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INFLUENCE OF GEOLOGICAL AND STRUCTURAL ASPECTS ON DRAINAGE MORPHOMETRIC PROPERTIES OF THE KOLLAM VAGU, MADDIERU AND PALERU STREAMS IN KURNOOL DISTRICT, ANDHRA PRADESH

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ABSTRACT : Three drainage basins namely the Kollam Vagu, Maddieru and Paleru streams of similar order in Kurnool district have been taken in order to study the influence of geological and structural aspects on various morphometric parameters. Some important morphometric parameters for the three basins were quantified and the results are presented. These three basins are located more or less on similar climatic conditions, but their geology and structural elements vary greatly. The deviations from the normal in the various morphometric properties of the drainage basins could be due to geologic and structural (tectonic) aspects.

INTRODUCTION

The quantative analysis of morphometric properties of a drainage basin has been useful in many application studies like estimation of runoff, flood discharge, groundwater recharge, sediment yield, soil as well as water conservation, environmental analysis and so many. The various morphometric properties depend on various aspects like geology, tectonics, vegetation and climate etc.

Extensive studies on drainage morphometry using statistical and empherical techniques have been made since 1940's by well-known scientists including Hortin (1945), Schumm (1956), Chorley (1957), Morisawa (1962), Strahler (1964), Gregory and Walling (1973), and many others. In India also quite a number of studies were made and these works were reviewed by Singh (1983). Horton (1945) formulated some basic concepts on drainage morphometry and these are popularly known as "*Horton's laws of morphometry*".

Of the various aspects, the geology and tectonic elements of that basin have a more pronounced control on basin morphometry through differential rates of weathering and erosional processes of varying degrees of resistance. Three drainage basins (of similar order), namely the Kollam Vagu, Maddieru and Paleru in Kurnool district of Andhra Pradesh have been selected to study the impact of geologic and tectonic (structure) over some morphometric parameters of these basins (Fig. 1). The three drainage basins have similar climatic conditions but different geological and tectonic setting.

The various morphometric parameters of the basins are described below :

METHODOLOGY

Survey of India toposheets (1 : 50,000) are the chief tools used for this study. Aerial photographs were also used for delineating landform units and lineaments in each drainage basin (Prasada Raju, 1984). Geological map presented here is adopted from Geological Survey of India (Cuddapah Basin Geological and Mineral map, 1981). Linear measurements, like stream length, perimeters etc. are measured with opisometer, area calculations were made by planimeter and grid-count method. Important parameters like stream length, gradient and basin area against stream order plotted on semi-log graph paper (Fig. 2).

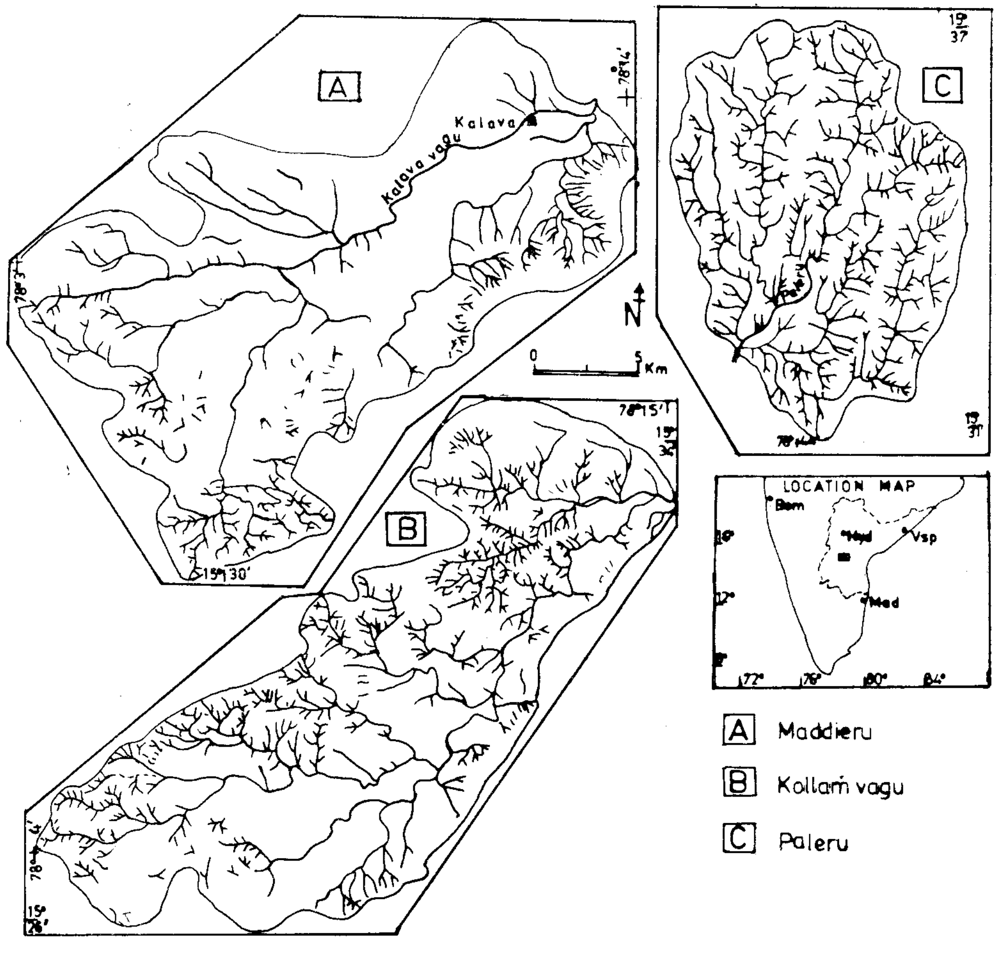

Fig.1

Fig. 1. Drainage Basins from Different Geological and Geomorphological Envoirns

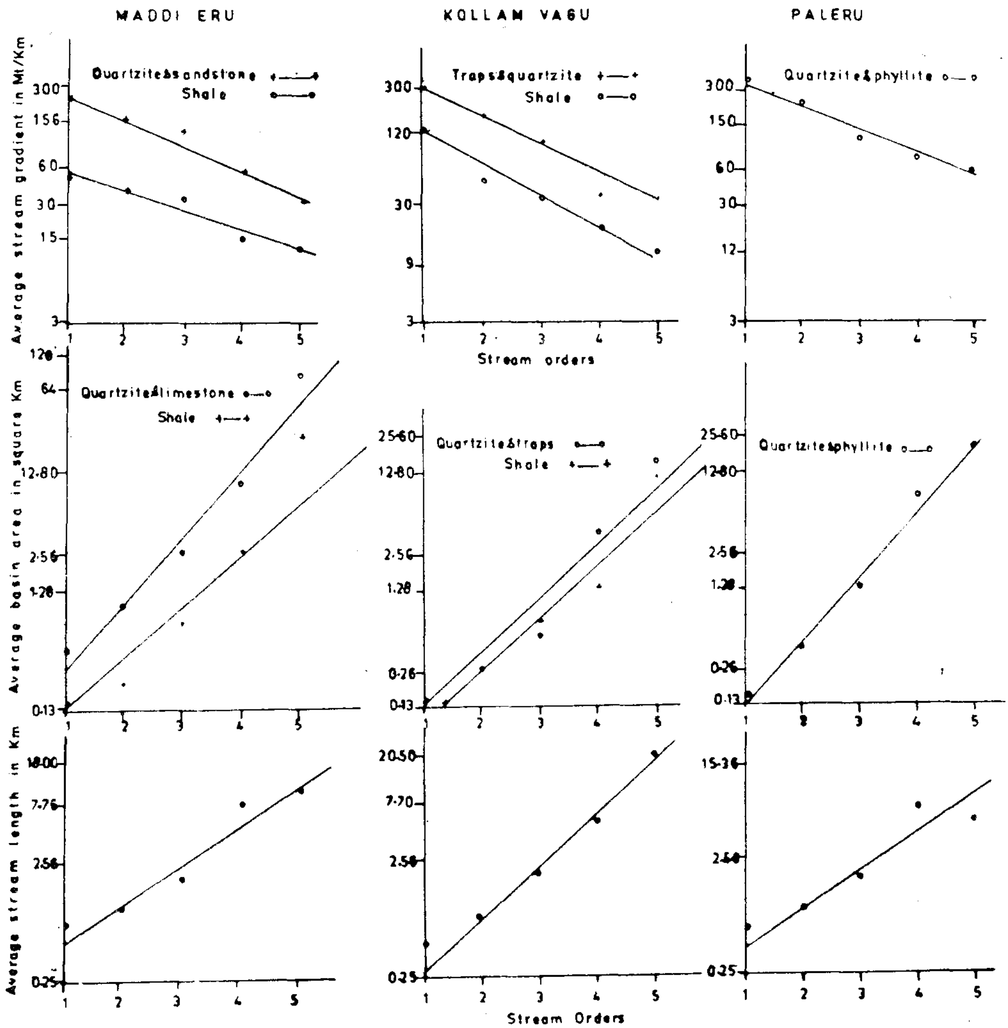

Fig. 2. Morphometric Parameters of Three Drainage Basins from Different Geological and Geomorphological Environments.

STREAM ORDER VS STREAM NUMBER

It has been indicated from the Table I, and graph (Fig. 2) that there is a progressive decrease in the number of stream segments as the stream order increases as described by Horton (1945).

STREAMS ORDER VS STREAM LENGTH

It is appearent from the table and Fig. 2 that the average length of first order and second order streams of Maddieru are greater than with those of the Kollam Vagu and Paleru streams. This is because, the major part of Maddieru basin developed over gently sloping (Cuesta) terrain and which inturn consists of more resistant rocks of quartzite and sandstones of Paniam and Banaganapalla formations respectively. Morisawa (1962) expressed the idea that ' the streams flowing over flat-lying resistant beds causes an increase in length which are flowing on it '.

TABLE I

Drainage morphometric properties of the three streams

Sr. No.	Morphometric Parameters	Kollam Vagu	Paleru	Maddieru
1	Perimeter (P) in Km ..	60	33.60	62.50
2	Area in Sq. Kms. ..	120.30	73.50	125.50
3	Total relief (r) in meters (difference between maximum and minimum elevations) ..	251	555	211
4	Number of streams of individual orders (Nu)—			
	1st order ..	588	345	308
	2nd order ..	148	87	70
	3rd order ..	33	18	22
	4th order ..	8	5	5
	5th order ..	2	2	2
	6th order ..	1	1	1
	Total number of streams (all orders) ..	780	458	408

Sr. No.	Morphometric Parameters	Kollam Vagu		Paleru		Maddieru	
		Total Length of Individual	Average Length	Total Length of Individual	Average Length	Total Length of Individual	Average Length
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
5	Total length of streams of individual orders (Nu) and average length of individual orders in Kms.—						
	1st order ..	170.40	0.30	126.40	0,36	143.40	0.46
	2nd order ..	72.80	0.49	51.20	0.58	46.40	0.66
	3rd order ..	39.20	1.18	19.20	1.06	24.00	1.09
	4th order ..	19.20	2.40	21.60	4.32	22.40	4.48
	5th order ..	21.60	10.80	6.40		12.80	6.40
	(i) Total length of all orders in Km (ΣLu) ..	323.20		224.00		248.00	
	(ii) Average length of stream segments in Kms ..		0.41		0.41		0.60

TABLE I—*Contd.*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
6	Stream frequency of individual orders $F = \frac{Nu}{a}$						
	1st order ..		4.88		5.10		2.45
	2nd order ..		1.23		1.18		0.56
	3rd order ..		0.27		0.24		0.17
	4th order ..		6.06		0.06		0.04
	5th order ..		0.02		0.03		0.01
	Stream frequency (F) $= \frac{Nu}{a}$ (all together orders) ..		6.47		6.21		3.25
7	Bifurcation ratio (B) $= \frac{Nu}{Nu+1}$						
	1st/2nd order ..		3.97		3:96		4.40
	2nd/3rd order ..		4.48		4.83		3.18
	3rd/4th order ..		4.12		3.60		4.40
	4th/5th order ..		4.00		2.50		2.50
8	Length ratio (L) $= \frac{Lu}{Lu-1}$						
	2nd/1st order ..		0.42		0.40		0.32
	3rd/2nd order ..		0.53		0.37		0.52
	4th/3rd order ..		0.49		1.12		0.93
	5th/4th order ..		1.12		0.29		0.57
9	Drainage density of individual orders (D) $= \frac{Lu}{a}$ Km						
	1st order ..		1.42		1.72		1,13
	2nd order ..		0.62		0.70		0.37
	3rd order ..		0.32		0.26		0.19
	4th order ..		0.16		0.29		0.18
	5th order ..		0.18		0.06		0.10
10	Drainage density (D) per sq. km. $D = \frac{Lu}{a}$ ..		2.68		3.04		1.98
11	Ruggedness Number (H) $= \frac{Dr}{1000\,P}$ ..		0.68		1.66		0.42
12	Relative relief (R) $= \frac{100r}{1000P}$ ..		0.42		1.63		0.33

TABLE I—*Contd.*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
13	(a) Relief (max) in meters above MSL ..		517		887		526
	(b) Relief (min) in meters above MSL ..		266		332		315
	(c) Total relief of the basin in meters ..		251		555		211
14	Total length of the drainage basin (along the trunk stream in Kms) ..		26.40		12.00		21.60
15	Ratio of channel length to perimeter $\frac{Lu}{P}$ ..		5.38		6.66		4.00
16	Circularity of the basino r elongation ratio $Rf = \frac{Au}{Lb^2}$ ..		0.17		0.37		0.21

STREAM ORDER VS GRADIENT

It is evident from the Fig. 2 and Table I, that the drainage basins developed over different lithologies show variations in gradients. The streams flowing over traps, quartzites and sandstones have high gradients, especially along first and second order streams, because these rocks have high resistance to weathering and erosional processes and forms steep escarpments along the major lineaments. On the otherhand, streams that are developed over limestone, phyllites and shales how gentle to moderate. gradients.

STREAM ORDER VS BASIN AREA

It is evident from the data presented in Table I and Fig. 2 that the lithology and structure have had influence over drainage basin parameters. Considerable part of the Maddieru and Kollam Vagu drainage basins underlain by Narji limestones and Vempalle dolomites have a few drainage channels, because of development of local Karst topography. With the result, basin area increased to a particular order. Similarly, major portion of the Maddieru basin underlain by Paniam quartzites, shows larger basin area for a given order, shows greater length for first and second order streams. For this Marisawa (1962) suggested that streams flowing over flat-lying resistant beds cause an increase in length of streams flowing on it which intrun resulted in the increase of drainage basin areas. On the other hand, Paleru river basin consists of uniform lithology (Cumbum phyllites/slates and to a certain extent Baironkonda quartzites) and has high density of drainage network per unit area, resulting in small drainage areas.

DRAINAGE DENSITY

It is defined as 'the ratio of total length of stream segments to the drainage basin area' and is a measure of the roughness of the terrain or texture. It is evident from the Table I, that the drainage density of Paleru stream is very high (3.04 km per sq.km) followed by Kollam Vagu (2.68 km per sq.km) and the least in the case of Maddieru (1.98 km per sq.km). These variations in density of drainage is attributed to the lithology and relief. The low drainage density of Maddieru is because of solution and formation of underground drainage network in the limestone area and presence of very resistant strata (of Paniam quartzites). The climate factor here plays secondary role because these three drainage basins are situated in a more or less similar climatic region.

RELIEF RATIO

It is measured as ' the ratio between total relief of a basin and the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956, P. 112). It has been observed that the relief ratio is greater (1.67) for the Paleru while it is too small (0.31) for Kollam Vagu. This is because of the fact that the Paleru stream gathers its waters high in the scarps of Nallamalai hills, naturally having steep slopes. Contrary to this, the Kollam Vagu and Maddieru flowing over gently sloping (Cuesta) terrain, have low relief ratio.

RUGGEDNESS NUMBER (H)

It is a product of drainage density and relief. It is evident from the Table I, the ruggedness number for the Paleru is about three times greater than that of the Kollam Vagu and Maddieru. The high ruggedness of the Paleru is due to cumulated affect of high basin relief, steep slopes, less resistant rock strata (Cumbum slates/phyllites) and high rainfall (comparatively). While in other cases the low ruggedness is associated with high resistant strata of (quartzites, sandstones and limestones), gently sloping terrain and low rainfall.

STREAM FREQUENCY

As shown in the Table I, that the stream frequency is very high for Paleru followed by Kollam Vagu and Maddieru. These variations on the stream frequency are attributed to lithology and structure.

BIFURCATION RATIO

Generally the Bifurcation ratio varies from 3.0 to 5.0 for watersheds where geologic structures does not distort the drainage pattern (Strahler, 1964). The low bifurcation ratio between 4th and 5th order of the Paleru is attributed to the lithological control, as its streams flowing across the ridges and valleys. Whereas, in the case of Maddieru, low bifurcation ratio between 4th and 5th order is due to gently sloping and resistant strata of Paniam quartzites, Narji limestones and Banganapalle sandstones.

BASIN SHAPE

The Paleru river shows marked circularity because of uniform lithology. By contrast, Maddieru and Kollam Vagu show much elongation and less circularity, as such that these streams, follow major fault planes (fig. 3, 4). Miller (1953) found that the high circularity of the basins associated with homogeneous geological formations resulted in small drainage basin areas with geometric similarity. On the other hand, basins situated on moderately dipping quartzites (Cuesta) were highly elongated hence less circularity.

CONCLUSIONS

From this analysis it can be inferred that the geology has major influence over other factors. It is worth mentioning that all the three drainage basins are located on the same major physiographic unit and climate conditions (except for a slight variation in the amount of rainfall). Hence, the anamolies in the various morphometric parameters explained above can be related to geological and structural aspects, rather than other factors like climate and physiography.

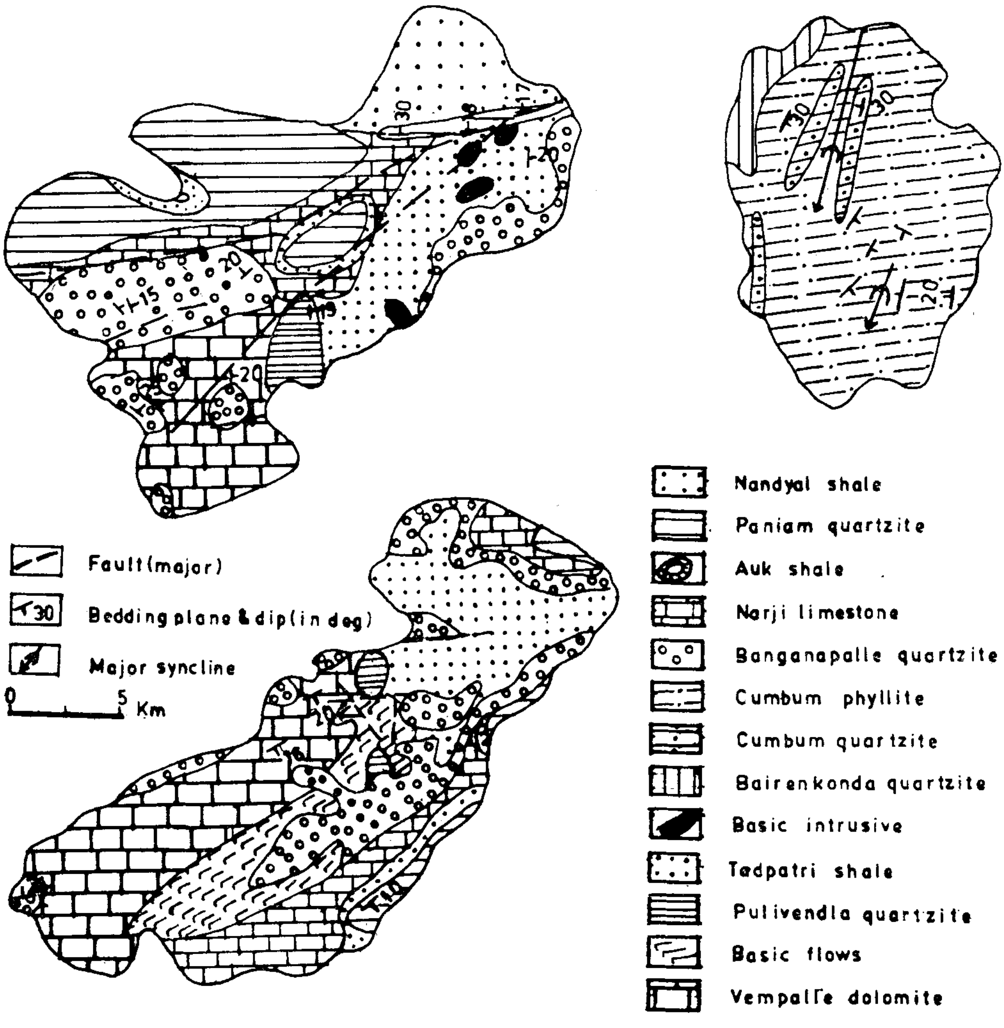

Fig. 3. Showing Geological Formations of Three Drainage Basins.

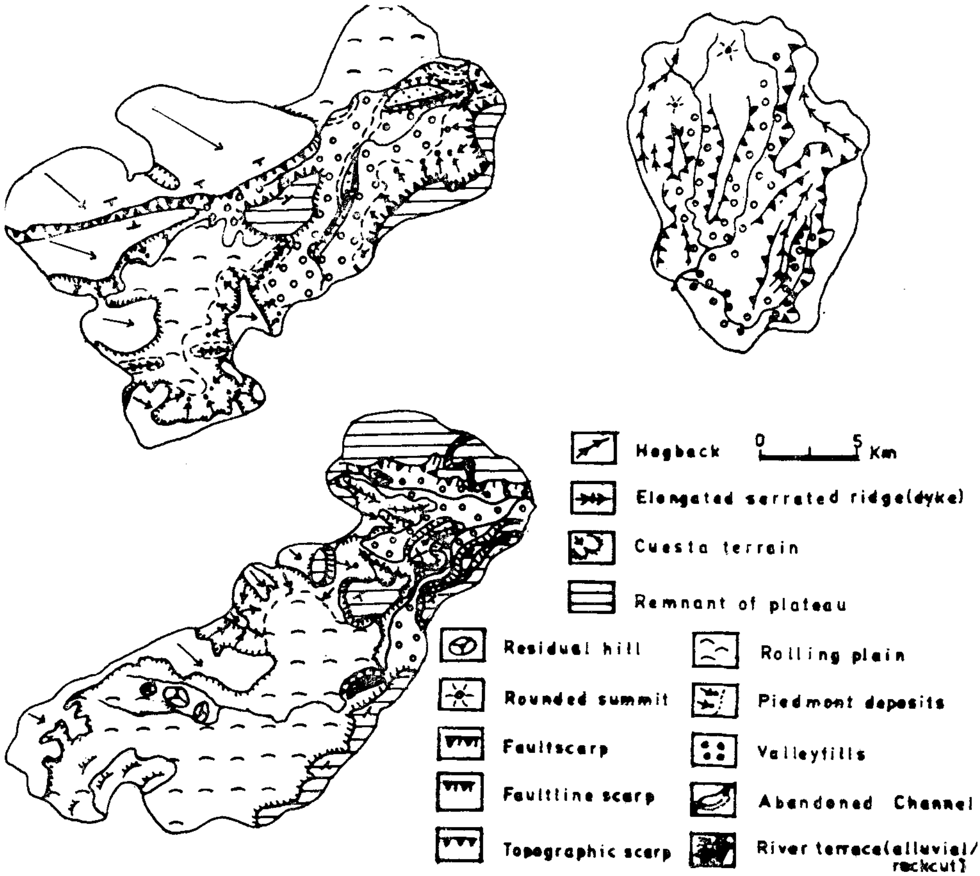

Fig. 4. Showing Geomorphological Features of Three Drainage Basins.

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