C H A P T E R - V

RELIEF AND SLOPE ANALYSIS

1. GENERAL FEATURES
2. RELIEF ANALYSIS
3. SLOPE ANALYSIS
4. DISCUSSION

GENERAL FEATURES

From the point of view of relief, the study area, though relatively small in areal extent, provides fantastic diversity. Within its limits area encountered a wide variety of relief features located at different altitudes. Its various physiographic divisions are seen to be made up of assemblages of different landforms in various combinations. Numerous occurrences of ridges, hills, dissected plateaux, undulating uplands, valleys, flood plains, alluvial plains and coastal plains mark the physiographic diversity, with an altitude variation, fluctuating between M.S.L. and 882 m.

The diversities in slope, shape, size and altitude of the various topographic features mark the relief of the terrain, which has evolved under the varied conditions of lithology and structure influenced by neotectonism and sea level changes. The various geomorphic changes that have occurred in the course of the evolutionary history brought about by the natural agencies like weathering, fluvial and coastal marine processes also contribute substantially to the relief and slope. In the study area, the relief features and the related slopes of different nature are obviously the results of all these controlling factors and the area presents an unique picture of basaltic Tertiary and Quaternary landscape.

As it has been amply established in the foregoing pages, the entire landscaps and relief diversity typically reflect the geological characteristics of the terrains. The (entire) topography in the form of plateaux, uplands and coastal alluvial plains. The entire landscape from the east to west has been divided as under :-

i. Eastern trappean rugged relief of ridges, hills and dissected plateaux with intermontane valleys.

ii. Undulating uplands with ridges and hills.

iii. Alluvial and coastal plains with low summit hills and mounds.

The topographic aspects of the study area have already been discussed in the Chapter III. The high relief of the landscape is marked by the ridges and hills of trap ranging in height from 300 m to 882 m, and is made up of linear, parallel or arcute ridges, the triangular hills or clusters of irregular shaped hills. The relief of the uplands is marked by ridges and hills of traps and sedimentary rocks (Cretaceous and Tertiary) while the plains of the Quaternary alluvium show low relief.

The topographic maps (Survey of India) of 1" = 4 miles or 1 : 250,000 scale were critically studied to obtain a clear view of the relief; various maps and diagrams pertaining to relief studies were also based on the topographic sheets.

slopes are rather steep and cliffy. A rectangular pattern (joint controlled) and deep cutting are the typically diagnostic features of these 'Khadis'. The zig zag courses of these streams are again the reflection of the control exercised by the joints in the basalts.(Plate IV 6).

A very significant feature of the drainage that attracts immediate attention is that of the extremely curvaceous or meandering channels of the streams of even middle order (4th to 6th). The Khadis that drain the hilly terrain, show considerable resemblance to meandering within the trappean areas. The steepness of their channels erroneously gives an impression of entrenchment. But in-fact, the entire phenomenon is related to the intense criss-crossing of the various joint sets which provide tortuous openings for the flowing water; steep and deep erosion resembles entrenchment. In contract, the streams that flow over uplands (4th to 6th order) show genuine meandering. The various streams not only flow through channels made up of sharp bends, curves and loops, but they show a distinct entranchment. But this vertical cutting of the channels, is obviously related to the neotectonic uplift of a low gradient terrain, mostly the areas in between the parallel east-west aligned tectonic 'highs' and ridges. (Plate IV 7).

The E-W, S-N or NE-SW and SE-NW coursed linear and parallel streams flow straight towards the west from the basaltic hills, drain the plateaus and uplands and flood the

RELIEF ANALYSIS

The relative (Comparative) relief in terms of altitude and areal distribution forms the main aspect of the relief analysis, and by using various methods following illustrations have been prepared to show the distribution pattern of the relief (Fig. V1).

i. A relative Relief map.

ii. Hypsographic curve.

iii. Histograph and Frequency curves.

iv. Cross-section profiles.

The trigonometric stations, bench marks, spot heights and contours (at interval of 100 m) have been taken into account for obtaining the height or altitude of hills and places. A Relative Relief map (Fig. V 1) has been prepared by using the method given by Smith (1935) and Raize & Henry (1937). The relief pattern of the terrain between M.S.L. and 882 m demarcated into 8 zones, with the intervals of 100 m, and all the zones have been differently shaded to highlight the relief variation altitude wise. The area lying within each zone has been measured and tabulated (Table V 1). The spot-heights shown on the toposheet (scale 1 : 250,000) falling within each relief zone have been counted and grouped at the intervals of 50 m, their frequency is shown in Table V 1. From tabulated data of the table, hyprographic curve has been drawn which indicates the proportions within the intervals

of 100 m altitudes. On this curve, the relief area has been plotted on the scale 1 cm = 40 sq.km and the altitude being shown on a vertical scale 1 cm = 100 m.

Next to this, in the table; the obtained spot height frequency (at interval of 50 m) is plotted as histograph and frequency curves (50 m & 100 m). Lastly, the profiles have been constructed along some selected cross-section lines as under :

i. The cross-section lines-west to east, at :

(1) 21°.30'N.
(2) 21°.40'N.
(3) 21°.50'N.
(4) 22°.08'N.

ii. The cross-section lines-south to north, at :

(1) 73°.20'E.
(2) 73°.35'E.
(3) 73°.50'E.
(4) 74°.08'E.

The profiles drawn along the various cross-section lines on the Fig. V 1 project the major landforms, and provide an overall view of the relief of the terrain, the step like arrangement of the landscape being the most striking feature.

Table No. V. 1

Relative Relief of the Study Area

Height interval in m.	No. of spot heights frequency 50 m	100 m	Area (Sq.km) Interval (100 m)	Area (%)
MSL - 50	25			
51 - 100	44	69	2105.00	27.7
101 - 150	8			
151 - 200	31	39	1390.00	18.3
201 - 250	33			
251 - 300	18	51	1367.00	18.0
301 - 350	25			
351 - 400	34	59	1352.00	17.8
401 - 450	11			
451 - 500	21	32	1025.00	13.5
501 - 550	13			
551 - 600	4	17	273.00	3.6
601 - 650	15			
651 - 700	-	15	76.00	1.0
701 - 750	1			
751 - 800	3	4	9.00	0.10
801 - 850	-			
851 - 900	1	1	-	-

An analysis of the data based on different maps, diagrams and profiles, and its corralation with the relief characteristics, lithology, structure and drainage appropriately explains the phenomenon of landscape evolution, salient features which are discussed below.

The ENE-WSW aligned ridges and hills rising from approximately 300 m upto the heights of 882 m are observed to show a step-like landscape, controlled to a considerable extent by the jointed basaltic terrain. The present day morphology of the entire area points to three well-defined levels, each characterised by areas of flat terrains with ridges and hills, as under :-

i. the plateaux comprising an area of 85 sq.km (about 1% area of the whole terrain) with two levels at 600 m (and above) and 400 m. The higher plateau includes those of Mal-Samot plateau (600 m), and Juna Raj (600-650 m). The Mosda plateau or Babadoti Dungar (in Mosda group of hills) has an altitude of 400 m and forms the lower level plateau.

ii. the uplands terrain with an area of about 2700 sq. km (35.7% of the study area) is marked by two types :

(1) the trappean uplands in the east showing an undulating terrain ranging in altitudes of 200 m to 300 m. (Dediapada uplands and the eastern part

of the Netrang uplands).

(2) The Tertiary uplands are typically characterised by a rolling topography merging into the coastal plains to the west (the western part of the Netrang Uplands) and rising eastward into the trappean uplands (Western part of the Natrang uplands and the Kadvali uplands).

iii. The plains (rising upto 200 m) consist of about 3500 sq.km (46% of the study area) area and make up the largest relief feature in the region. These plains are of three types :

(1) The western alluvial plains to the north of Narmada consisting of deposits brought by the inflowing tributaries.

(2) The conspicuous flood plains of Narmada mainly confined to the southern bank of the river (i.e. north of the western basaltic hills).

(3) The coastal plains to the west of the uplands/ the western basaltic hills, that end up gradually into the coastline.

This step-like landscape, when examined in detail, shows several very interesting relief characteristics. While the successive levels in the hilly terrains and the uplands are characterised by linear ridges, linear rows of conical flat topped hills and cluster of smaller hills

separated by low-lying areas, the coastal plains and the northern alluvial plains contain sporadic ridges and hills. The intermontane valleys in the basaltic terrain, are narrow and steep while those in the uplands are shallow and wide. A distinct transition is observed in the characteristics of the high and low grounds of the Netrang and Kadvali uplands. The total area occupied by the ridges and hills is about 1300 sq. km (i.e. about 17% of the total study area).

SLOPE ANALYSIS

Analysis of slope and study of slope characteristics, were carried out by means of cross-section lines and profiles. For this purpose, the topographic sheets of the scale 1 : 50,000 were used. The cross-section lines were drawn in various directions from the highest point (Δ 882 m) located on the Dhamanmal Dungar. From this point, section lines radiate across terrains of varying reliefs and the respective profiles project the relief features. Ten representative section emanating from the eastern hilly, terrains cover the entire study area in various directions. (Fig. V 2). These profiles ideally bring out the slope characteristics of the study area. The author has, with the help of these profiles, calculated following parameters :

i. Relief Ratio
ii. Slope
iii. Gradient
iv. Configuration and nature of slope.

Table VI 2 give the details along the different cross-section lines. Cross-section Profiles (Fig. V 3 i, ii, iii, iv) are drawn and each profiles has been briefly described below :

Profile I Dhamanmal Dungar - Malsamot Plateau

This profile, extending SE ward from Dhamanmal Dungar for 17 km cuts across the rugged basaltic terrain, especially the Piplod hills, Terav valley and the Mal-Samot plateau. Across this profile, apart from the river Terav, the Khadis of Som, Bo‡gla and Sankali are also encountered. In general, the high altitude ridges are elongated, convex shaped with gentle to steep slope, with secondary ridges, showing concave steep to gentle slopes. The conical narrow or broad base hills are either on the plateau or on ridges. The ridges/plateaux are either cliffy or with steep slopes finally getting gentler, providing concave flatland. This latter phenomenon is obviously due to the accumulation of scree or wash material from the overhanging cliffs. The variation in the slope angles and shapes, appear to be controlled, to a great extent by the dips and strikes of the numerous joints and fractures in the basalts across which the profile runs. (The author would however mention at this point a word of caution. The actual slope as shown on a particular profile may not be the true slope because, the value of slope angle in any other direction except that at right angles to the actual slope will always be less than the maximum). The joint and fracture pattern and the criss-cross dissection of the trappean terrain are seen expressed by a variety of slopes, steep, gentle

TABLE No. V.2

SLOPE ANALYSIS AND CHARACTERISTICS

Cross Section Profile - I at (882 m peak) 17 km long Malsamot Plateau.

No.	Relief ratio	Slope Degree	Gradient Degree	Characteristics of slope
1	0.41	67°.71'	22.29	Conical hill, steep slope.
2	0.26	75.43	14.57	Ridge, convex form, gentle to steep
3	0.12	83.16	6.84	Tangential concave valley.
4	0.28	74.36	15.64	Round hill, convex and steep slope.
5	0.019	88.92	1.08	Ridge, concave, gentle slope.
6	0.50	63.43	26.57	Step like ridge steep and concave slope.
7	0.40	68.20	21.80	Conical hill, concave steep to gentle slope.
8	0.53	62.08	27.92	Concave, Steep to gentle slope.
9	0.021	88.80	1.20	Ridge concave slope.
10	0.13	82.59	7.41	Ridge, Steep cliffy slope and valley, steep slope.
11	0.25	75.46	14.04	Broad valley, concave, gentle slope.
12	0.2	78.69	11.31	Valley, concave, steep and gentle slope.

In general rugged relief

Cross - Section Profile II

882 m peak 27 km long Sagbara hills.

No.	Relief	Slope Degree	Gradient Degree	Slope characteristics
1	0.27	74.89	15.11	Conical hill and ridge, convex form, gentle and steep slope.
2	0.23	77.26	12.74	Tangential steep slope
3	0.019	88.88	1.12	Concave, gentle slope
4	0.0049	89.72	0.28	Concave flat terrain of the upland, very gentle slope.
5	0.088	84.93	5.07	Valley, concavity is towards valley, normal gentle slope.
6	0.01	89.43	0.57	Round top hill, concave, gentle slope.
7	0.024	88.63	1.37	Round top hill, concave, gentle slope
8	0.21	78.11	11.89	Conical hill, concave, steep and gentle slope.
9	0.14	82.15	7.85	Flat round top ridge convex shape gentle and steep slope.
10	0.020	88.83	1.17	The plain terrain, concave form, gentle slope.

Cross-Section Profile III

40 km long SW of Karjan River

No.	Relief ratio	Slope Degree	Gradient Degree	Slope characteristics
1	0.055	86.85	3.15	Flat top ridge, convex conical hill.
2	0.11	83.68	6.27	Ridge, convex and concave forms with gentle to steep and gentle slopes.
3	0.012	89.31	0.69	Low altitude round concave shaped ridge, gentle slope.
4	0.067	86.19	3.81	Round concave hill, gentle slope.
5	0.070	85.96	4.04	Round top hill, concave, uniform gentle slope.
6	0.070	85.96	4.04	Valley, steep and gentle slope.
7	0.11	83.68	6.27	Flat top hill concave shape, steep and gentle slope.
8	0.022	88.73	1.26	Low altitude round hill, concave, gentle slope.
9	0.015	89.14	0.84	Ridge - over the upland, convex, gentle and steep slope.
10	0.004	89.98	0.021	Very gently rolling uplands concave saucer shape gully or valley gentle slope.

In general eastern part is rugged of ridges and hills with intermont valleys. While western part is undulating uplands terrain comprising round concave low altitude hills.

Cross - Section Profil IV

882 m peak 56 km long towards SW in Kim river basin.

No.	Relief Ratio	Slope Degree	Gradient Degree	Slope characteristics
1	0.16	80.98	9.02	Conical hill - ridge, pyramid shape, steep slope.
2	0.12	83.38	6.62	Conical hill convex and concave shapes, gentle to steep and gentle slopes.
3	0.11	83.61	6.39	High altitude hill, conical shape, steep slope.
4	0.032	88.18	1.82	Round hill, concave, gentle slope.
5	0.064	86.34	3.66	Round flat ridge, convex, gentle and steep slope.
6	0.031	88.24	1.76	Low altitude round hill, concave, gentle slope.
7	0.05	87.14	2.86	Ridge, concave, steep to gentle slope.
8	0.12	83.16	6.84	Hills and ridge concave form steep and gentle slopes.
9	0.036	87.92	2.08	Flat ridge steep gentle slope towards Terav river valley.
10	0.06	86.57	3.43	Conical hill concave, gentle slope towards Terav river valley.
11	0.086	85.10	4.90	Conical hill concave, steep and gentle slope
12.	0.0089	89.48	0.52	Upland, concave,very gentle slope.
13	0.031	88.24	1.76	Conical hill & ridge concave steep and gentle slope.
14	0.011	89.35	0.65	Dissected upland, concave form, very gentle slope.
15	0.013	89.26	0.74	Round hill over the upland, concave, gentle slope.
16	0.026	88.53	1.47	Broad round hill over the upland, concave, gentle slope.
17	0.047	87.31	2.69	Low altitude round hill, concave, gentle slope.
18	0.011	89.38	0.62	Round top hill over the upland concave, very gentle slope.

Eastern basaltic terrain is rugged, hills & ridges, intermont valleys.

Western trappean uplands are undulating low altitude round concave hills.

Cross Section Profile - V

882 m peak 100 km long to Alia bet.

No.	Relief ratio	Slope degree	Gradient Degree	Slope Characteristics
1	0.31	72.61	17.39	Ridge and conical hill, steep cliffy slope.
2	0.13	82.41	7.59	Conical hill, concave - steep and gentle slope.
3	0.25	75.96	14.04	Steep slope.
4	0.16	80.91	9.09	Steep, tangential and gentle slope.
5	0.6	59.04	30.96	Tangential and gentle slope.
6	0.15	81.39	8.61	Flat top ridge convex and concave, gentle, steep and gentle slope.
7	0.16	80.91	9.09	Valley - steep to gentle slopes
8	0.17	80.46	9.46	Conical hill & ridge convex form gentle to steep slope.
9	0.11	83.66	6.34	Ridge convex form gentle steep slope towards the valley.
10	0.037	87.87	2.13	Gentle slope.
11	0.048	87.25	2.75	Gentle slope.
12	0.17	80.54	9.46	Steep and tangential slope.
13	0.073	85.84	4.16	Conical hill, tangential and gentle slope.
14	0.054	86.91	3.09	Gentle slope.
15	0.125	82.88	7.12	Tangential slope.
16	0.24	76.51	13.49	Steep slope.
17	0.028	88.39	1.61	Gentle slope.
18	0.085	85.16	4.84	Round hill, convex form, gentle and steep slopes towards the rivers Terav and Karjan.
19	0.175	80.07	9.93	Tangential slope.
20	0.025	88.57	1.43	Gentle slope.

No.	Relief Ratio	Slope Degree	Gradient Degree	Slope Characteristics
21	0.12	83.16	6.84	Low round top ridge concave steep to gentle slopes.
22	0.053	86.95	3.05	Gentle slope.
23	0.088	89.49	0.51	Upland, concave, gentle slope.
24	0.27	75.07	14.93	Ridge-upland tangential and gentle slope.
25	0.015	89.14	0.86	Hill on the coastal plain concave gentle slope.
26	0.0024	89.89	0.11	Coastal plain, very gentle slope.

Eastern & Western basaltic hilly rugged terrain with ridges, hills, valleys and undulating uplands and coastal plains. Convex and concave forms.

Profile

Cross Section VI

882 m peak - upto Jadeshwar 77 Km long line crosses Narmada

No.	Relief ratio	Slope Degree	Gradient Degree	Slope Characteristics
1	0.31	72.60	17.40	Conical hill and ridge, steep cliffy slope.
2	0.13	82.41	7.59	Tangential slope.
3	0.16	81.03	8.97	Ridge, concave form, steep, tangential and gentle slope.
4	0.095	84.56	5.44	Ridge steep and tengential slope.
5	0.18	79.70	10.30	Tangential slope.
6	0.11	83.66	6.34	Ridge, gentle slope.
7	0.04	87.71	2.29	Flat top ridge, tangential and gentle slope.
8	0.060	86.58	3.42	Ridge concave steep and gentle slope.
9	0.042	87.59	2.41	Gentle slope
10	0.08	85.43	4.57	Round convex form hill, gentle slope.
11	0.08	85.43	4.57	Tangential and gentle slope.
12	0.17	80.27	9.73	Tangential slope.
13	0.4	68.20	21.80	Steep slope.
14	0.088	84.92	5.08	Gentle slope.
15	0.12	83.15	6.84	Gentle slope.
16	0.17	80.54	9.46	Steep and tangential slope.
17	0.053	86.95	3.05	Gentle slope
18	0.067	86.19	3.81	Round hill, concave, gentle slope.
19	0.022	88.73	1.27	Flood plain, saucer shape, gentle slope.
20	0.048	87.27	2.73	Triangular hill over the upland, concave, gentle slope.

No.	Relief Ratio	Slope Degfee	Gradient Degree	Slope Characteristics
21	0.091	84.81	5.19	Tangential and gentle slope.
22	0.038	87.83	2.16	Gentle slope
23.	0.064	86.34	3.66	Low altitude convex ridge, gentle to steep slope.
24	0.051	87.09	2.91	Convex ridge over the upland, gentle and steep slope.
25	0.037	87.86	2.14	Round top ridge, steep and gentle slope.
26	0.074	85.76	4.24	Upland and hill, concave form, steep and gentle slopes towards the flood plains.
27	0.078	85.53	4.47	Convex elongated ridge, tangential and steep slope.
28	0.036	87.92	2.08	Ridge, concave, steep and gentle slopes over the uplands and alluvial plains.
29	0.010	89.41	0.59	Flood plain, very gentle slope.
30	0.00038	89.98	0.021	Coastal plains, very gentle slope.

In general Eastern basaltic hilly terrain has rugged relief, ifregular slopes. Western basaltic hills are also rugged & irregular in slope, while Kadvali uplands - undulating concave slopy terrain. Flood plains and coastal plains flat terrain showing very gentle slope.

Cross-Section Profile VII

882 m peak 50 Km long line cross es Karjan and Narmada, Sinor.

No.	Relief Ratio	Slope Degree	Gradient Degree	Slope Characteristics
1	0.28	74.36	15.64	Conical hill and ridge pyramid shape, steep cliffy slope.
2	0.66	56.31	33.69	Cliff, steep slope.
3	0.13	82.41	7.59	Plateau followed by tangential slope.
4	0.12	82.80	7.20	Plateau, and ridge, convex form, gentle and steep slope.
5	0.071	85.94	4.06	Dissected plateau and ridge convex form, gentle and steep slope.
6	0.20	78.69	11.31	Dissected plateau convex ridge, tangential and steep cliffy slope.
7	0.18	79.92	10.08	Ridge concave, steep and gentle slope.
8	0.13	82.41	7.59	Ridge and valley, convex, gentle and steep slope.
9	0.125	82.87	7.13	Hills, steep or tangential and gentle slope.
10	0.22	77.69	12.31	Ridge, steep and tangential slope.
11	0.096	84.49	5.51	Ridge, convex form, gentle and steep slope.
12	0.175	80.07	9.93	Conical hill, cliff and steep slope.
13	0.09	84.83	5.17	Conical hill, cliff, concave form, steep and gentle slope.
14	0.30	73.30	16.70	Valley steep cliffy and tangential slope.
15	0.24	76.50	13.50	Triangular hill, convex form, gentle and steep slope towards the valley.
16	0.15	81.47	8.53	Conical hill, steep and tangential slope.
17	0.33	71.57	18.43	Conical hill over the plateau, steep slope.
18	0.16	80.79	9.21	Plateau steep and gentle slope towards the flood plain.
19	0.00235	89.87	0.13	Flat saucer shape flood plain very gentle slope.

Eastern basaltic hilly terrain irregular slope. Plateau, ridges and hills and flood plains are of very gentle slope.

Cross-Section Profile VIII

882 m peak 41 km long line - Heran river Dudhpur (Near Wasna)

No.	Relief ratio	Slope Degree	Gradient Degree	Slope Characteristics
1	0.34	71.45	18.55	Conical hill and ridge, cliffy steep slope.
2	0.32	72.47	17.53	Valley, steep and gentle slope.
3	0.27	75.07	14.93	Valley, steep and tangential slope.
4	0.29	74.05	15.95	Tangential and steep slope towards the valley.
5	0.071	85.91	4.09	Flat round top ridge convex form gentle and steep slope.
6	0.31	72.72	17.28	Ridge and Valley Concave form, steep and gentle slope.
7	0.27	75.07	14.93	Conical hill between two Khadis, steep slope.
8	0.022	88.73	1.27	Ridge, steep and gentle slope.
9	0.12	83.09	6.91	Tangential gentle slope
10	0.27	7.507	14.93	Valley, steep slope.
11	0.0018	89.89	0.11	Flat alluvial plain, very gentle & slope.
12	0.035	88.01	1.99	Low altitude conical hill gentle slope.
13	0.094	84.62	5.38	Triangular hill concave steep and gentle slope.
14	0.032	88.17	1.83	Triangular hill, tengential and gentle slope.

In general Eastern basaltic hills (S of Narmada) are of irregular slope, rugged relief of ridges & hills followed by valleys. Alluvial plains are gently slopying with hill of concave slope.

Cross-Section Profile IX

882 m peak 50 km long line Phenaimata hill & Heran river.

No.	Relief ratio	Slope Degree	Gradient Degree	Slope Characteristics
1	0.21	77.88	12.08	Conical hill and ridge, pyramid shape, the steep cliffy slope.
2	0.31	71.94	17.28	Valley, steep slope.
3	0.36	70.20	19.80	Dissected plateau and Valley cliffy steep slope.
4	0.017	89.02	0.99	Ridges and hills step like form, steep and gentle slope.
5	0.044	87.48	2.54	Conical hill and ridge, convex and concave, gentle steep and gentle slope.
6	0.20	78.46	11.31	Steep-gentle slope.
7	0.27	74.33	15.38	Conical hill, concave and a tangential slope.
8	0.083	85.23	4.76	Conical hill, steep and gentle slope toward Ruwel river valley.
9	0.052	87.01	2.99	Triangular hill, gentle slope.
10	0.086	85.10	4.90	Conical & round hills and ridges intermittent spur, steep and gentle slope.
11	0.011	83.68	6.22	
12	0.15	81.37	8.53	
13	0.02	88.85	1.15	Flat ridge over the alluvial plain gentle slope.
14	0.025	88.47	1.43	Round low altitude hill, concave, gentle slope.
15	0.0046	89.74	0.26	Alluvial plain, gentle slope.
16	0.038	87.82	2.18	Ridge, concave, gentle slope.

No.	Relief ratio	Slope Degree	Gradient Degree	Slope Characteristics
17	0.30	73.03	16.97	Conical hill and ridge steep and cliffy slope.
18	0.17	80.77	9.77	Conical hill and ridge steep and cliffy as well as gentle slope.
19	0.039	87.75	2.25	Ridge, concave, gentle slope.

In general, Eastern & Northeastern rugged relief, irregular slopes and uneven topography turns to alluvial plains.

Cross-Section Profile X

882 m peak 48 km long line in NE Crosses Raminadi of Heran

No.	Relief ratio	Slope Degree	Gradient Degfee	Slope Characteristics
1	0.34	71.01	18.99	Conical hill and ridge pyramid convex form, steep slopes.
2	0.33	71.57	18.43	Cliff, steep slope.
3	0.12	83.16	6.84	Convex form ridge gentle, steep and tangential slope.
4	0.13	82.41	7.59	Steep and tangential slope.
5	0.087	85.03	4.97	Steep and gentle slope.
6	0.44	66.04	23.96	Devganga valley, steep slope.
7	0.08	85.43	4.57	Ridge and Valley, steep and gentle slope.
8	0.31	72.45	17.45	Convex form ridge, steep cliffy and tangential slope towards the valley.
9	0.22	77.47	12.53	Narmada valley steep tangential slope.
10	0.1	84.29	5.71	Ridge steep & tangential slope.
11	0.089	84.88	5.12	Ridge concave form, steep and gentle slope.
12	0.22	77.69	12.31	Tangential slope
13	0.05	87.14	2.86	Low altitude ridge, concave, gentle slope.
14	0.11	83.91	6.09	Tangential slope.
15	0.09	84.78	5.22	Ridge, steep and gentle slope.
16	0.023	88.69	1.31	Low altitude ridge, concave, gentle slope.
17	0.12	82.98	7.02	Steep like structure, broad valley, concave form, steep and gentle slope.
18	0.043	87.55	2.45	Concave, gentle slopes
19	0.015	89.14	0.86	Ridge, concave, gentle slope.

No.	Relief Ratio	Slope Degree	Gradient Degree	Slope Characteristics
20	0.05	87.14	2.86	Ridge, steep and tangential slope.
21	0.01	84.29	5.71	Triangular hill gentle slope.
22	0.036	87.95	2.05	Ridge on alluvial plain, concave, gentle slope.
23	0.028	88.40	1.60	Low altitude conical hill, concave, gentle slope.

Eastern basaltic hilly terrain (S. of Narmada) and Eastern basaltic hills (N. of Narmada), Kajalmata, Ambadungar Kawant hills rugged irregular slope - steep to gentle slope turns to alluvial plains with isolated conical or round hills.

and tangential, combining together to provide a relief of landforms, like plateau, escarpments, cliffs, conical hills, hills of irregular shapes and rows of hills, marked by slopes of varying gradients and shapes (straight, concave, convex etc.) All these have contributed not only to the ruggedness of topography but have also imparted a fascinating variety to the slope characteristics. This profile projects 12 landforms (Table V 2 I).

Profile II Dhamanmal Dunger to Sagbara hills

Extending southward from the Dhamanmal Dungar. this 27 km long cross-section line runs across the Piplod hills, Terav river valley, Mosda group of plateau and hills, and finally ends with the Sagbara hills. This line projects 10 profiles (table V 2 II) of a variety of topographic features that occur within the altitude range of 300 to 882 m of the basaltic terrain. The ground to the north of the river Terav shows ridges and conical hills with the cliffy and / or steep convex slopes. The steep slopes of these high altitude features, are themselves dissected by numerous secondary discending spurs with intervening valleys, which are also characterised by fairly steep concave slopes. Finally, this runs into the Terav valley. On the other hand to the south of the river Terav, low altitude convex shaped, elongated ridges with gentler slopes abound. These elongated ridges have produced concave but gently sloping flatlands that merge

into the uplands. The ground rises further south towards Sagbara hills, this part of the profile is marked by convex shaped ridges with flat tops, on which are located, in turn, steep sloped conical hills. Finally just at the southern limit (of the study area) the Sagbara hills abruptly terminate against the plains, forming steep slopes convex followed by concave.

Profile - III Dhamanmal Dungar to Netrang uplands.

This southwest running cross-section line with a length of 40 km crosses the western part of the basaltic hilly terrain, Ierav river valley, Dediapada Uplands, Karjan river valley, Mohan Khadi and finally ends up on the Netrang Uplands. The profile projects 10 landforms (Table V 2 III), each showing different slope characteristics. The profile of the landforms, gradients and slopes projected along this section line are distinctly different from those of the profiles I and II.

The portion falling within the high altitude region to the east of Terav, is as usual characterised by ridges and conical hills with steep convex slopes in its upper parts and with steep but concave slopes in its lower parts. Beyond Terav valley, the profile runs all along the low undulating uplands of Dediapada and Netrang. The uplands terrain exhibits low altitude round topped ridges with much gentler gradient and concave

slopes. Also, the profile reveals round top hills as well as broad based or sharply pointed conical hills. The gentleness of the gradient and concavity of the slopes, have imparted a typical undulating topography to the uplands.

Profile - IV Dhamanmal Dungar to Tertiary Coastal Plains.

The cross-section line runs westward from the Dhamanmal Dungar for 56 km and crosses the eastern rugged basaltic hills, uplands of Dediapada and Netrang and finally ends on the Tertiary coastal plains. The rivers Terav, Karjan and Kim are encountered along this profile. These rivers as well as the other small tributaries (Dhir and Mohan Khadis), exhibit considerable diversity in their channel slopes. Terav is marked by a narrow valley with steep convex sides. The courses of smaller khadis of Dhir, Mohan and others are also narrow, relatively deep with steep convex and straight slopes. The valley of Karjan is somewhat broader with relatively straight and concave slopes. On the other hand, the course of the Kim river, within the Tertiary uplands, shows a broad shallow channel with cliffy banks 4 to 8 m high. In all 18 land features are projected on the profile (Table V 2 IV). The features on the profiles, to the west of the river Terav, within the uplands, consist of the ridges are of low altitude, elongated, with gentle convex slopes. And further, westward, the ridges are seen becoming broad and round topped while

the hills are typically conical, with gentle concave slopes. The section in the slope profile from east to west ideally shows the change over from convex to concave over the uplands and to the coastal plains.

Profile - V Dhamanmal Dungar to Aliabet

This profile extending westward from Dhamanmal Dungar to Aliabet in the west (an island at the month of the river Narmada), forms the largest section covering a distance of about 110 km. The profile shows a wide variety of landforms, characteristic of each of the physiographic units, viz. the eastern rugged basaltic hilly terrain, the Western basaltic hills, the Kadvali Uplands and the Tertiary Quaternary coastal plains. This profile also ideally shows distinct levels, which characterise the step like topography of the terrain. The three main levels, plateau, uplands and the coastal plains, show very well defined slope characteristics in terms of altitude, gradient and shape. On the trappean plateaux, the ridges as usual show steep sloped convex forms. The each of the two plateau high level are characterised by high altitude conical hills rising between 700 to 880 m, the hills are marked by steep slopes. On the uplands, the basaltic hills west of Terav exhibit flat topped ridges, dotted with pointed or rounded hill summits. The hills and mounds occuring within the coastal plains are low,

show gentle gradients and form concave slopes. The rivers Terav, Karjan and Madhuvati all confined to the basaltic terrain, have formed narrow valleys 30 to 40 m deep. The profile projects 26 different landforms which are listed in the (table V 2 V).

Profile - VI Dhamanmal Dungar to Jadeshwar

This 77 km long cross-section line WNW from Dhamanmal Dungar to Jadeshwar covers the eastern and western basaltic hills, the Tertiary upland of Kadvali and the floodplains of Narmada. It also crosses the rivers Terav, Karjan and Madhuvati. It also shows the profiles of the floodplains and a major meander curve of Narmada. The river Terav, Karjan and Madhuvati are seen on the profile as narrow as 20 to 30 m deep steeply inclined/cliffy valleys. In all 30 landforms are projected on the section line (Table V 2 VI). Within the eastern basaltic terrain, the dissected plateaux, ridges and hills are characterised by steep cliffy slopes tops of these high altitude features dotted with conical hills, which themselves are steep. The western part of the basaltic terrain and the adjoining uplands comprise ridges and hills of low altitude which are somewhat widely spaced, slopes are concave steep followed by gentle. The western uplands nearer to the flood plains, show low hills separated by broad depressions, imparting an undulating profile. The summits of the hills are both sharp as well as rounded, the slopes being gentle and concave. The uplands gradually merge into the flood

plains, the latter are almost flat and gradientless.

Profile - VII Dhamanmal Dungar to Sinor Village (across the river Narmada)

Northwest of Dhamanmal Dungar at a distance of 50 km across Narmada is the village of Sinor. The profile along this cross section line presents 19 land-forms (Table V 2 VII) which include those of basaltic hills, Narmada flood plains and the meander zones of the rivers Karjan and Narmada within the Narmada flood plains. As usual, the river villeys of Terav and Karjan divide the eastern and western basaltic hills. Along this profile line the ridges and hills of the basaltic terrain show cliffs and steep slopes, and plateau and ridges topped by conical hills. The various secondary ridges show steep but straight slopes. The foot hills and lower portions of the ridges and hills are marked by gentle slopes, merging into the flood plains. The valley of Terav shows relatively steep concave slopes. The terrain of the flood plains and meander zones is more or less saucer shaped and flat, very gently rising to the SE towards the hilly terrain.

Profile - VIII Dhamanmal Dungar to Heran River

This cross-section line extends NNW of Dhamanmal Dungar across the rivers Narmada and Heran upto Dudhpur village (near Wasna) spanning a distance of 41 km. The profile crosses two physiographic units - basaltic hilly

terrains (S of Narmada) and the Western hilly and undulating alluvial plains (N of Narmada) and projects 14 features (Table V 2 VIII). The landforms encountered along this line show considerable diversity in terms of altitude variation, slope characteristics and valley features. Apart from the usual high altitude features of the hilly terrains, the portion covering the ground through which flow the river Narmada and its tributaries like Ruwal, Men, Aswan and Heran (Via Orsang), provides a landscape which is marked by quite different slope characteristics. For the most part north of Narmada, the profile runs across an undulating terrain, on the whole showing a much subdued topography. The hills are of low altitude, merging into alluvial plains through moderately steep to gentle concave slopes. The hill tops are of both types sharply pointed as well as rounded, the upper slopes being steep and straight while the lower portions gentle. The extensive intervening plains do not show any significant gradient, and the scattered hills rise above them through well marked gentle concave slopes. Wherever the section line crosses the rivers, a drop in the height of the order of 5 to 15 m is observed on the map. The banks are generally steep and cliffy.

Profile - IX Dhamanmal Dungar to Phenai Mata hill and Heran River

This cross-section line about 50 km long, between Dhamanmal Dungar and the Phenai Mata hill extends across

Narmada, and crosses the rivers Devganga, Narmada, Ruwel, Men, Aswan and Heran in a northerly direction. The projected 19 landforms (Table V 2 IX) on the profile show a variety of slope characteristics quite different from the trappean terrain.

The trappean landscapes to the south and north of Narmada mark two levels on this profile - high altitude ridges and hills with plateaux and the lower altitudes hilly terrain running into the Narmada valley.

North of Narmada, the cross-section line crosses the Vadgam-Limdi, Naswadi and other scattered trappean hills. These are again low altitude hills with steep to gentle concave slopes. In many cases, the low altitude hills with pointed or round topped summits showing straight and uniform slopes, the concavity restricted to their bases where they merge into the alluvial plains. The Devganga river shows a narrow valley with steep convex slopes, while the river Narmada has formed a broad valley with straight and gently sloping sides. The rivers Ruwel, Men, Aswan and Heran have formed shallow broad depressions ranging in depth from 5 to 15 m.

Profile - X Dhamanmal Dungar to Rami River in Heran river valley.

This cross-section line extends NNE from Dhamanmal Dungar to Rami river, a tributary of the river

Heran. This 48 km long cross-section line, on crossing the Narmada, passes through the basaltic hills of the Kajalmata, Amba dungar and Kawant. Further northeast, are encountered the low lying rocky to elluvial plains upto the river Rami and Heran. Along this line, the valleys of Devganga, Narmada, Men and Heran are rather narrow and deep with the steep convex to concave slopes. In all 23 landforms (Table V 2 X) are projected on the cross-section line. In general, the hilly terrain consists of ridges and hills with cliffy and steep slopes at high altitudes. The ridges and hills show convex, conical and flat rectangular shapes with gentle convex slopes. While the intervening lower ground show flat terrains with gentle slopes. The low altitude hills of the plains are either conical with sharp summit or round topped, marked by gentle concave slopes in their lower portions.

DISCUSSION

From the foregoing description of the relief features and slope characteristics of the study area, certain very important geomorphic controls that have been responsible for the total landscape evolution have emerged. It is evident that the most important factor is that of geology. The diversity of geological formations of different ages, each characterised by its own lithology and structural features, have controlled the relief and slope in the different physiographic units.

A close co-ordination is seen to exist between relief and geology. The high altitude rugged terrain is typically basaltic, comprising horizontal lava flows of basalt. The intricate fracture pattern of these basaltic flows, together with thicknesses and hardness of the successive layers, have combined together to give rise to a fantastic assemblages of landforms that include flat-topped plateaux, ridges and hills with cliffy and steep slopes and serrated ridges with conical hills, sharp crested or round topped and a variety of clusters of bizarre - shaped hills.

The high altitude terrain, is marked by a more rugged relief and narrow steep valleys and khadis. The slopes of hills in general are steep concave. The relatively low altitude hilly terrain representing lower lava flows is characterised by a much less rugged topography. Though the landforms continue to be indentical, they are more opened spaced, the intermontane valleys are broader with gentle concave slopes. In totality, however, the relief and slope characteristics point to dominance of erosive processes.

In the terrain to the north of river Narmada, the trappean highlands slope into alluvial plains, the uplands being almost absent, while in the south, they are flanked by uplands which, further West, merge into coastal plains. To the south of Narmada on proceeding

towards the uplands, there is not only a marked fall in the altitude, but the overall relief also shows a distinct change. Even within the uplands, the trappean portion is somewhat different from the Tertiary upland. The former comprises a low relief basaltic ground not so rugged with scattered hills and ridges. The hills are the remnants of lava flows and the projecting portions of intruding dolerite dykes. Otherwise the entire landscape is gentle undulating. Tertiary uplands show comparatively a much subdued topography and the undulations representing alternate highs and lows, reflect the anticlinal and synclinal flexures of the sedimentary formations. The slopes are gentle and concave. The uplands as a whole represent sites of both erosion and deposition.

The coastal plains, are devoid of any ruggedness. Except for a few sporadic hills and mounds of Tertiaries, the ground is flat and gently sloping seaward. These plains consist of Quaternary alluvial soils and coastal deposits, and the plains thus point to a dominantly depositional phenomenon.

To the north of Narmada, the alluvial plains show comparatively much more variety in respect of relief. The entire physiographic unit is seen to represent alluvial deposits of the various rivers, through which rise numerous low hills and ridges of

basalt and Cretaceous sedimentary rocks (Bagh beds). An interesting feature of these plains is the effective control of E-W faults in giving rise to the numerous rocky projections.