Trans. Inst. Indian Geographers
Vol. 4, No. 2, July 1982

MORPHOMETRIC PERSONALITY OF THE HIMALAYAN TECTONIC UNITS

J. S. RAWAT and S. C. JOSHI, Nainital

ABSTRACT : The study extends to the lower catchment of the Ramganga river along the central sections of U. P. Himalaya. The working hypothesis introduced here reveals that the morphometric parameters are largely controlled by the tectonics. The Crystalline tectonic unit, comprising of the High Grade and Low Grade metamorphics composed of gneiss, phyllites and quartzites is passing through an early young stage of geomorphic development having moderate values of the drainage density (3.17 Km/Km^2), stream frequency (6.00 No/Km^2), ruggedness number (4.16), drainage texture (7.35) and bifurction ratio (3.00) and high values of relief ratio (0.08) and basin circularity ratio (0.68). The rocks of the Krol unit (younger and weaker than the Crystalline unit) are passing through a young stage of geomorphic development and demonstrate high values of drainage density (3.63 Km/Km^2), stream frequency (6.50 No/Km^2) ruggedness number (5.55), drainage texture (8.85), bifurcation ratio (3.12), basin slopes (27.31°) and relief ratio (0.09). The drainage basins devoloped in the Siwalik unit (younger and weaker than Krol), however, exhibit the characteristics of early young stage in the Siwalik-mountainous and early mature stage with low values of the above variables in the Siwalik–foothills. The distinct nature of the morphometric personality between the Siwalik and the Krol and the Crystalline units corroborates the existence of the Main Boundary Fault and thrust respectively

Statement of the Problem

Horton (1932) classified the factors of drainage basins into five groups i.e., morphologic, soil, geologic structure, vegetational and climate. The working hypothesis introduced here reveals that the drainage basin characteristics are largely controlled by the tectonics.

Study Area

The area of investigation lies between 29°22' and 29°50' N Latitudes and 78°35' and 79°50'E. Longitudes (Fig. 1), encompassing an area of 1957 Square Kilometres in the Lower Ramganga catchment of the Western Ramganga river (henceforth called Ramganga). Administratively, it includes parts of the districts of Almora, Pauri Garhwal and Naini Tal in the central sections of U.P. Himalaya. The basic inspiration that has led the authors to select the area for study is that it falls in the catchment of a multi-purpose project i. e. Ramganga dam, completed at the cost of Rs. 133 crores, at a transition site between mountains and plains.

Geological Setting

The structural, lithological and stratigraphical framework of the study area is very

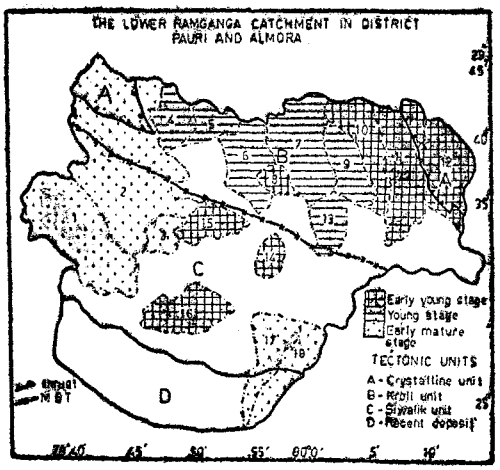

Fig. 1 Showing the fifth order basins of different geomorphic stages;
1. Sona River, 2. Palain River, 3. Baila Nadi, 4. Upper Mandal River,
5. Wudar Gad, 6. Katera Raula, 7. Kalli Nadi, 8. Golagadi Nadi,
9, Patlion Gad, 10. Deo Gad, 11. Badhangarh Nadi 12 Nair Nadi, 13 Khamaldasot, 14 Boksgadi Sot, 15. Gaujera Nadi, 16. Maira Sot, 17 Koti Rao, 18. Phika Nadi.

much complicated. A detailed description of the various formations encountered in the area is given by Rupke (1974). A generalized and simplified sequence after Rupke is given in Table I which includes the major tectonic units, stratigraphical formations andl ithologies of the study area. Table I indicates the tectonic complexity of the area including the tectonic units i. e. the Crystalline unit, the Krol, the Siwalik and the Bhabar. The crystalline and Krol units are separated by a thrust viz. South Almora Thrust. The allochthonous Krol and autochthonous Siwalik units are separated by Main Boundary Fault

Measurements and Results

All the fifth order basins (18) were selected for the purpose of the study (Fig. 1) from the S. O. I. topographical sheets (1/50,000). The morphometric characteristics such as stream length, stream number, basin area and relative height were measured from these SOI sheets and these measurements were used to derive the stage of geomorphic development by using hypsometric integral (Strahler, 1964), drainage density, stream frequency, drainage texture, stream length ratio, bifurcation ratio, basin slope and relief ratio for all the 18 basins. The results of these basins are presented in Table II.

Stratification of the Selected Drainage Basins

In order to work out the working hypothesis, all the selected drainage basins were stratified into different stratum according to the tectonic units and the mean morphometric characteristics of each stratum was computed (Table II) by using the data of Table II. The Palain drainage basin has been excluded since it strecthes over more than one tectonic unit.

Interpretation

The morphometric personality of the Crystalline, Krol and Siwalik tectonic units as presented in Table III reveal the following:

(1) Morphometrically, with regard to basin slope, relief ratio, stream length ratio and basin circularity ratio, there is no marked difference in the Crystalline and the Krol units, but these may be differentiated by their stages of geomorphic development drainage density, stream frequency, ruggedness number, drainage texture and bifurcation ratio (Fig. 2). Due to the hard bedrock e. g. gneiss, phyllites and quartzites of the crystalline unit as compared to the Krol unit, the erosion itensity is relatively less in this case and only 40 per cent area of the total land has been eroded by the fluvial process, while in the Krol unit the per cent of consumed land stands at 50 per cent. The impermeability of the bed--rocks of the Crystalline unit does not allow a larger number of streams to develop than that of the Krol unit and it is due to this fact tha

Table I

Tectonic Units Stratigraphical Formations and Lithology of the Lower Ramganga Catchment

Tectonic units	Formations	Lithology
The Crystalline	High Grade Metamorphics	Gneiss and granite
	Low Grade Metamorphics	Phyllite and quartzites
	THRUST	
The krol	Kophara	Shale, limestone (black) carboniferous shale,
	Subathu	Red shale, limestone.
	Lower Tal	Shale (blackish) Conglomerate.
	Krol	Limestone red / green shale.
	Blaini / Infra Krol	Fluxaturbide, limestone.
	Nagthat	Sandstone, slates
		Orthoquartzites, grits, shale, grey-wacke
	MAIN BOUNDARY FAULT	
The Siwalik	Upper	Grey-wacke shale,
	Middle	Shale, sandstone, greywacke
	Lower	Sandstone, subgrey wacke
	BREAK OF SLOPE	
Bhabar (Recent deposits)	Bhabar	Gravel coarse sand minor clay beds

the bifurcation ratio, drainage density, stream frequency and ruggedness number are moderate in the former case and rela tively higher in the latter.

(2) Relief ratio and the stage of geomorphic development are two similar characteristics of the Crystalline and Siwalik mountainous units, while values of all other morphometric parameters were found different (Fig. 2) The differences between stream length ratio and basin circularity ratio are notable. The lower order streams are larger than the higher order ones in the Crystalline unit and, therefore, the stream length ratio is low. While in the Siwalik unit, the lower order streams are smaller than the higher order ones. Consequently, the stream length ratio is relatively higher than that of the Crystalline unit. The increasing length of the higher order streams produces elongated basins in the Siwalik, while the decreasing length of the higher order streams in the Crystalline unit tends to give rise to circular basins as evidenced

by circularity ratio.

(3) All the values of the morphometric parameters, including the stage of geomorphic development of the Crystalline unit are different from Siwalik foothills. The difference is mainly due to the post-tertiary deposits in the lower part of the Siwalik foothills. The lower order streams in this unit, have originated only in the upper part of the Lower Siwalik formation, while in the post-tertiary deposits, only the main stream is in existence, and the minor streams are braided, Consequently, the morphometric parameters like drainage density, stream frequency. ruggedness number, drainage texture and bifurcation ratio are low. The high stream length ratio in this unit is responsible for elongated basins as evidenced by the low circularity ratio.

(4) Drainage density, stream frequency, ruggedness number, bifurcation ratio are the similar mophometric parameters of the Krol and Siwalik mountainous units. These units may be differentiated on the basis of their stages of geomorphic development, stream length ratio, basin slope and basion circularity ratio (Fig. 2).

(5) The Krol and Siwalik foothills are morphometrically two distinct units (Fig. 2). The basins of the Siwalik foothills are passing through early mature stage while in the Krol unit, these are undergoing a young stage of geomorphic development. whereas, the morphometric parameters like drainage density, stream frequency, ruggedness number, bifurcation ratio are high in the

Table II

Morphometric Characteristics of Drainage Basins of the Lower Ramganga Catchment

Name of the basin	Hypsometric integral (Sga)	Drainage density (in Km/Km) (Da)	Stream frequency (in no Km(St)	Ruggedness number (Rg)	Drainage texture (Dt)	Stream length ratio (Lr)	Bifurcation ratio (Br)	Basin slope (in degree) (Sb)	Relief ratio (Rr)
Sona river	497	3.39	4.22	2.33	2.34	1.79	8.00	24	0.04
Palain river	442	3.14	4 38	4 48	4.37	0.51	11.00	23	0.06
Baila Nadi	595	2 38	3 45	1.16	3.88	0.62	2.00	17	0.07
Upper Mandal river	575	3.06	6.84	2.69	9.44	0.06	2.00	32	0.10
Wudar Gad	585	3.98	8.45	3.58	8.77	1.44	4.00	27	0.12
Katera Raula	477	3.62	7.28	5.14	10 83	1.41	3.00	28	0.10
Kalli Nadi	520	3.65	6.63	2.99	11.35	0.73	4.00	28	0,06
Golagadi Nadi	775	3.35	6.66	2.34	5.76	0.72	2.00	29	0.14
Patlion Gad	595	4.61	6.10	4.88	9.79	0.85	3.00	26	0.09
Deo Gad	640	3.24	5.80	5.18	6.99	1.09	2.00	25	0.09
Badhangarh Nadi	612	3.49	4.70	6.42	7.88	1.37	5.00	27	0.09
Nair Nadi	602	3.97	6.27	4.76	11.35	0.83	3.00	26	0.08
Khamaldasot	575	3.10	5.45	4.03	6.73	0 70	2.00	27	0.11
Boksgadi sot	665	3.31	6.06	2-52	3.18	0.09	2.00	20	0.11
Gaujera Nadi	742	4.31	7 93	3 10	9.22	1.33	2.00	23	0.13
Maira sot	695	3.46	5.87	1.52	10.03	1.73	2.00	17	0.07
Koti Rao	425	2.28	3.85	1.11	5.07	2 16	2.00	12	0.03
Phika Nadi	492	2.48	3.71	1.68	4.98	3 27	2.00	10	0.04

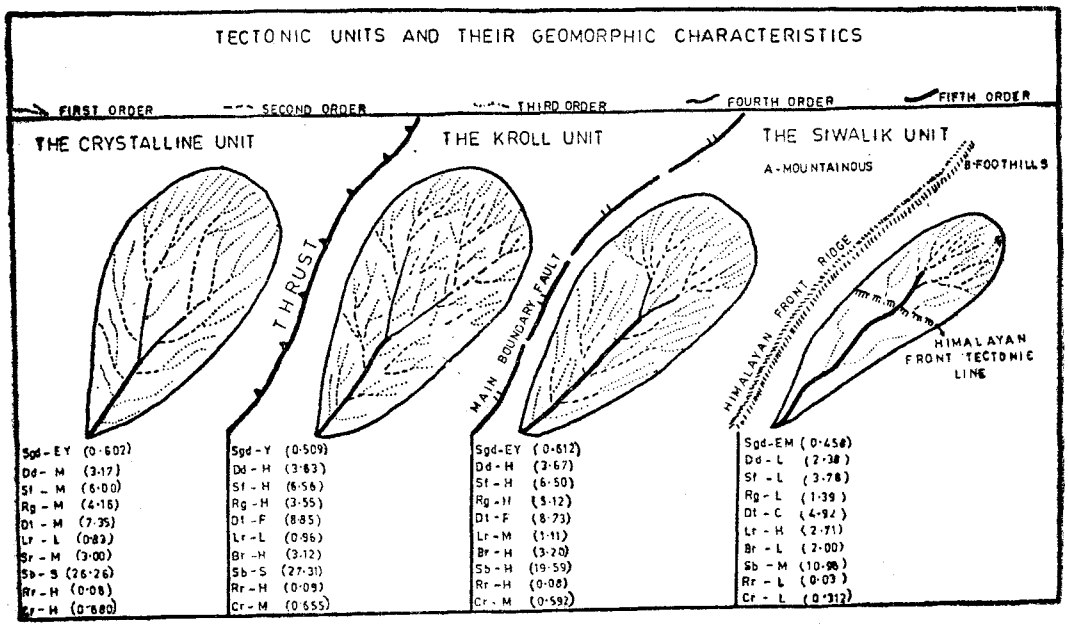

Fig. 2 Fifth order hypothetical basins showing the drainge system and geomorphic characteristics of different tectonic units (See table II for the explanation of symbols).

Table III

Tectonic Units and their Morphometric Characteristics in the Lower Ramganga Catchment

Tectonic units	Hypsometric integral (Syd)	Drainage density (in Km/Km²) (Da)	Stream frequency (in No/Km²) (St)	Ruggedness number (Rg)	Drainage texture (Dt)	Stream length ratio (Lr)	Bifurcation ratio (Br)	Basin slope In Degree (Sb)	Relief ratio (Rr)	Basin circularity ratio (Cr)
The Crystalline	0.602	3.17	6.00	4.16	7.35	0.83	3.00	26	0.08	0.680
The Krol	0 509	3.63	6.56	5.55	8.85	0.96	3.12	27	0.09	0.655
The Siwalik										
(i) Mountainous.	0.612	3.67	6.50	5·12	8.73	1.11	3.20	20	0.08	0.592
(ii) Foothills	0.458	2.38	3.78	1.39	4.92	2.71	2.10	11	0.83	0.312

Krol unit, these are low in the Siwalik foothills. Drainage texture is fine and stream length ratio is low in the former case while these are coarse and high in the latter case.

(6) With respect to the stage of geomorphic development as well as morphometric attributes, the Siwalik mountainous and Siwalik foothills are different units (Fig. 2). The considerable differences between these two units are caused by the distinct nature of deposition (alluvium) in the lower part of the foothills. The Siwalik mountainous unit is passing through an early young stage of geomorphic development while the Siwalik foothill unit is undergoing an early mature stage. Drainge density, stream frequency, ruggedness number, bifurcation ratio are high in the former and are found low in the latter.

(7) Thus, the distinct nature of morphometric personality between the Siwalik and the Krol, and the Krol and the Crystalline units corroborates the existence of the Main Boundary Fault and thrust respectively.

References

Horton, R. E. (1932) : Drainage basin characteristics, *Trans. Amer. Geol. Union*, Vol. 10, pp 350-361.

Rupke, J. (1964) : Stratigraphic and structural evolution of Kumaun Lesser Himalaya *Sedi. Geol.*, Vol. 11, pp. 81-266.

Strahler, A. N. (1964) : Quantitative geomorphology of drainage basins and channel networks, in *A Handbook of Applied Hydrology* (ed.) by Chow V. T., Mc Graw Hill,

Addresses of the authors

J. S. Rawat, Lecturer, Depr. of Geography, Almora Campus, Kumaun University.

S. C. Joshi, Lecturer, Dept. of Geography, D. S. B. Campus, Kumaun University.