below:
FIG. 2.6 RATE OF EROSION, PATHARIA HILL
Volume of basalt removed:

\[ 6600' \times 6600' \times 125 = 5.445 \times 10^9 \]

\( (1.25 \text{ miles} \times 1.25 \text{ miles}) \times \frac{1}{3} \text{ Contour interval} \)

\[ 5.445 \times 10^9 \times 30^3 = 1.47015 \times 10^{14} \]

\( (1' = 30 \text{ cm.}) \)

Vol. \times \text{Density} = \text{Mass}

\[ 1.47015 \times 10^{14} \times 3 = 4.41045 \times 10^{14} \]

\( (3 = \text{Average Sp. Gr. of Basalt}) \)

\[ \frac{4.41045 \times 10^{14}}{450} = 9.801 \times 10^{11} \text{ pounds} \]

\( (1 \text{ Lb.} = 450 \text{ gms.}) \)

\[ \frac{9.801 \times 10^{11}}{2240} = 4.37544 \times 10^8 \text{ tonnes} \]

\( (1 \text{ ton} = 2240 \text{ Lbs.}) \)

\[ \frac{4.37544 \times 10^8}{1,000000} = 437.544 \text{ Megatonnes} \]

So the total material removed from 1.25 miles x 1.25 miles area during the last 65 million years has been 437.544 megatonnes. If the rate of denudation is taken as constant, then the rate per year of erosion is as follows:
\[
\begin{align*}
(1) \quad \frac{437.544}{65,000,000} &= 6.73144 \times 10^{-6} \text{ Megatonnes/one year} \\
(11) \quad \frac{437.544}{65,000} &= 6.731144 \times 10^{-3} \text{ Megatonnes/one thousand year} \\
(iii) \quad \frac{437.544}{65} &= 6.7314461 \text{ Megatonnes/one million year}
\end{align*}
\]

The problem of unequal erosion of basalt is explained as due to the fact that the flows of the area, where one finds at present extensive plains have been converted into soil by weathering and has been transported to some other place resulting in rich black cotton soil namely "regur".