Study of Morphometry Under Varying Lithological Conditions in the Selected Basins of Indravati

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DATED :

Certified that the dissertation entitled 'STUDY OF MORPHOMETRY UNDER VARYING LITHOLOGICAL CONDITIONS IN SELECTED BASINS OF INDRAVATI RIVER' submitted by Miss ARCHANA SRIVASTAVA is for the degree of Master of Philosophy is a bonafide work to best of my knowledge and may be placed before the examiners for their consideration.

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DEDICATED TO MY PARENTS

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INTRODUCTION

CHAPTER I

INTRODUCTION

Geography, is the science of the surface of the earth and its inhabitants. Of its many branches we are now, concerned with geomorphology, which deals with the surface of the lithosphere, explaining its origin and'interpreting' its history. Thus, geomorphology is the science of study of landscape. It developed rapidly from early 40's. After the introduction of quantative analysis of drainage basis as a fundamental and appared. A lot of emphasis has been laid on the intensive study of a basin and its evaluation. The term Geomorphology is used in different branches of science to analyse the shape, form and structure. This term is primarily, applied to the quantitative measurement of land forms known as geomorphology.This is further divided into two-General geomorphology, an extensive and general study and Specific geomorphology, intensive study. Early 40's was the revolutionary period, when geomorphology included in quantification of drainage basins and thereafter several research work have been carried out. Geomorphology, in the begining was limited in United States and U.K.. Later, it rapidly spread to other contries. Indian scholars accepted it after the end of 60's.

1.1 REVIEW OF LITERATURE:

" Morphometry ", which means measurement and mathematical analysis of the earth's surface and of the shape and dimensions of its land forms. The basic points for the investigation of the earth landforms, was the area, altitude, volume, slope and texture. Dury (1952)[1], Twidale, Jenning and Christan(1957)[2] applied various methods for the analysis of the land forms and classified in different ways. They presented in the form of graph, maps and statistical indices. Some methods of morphometry was devised but analysis was based on descsip tion. Recently, morphometry is being applied for intensive analysis of small morphologicaunits, i. e. river terrain. In 1945 Horton[3] provided a new approach in geomorphology, pioneered the quantitative approach to drainage basin description realising that the hydrological characteristics of a drainage system are organically linked to their morphologic characteristics. After his paper in 1945 he lead the structure and directtion for the geomorphological research, since then numerous works have been done in this field. Horton was the first person who, realised that dynamicity of drainage basin and its hydrological characteristics are closely related to their morphology. He analysed the inter

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1. Dury, G.H.(1970):"Essays in geomorphology", Heinmann, London, pp.235.
2. Twidale,Jenning,&Christan(1957): "Introduction to morphometry"Journal of Geology,p.88.
3. Horton R.E.(1945):"Erosional development of stream and their drainage basin,Hydrological approach to quantitative morphology"Bull.Geol Soc.Amer. Vol. 56, pp. 275-370.

relation ship of the function of drainage basin to the numerical values. After him Strahler (1952)[1], Schumm (1956)[2], Melton(1958)[3], Kesseli (1946)[4], Miller (1953)[5], Russel (1949)[6], Smith (1958)[7], Morisawa (1962)[8], Scheidegger (1965)[9], Shreve (1967)[10] and various others have

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1. Strahler, A.N., (1952)," Hypsometric(area altitude) Analysis of Erosional Topography", <u>Bull. Geol. Soc. Amer.</u>, 63, pp.1117-1142.

2. Schumm, S.A. (1956), " The Evolution of Drainage System and slope in Badlands at Perth Amboy, New Jersey ", <u>Bull. Geol. Soc. Amer.</u>, 67, pp. 597.

3. Melton, M.A. (1958), " Geometric properties of Nature Drainage systems and their representation in an EC Phase Space ", <u>Journal of Geology</u>, 66, pp.25-54.

4. Kesseli, J.F. (1946), "A neglected field in geomorphology <u>Annals Assoc. Amer. Geog.</u> Vol.86, pp.93.

5. Miller, V.C. (1953),"Relation of Quantitative Geomorphic study of Drainage Basin characteristics in the Clinch Mountain area, Virginia and Tennese", <u>Technical Report</u>, 3 Columbia University, New York.

6. Russell, R.J. (1949)," Geographical Geomorphology", <u>Annals Assoc. Amer. Geog.</u> Vol. 89, pp.10

7. Smith, K.G., (1958), " Environal Processes land forms in Ladlands, National Movement, South Dacota ", <u>Bull. Geol. Soc. Amer.</u> Vol. 69, pp. 975- 1000.

8. Morisawa, M.E., (1962), " Relation of quantitative Geomrohphology Of Streams floe in Representative Watersheds of Applachian Plateau Province", <u>Bull. Geol. Soc. Amer.</u> Vol 73, pp. 1025 - 1046.

9. Scheidegger, A.E. (1965), " The Algebra of Streams, Order Number ", <u>U.S. Geol. Sur. Prof. Paper</u>, 525 -8, pp.187 - 189.

10. Shreve, R.L. (1967), " Infinite Topological Random Channel Network ", <u>Journal of Geology</u>, Vol. 75, pp. 188- 186.

continuously stressed on morphometry.

Gardiner (1982)[1], studied drainage basin morphometry under following headings "Network, Delimitaton Sampling, Variable definition and analysis."Generally the the delimitations of drainage net and data related to morphometry are derived either from topographic maps or remote sensing sources and these sources have certain limitations, such as surveyors, convectios for field mapping process of plotting of streams on the map, scale of the map and data of the survey because time plays a vital role in development and extension of drainage net (Gregory and Gardiner, 1975)[2]. Suggestions of some scholars was that function of the identoty of drainage basin should be based on field survey, is irrelevant in larger areas. Morisawa (1957)[3] suggested the use of contour crenulations to identify the small streams which exists in the field not in map, was highly criticised by Gregory (1966)[4] because

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1. Gardiner, V. (1981), " Drainage basin morphometry: Quantitative analysis of Drainage basin form", Perspective in Geomorphology, Ed. H.S. Sharma, Concept publishing Co. New Delhi, p. 107.

2. Gregory K.G., and Gardiner, V.(1975), " Drainage Density and Climate ", Zeitschrift Fur Geomorphologie, 19, pp 287-88.

3. Morisawa M.E. (1957), " Accuracy of determination of stream lengths from topographic maps ", Trans. Amer. Geog. Union, 38, pp.86-88.

4. Gregory, K.J.(1966), " Dry valleys and the composition of the Drainage networks ", Journal of Hydrology, 4,pp. 327 - 340.

it may include fossils of palaeohydrologocal eleme nts. On Shreve (1974)[1] suggestion of " A value of channel slope should determine to define the source of channel ", was applied by Smart (1978).[2] Hydrologiaal and morphological methods were introduced by Shreve. Shreve's third method of exterior links in which he analyded that " all exteror links, either from stream lines on the map or contour crenulations are extended head ward to water shed to delimit the basin and drainage network" was not famous and rarely used in U.S.A.by the mesh - length extension network.

The revolutionary introduction in the field of drainage morphometry of the idea of stream order was given by Horton. According to Bowden and Wallis (1964)[3], the stream order concept is " The touch stone by which drainage drainage net characteristics could be related to each other and to hydrology and erosional processes".

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1. Shreve, R.L.(1974), " Variation of Mainstream length with basin area in River networks," Water Resource Research, 10, pp. 1167 - 1177.

2. Smart, J.S. (1978), " The analysis of drainage network composition ", Earth Surface Processes, 3 pp. 129 - 70.

3. Bowden and Wallis, J.R. (1964), " Effect of stream Ordering technique on Horton 's Laws of Drainage composition " Geological Soaiety of American Bulletien Volume, 75, page: 767 - 774.

Ordering described by Horton and modified by Strahler in 1952 as, " All finger tips designated as the fiest order, two first-order produces a second order segments, two second orders provided a third order and so on. Melton (1959)[1], accepted this idea because of this advantage of this simple method, i.e. it can be derived mathematically from concepts of elementary combinational analysis, But this method was highly critised- firstly, the order of trunk stream is not changed by the addition of tributary stream of lower order and secondly, the addition of a single first order stream could raise the order of the trunk stream.

Scheidegger (1965)[2], stated "An algebra of segment which is associated and cumulative. Gardiner (1977)[3] first used grid squares of mapping Drainage density and also introduced the relation ship of topological characteristics of drainage network in selected quadrants.

Horton's supplementary law is summarised by Gardiner(1981)[4] in which relation ship of morphometric parameters was tested by him, using huge data.

After two decades, Horton's method was used to examine and determine the basin morphometry in different climatic and lithologic conditions.

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1. Melton, (1959), "Aderivation of Strahlers' channel ordering system ", Journal of geology 67, pp. 345-346.

2. Scheidegger, (1965), " The algebra of stream order, numbers " U.S. Geol. Surv. Prof. Paper, 525 B, pp. 187-189

3. Gardiner, V. (1977), " Estimated Drainage density and Physical Regions in S.W. England, National Geographer Vol, 12 pp. 115- 118.

4. Gardiner, (1981), op. cit. Ref. page no. 4

Ghose, et.al. (1963)[1], Ghose and Pandey (1963)[2], Singh and Ghose (1973)[3], worked on the arid region applying morphometric parameters to the drainage basin.

Comparison betweem the lithological conditions using same method was done by Gardiner (1971)[4], Brunden (1969)[5], Tondon (1964)[6], Padmaja (1975)[7], Mithal et,al.(1974)[8], Gregory(1976)[9], Gregory and Gardiner(1975)[10],

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1. Ghose,B. Pandey, S. ,Lal,G (1967) " Quantitative Geomorphology of the Drainage Basins in the Central Luni basin in W. Rajasthan ", Zeitschrift fur geomorphologie, I, pp. 146-160.

2. Ghose and Pandey, S. (1963), " Quantitative Geomorphology of Drainage Basins" Journal Ind. Soc. Soil Sc., 11 pp.259 274.

3. Singh S. and Ghose B (1973), " Interrelation ship between quqntitative geomorphic characteristics of drainage basins sub-humid to humid environment of Rajasthan" Annals of Arid Zone 12, pp. 82-89.

4. Gardiner V. (1971), " A drainage density map of Dartmoor", Repot Trans. Devonshire Assoc. Advamcement Sc. 103,pp167-80.

5. Brunsden, (1969), "Dartmoor ", Geog. Assoc.

7. Padmaja, S. (1975), " Some aspects of a quantitative drainage characteristics of Dhund Basin , Geographical Review of India Vol. 37, pp. 158- 64.

6. Tondon S.K. (1974), " Litho-control of some Geomorphologic properties, Zeitshcrift fur Geomorphologie, 18, pp. 460-71.

8. Mithal R.S., Prakash B. and Bajpai I.P., (1974) 2 Drainage basin network morphometric study of a part of the Garhwal Himalayas", Himalayan Geology, Vol. 4, pp. 195-215

9. Gregory (1976), "drainage network and climate of Derby-Shire " Ed. Geomorphology And Climate, Wiley.

10. Gregory and Gardiner(1975), "Drainage Density and Climate" Zeitschrift fur Geomorphologie, 19 pp. 287- 98

worked on postulating the variations in the basin due to climate conditions and their effect. Morgan (1971)[1], William(1972)[2], Bassett and Ruhe(1973)[3], studied about the drainage network under Karst region.

In India, the adaptation of Hortonian method is recent and several scholars have tested and analysed them working on different basins, Singh (1960),[4] produced the study on Rajmahal Hills. Morphometric evaluation was studied by Asthana(1967)[5], in Alwar district. He considered three aspects of terrain i.e. geology, configuration and drainage. Singhs' (1969),[6] was based on Topa and Shilpi rivers of Ranchi, giving inter-relation ship between length and drainage area. He postulated that " As order increases, area of each basin

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1. Morgan R.P.C(1971), " A morphometric study of some valleys systems on the English Chalklands, Trans. Instt. Brtish Geog. Vol. 54 pp. 33-44.

2. William(1972), " The analysis of spatial characteristics of Karst terrain ", ed. R.J.Chorley, Spatial Analysis in geomorphology.

3. Bassett, J.L. Ruhe R.V. (1973), " Fluvial geomorphology in Karst Terrain, ed. Morisawa, Fluvial geomorphology Binghamton New York University.

4. Singh (1960) "Geomorphological Evolution of the Highlands of Rajmahal " National Geographical Journal of India , Vol. VI part 1, PP. 1-13.

5. Asthana V.K.(1967),"Morphometric evaluation of Land form in Almora & its environs" Nat. Geog. Jour. Ind. Vol. XIII, Pt. 1, PP. 37-54.

6. Singh R.P. & Kumar A.(1969),"Geomorphological evolution of stream orders of Topa & Shilpi Basins, Ranchi Nat. Geog. Jour. In. Vol. VIII,p. 119-29.

Decreases in a region of high precipitation. Singh (1970)[1] study of Hoshiarpur(Kangra) was based on relation between different parameters and basin circularity ratio is controlled by relief, slope, area, underlying, topography and ruggedness. Kharakwal(1970)[2], attempted his work and gave the idea that basin height, ground slope of basin, channel gradient and drainage density have negative correlation with hypsometric integral in accordance with Strahler.

Satpathy (1972-73)[3], analysed the landforms of Deo river basin(Singhbhum)with the help of Morphological information. Pal, S.K.(1973)[4] attempted quantitative geomorphology of the drainage basins in Himalayan region. Kumar (1973)[5], has tried to distinguish

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1. Singh (1970), " Basin circularity ratio as a terrain type element: A case study of Hoshiarpur , Kangra tract, Deccan Geographer , Vol. VIII, PP.119-28

2. Kharakwal S.C.(1970), " Morphometric study of a Himalayan basin - A sample study " Nat. Geo. Jour. In. Vol. 16, part 1, pp. 47-60

3. Satpathy P.P., Debidutt(1972-73), " Quantitative analysis of landforms- A case study in the Deo river of Bihar" Geographical Out look , Vol. IX pp. 57-66.

4. Pal S.K.(1973)," Quantitative Geomorphology of Drainage basins in the Himalaya ", Geographical Review Of India, Vol. 35, pp. 81-101.

5. Kumar A. (1973-75), " Pair wise Relation ship of Basin area and stream length- A case study of the upper Burha Basin " Geographical OutLook, Vol.X, p.49-58.

the relationship between variables of drainage basin morphometryand applied pair wise correlation in upper Burha basin. Singh, Gupta and Kaith(1976)[1], presented relation ship among morphometry attributes. They gave conclusion that bifurcation ratio dominates and influences the discharge and distribution of surface runoff but ratio of bifurcation is not an independent variable.

Padmaja (1976)[2], using Horton'S and Strahler's method worked on Mej river basin under different geological formations. Singh and Srivastava(1977)[3] studied Belan river basin and demarcated different slope zones. Sharma and Padmaja(1977)[4], correlated various geomorphic variables in varying lithologies of Morel basin and concluded that the Ratio of bifurcation varies from basin to basin, according to different lithology.

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1. Singh, Gupta & Kaith, (1976), " Multiple relation ship between ratio of bifurcation and some morphometric variables of drainage basin in Banas Catchment", Deccan Geographers Vol.XIV No. 2, pp. 151-156

2. PadmajaG.(1976)," Geomorphology of the Mej river basin Rajasthan " Unpub. Ph.D. thesis University of Rajasthan Jaipur.

3. Singh S. and Srivastava(1977) " A stastical analysing of the average slopes of the Belan Basin" Deccan Geographers, Vol. XV pp. 307-316.

4. Sharma H.S. & Padmaja(1977) " Quantitative Geomorphic characteristics of streams of Moreal Basin Rajasthan" Geographical Review of India, Vol.39 pp. 353- 366.

Verma and Bhattacharya(1978)[1] gave the relation ship of some theoretical measuement by analysis of 101 third orderbasins. Singh (1979)[2], produced the drainage density of 23 basins of 5 different physiography conditions of Ranchi and cocluded that geological structure rainfall a nd slope contols drainage density.

Pofali (1979)[3], studied an account of linear , areal and relief characteristics of drainage network of Vidarbha region. Singh and Upadhyay (1981)[4] proved that Horton's and Strahler's model is related to drainage may not be applied in totality. Padmaja and Soudervallie (1981)[5] discussed the variations of bifurcation ratio in Godavari and Krishna basin.

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1. Verma V.K. & Bhattacharya G. (1978)," Graph theoretic concepts and drainage nets " Nat. Geog.Jour. Ind. Vol. 24, pp. 62 - 65.

2. Singh S. (1979) " A geomorphological study of drainage density of small drainage basins of the Ranchi plateau India " Nat. Geog. Jour. Ind. , Vol. 35 pp. 215-230.

3. Pofali R.M. (1979) " Linear characteristics of the drainage net work of Vidarbha Region " Deccan Geographers Vol. XVII pp. 631-643.

4. Singh S. and Upadhyay D.P. (1981) " Topological and Geometrical study of Drainage network, Perspectives in Geomorphology , Ed. H.S.Sharma, Vol.2, pp.191-233.

5. Padmaja & Soudervallie (1981), " The behavioral pattern of bifurcation ratios in Godavari and Krishna basin, A.P. Perspectives in Geomorphology Vol. 2, p.235-45.

Vats (1985)[1], studied morphometric variables in the Mithri river basin and correlated these variables. Others, like Joshi and Rawat (1985)[2], studied a quantitative analysis in Upper Ramganga Catchment. Pofali (1985)[3], studied on Hiran catchment and related to the land resources & management with the help of aerial photograph Rawat (1985)[4], studied about the hydrometric implications of morphometry and geology with reference to lower Ram Ganga catchment . Bhamare (1985)[5] correlated morphometry with hydrology and studed about the Panzara river basin taken under homogenous litho- climatic conditions.

Latest work was done by Dohrenwend (1987)[6]

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1. Vats P.C. (1985), " Quantitative geomorphic characteristics of Mithri river basin." <u>Nat. Geog. Jour. Ind.</u> Vol. 31, pp. 18-22.

2. Joshi S.C. And Rawat (1985), " The upper Ram Ganga catchment: A quantitative geomorphic analysis. " <u>Geog. Rev. of Ind.</u>, Vol. 47, No.1, pp.18-24

3. Pofali R.M. Singh S.R., Batta R.K. (1985) : "Quant. -tative analysis of the Hiran Catchment for land resources Development and Management " <u>Nat. Geog. Jour. Ind.</u> Vol. 31, part 1 pp. 10-17.

4. Rawat J.S.(1985), " Hydrmetric implication of morphmetry and geology: A case study of lower Ram ganga catchment" <u>Journ. Geol. Soc. Ind.</u> Vol. 26, PP.734.

5. Bhamare S.M. (1985), " Morpho- Hydrological Analysis of Panzara basin " <u>N.G.J.I.</u> Vol. 31 pp. 23 - 27-

6. Dohrewend J.C. Athol, D. Abrahams and Brent D.T.(1987), " Drainage Development On Basaltic Lawa Flow : California and Nevada ". <u>Geol. Soc. Amer. Bull.</u> Vol.99 Sept. 3, pp. 405 - 413.

where the study was based on drainage development in Basaltic lava flow in California and Nevada and stated that After accumulation of an eolian mantle master drainage extends to all parts of flow. During this period of elongation drainage density and link frequency incresed rapidly where as the value of Shreves kappa(k) declined.

A few authors studied the theoretical aspect. Though there was great contribution of the scholars in morphometric field, still we need correlation of these variables in the development of the land resources, then only it willbe significant as pofali et.al.[1] attempted.

1.2 SIGNIFICANCE OF THE STUDY

According to above facts, an attempt has been made to draw the correlation of the morphometric variables and its variations under different lithological conditions, especially in hard and soft rocks. This aspect may be applied to the land use planning as is evident from the work done by K.N. Prudhviraju (1988)[2]. This aspect may also be taken into consideration for construction of dams, where, mimimum sediments, and maximum discharge of water is found.

The behaviour of streams under different lithological conditions, its adjustments to surrounding areas, reflect its lithological and climatic conditions and by the morphometric analysis it gives stress to the study.

Morphometry can be used to analyse land use pattern(a recent Study), land slides (study of slopes as a morphometric parameters), flood control etc. Branching of streams reflect geologic structure, lithological characteristics, general relief, plant cover, pedological characteristics, slopes and rain fall intensity, With the above variables in mind an attempt has been made to evaluate the lithological conditions of two basins of Bhaskel and Gudra in Indravati river basin.

1.3 SELECTION OF THE STUDY AREA :

Indravati river basin (Gudra and Bhaskel) has been selected as a basic unit because of its limited convienient and usually clearly defined topography units, available in a nested hierarchy of sizesoon the basis of stream ordering. Secondly,,it is comprising of totally different geological formations and structural conditions which will give a remarkable comparison for the study.

The selection of these river basins due to its location in Bastar region (Sedimentary and metamorphic rocks) and Koraput region (metamorphic). Its geology is the point of interest to the geologist and mineralogists from several years. No geologist had earlier, set foot in this area since the days of the great explorer

P.N. Bose who on the basis of regbonal traveses under taken during 1897-1900, described the rock types of the area as that of Dharwar facies.

A comparative study of the processes of dtfferent drainage basins is possible. On the other hand, this virgin land, where this type of work has not been carried out so far, has two lithological formations i.e., sedimentary and metamorphic. The comparative study of land forms developed by these different processes over different conditions will be of great interest.

1.4 LOCATION OF THE STUDY AREA:

Indravati river basin stretches from 80° to 83° eastlonitude and 18°25'N to 21°North, latitudes. It rises at an elevation of 915 meters, in Kalahandi district of Orissa on the western slope of eastern Ghats. It drains an area of 41,665 kms^2. lying in a relatively high rainfall zone with about 1524 mm. of rain fall annually. Politically, it is surrounded by Rayagada, of Orissa in the east, Junagarh ,Raigarh and Armori of Madhya Pradesh in North, Sbroncha in west, and Dantewara, Kotpad of Orissa Venkatpuram of Andhra Pradesh in south.

Gudra and Bhaskel, both the rivers ate an important north bank tributaries of Indravati river in Bastar and Koraput region respectivly. Geographically the Gudra extends from 81°E to 81°27' E of longitudes.

LOCATION MAP
GUDRA AND BHASKEL

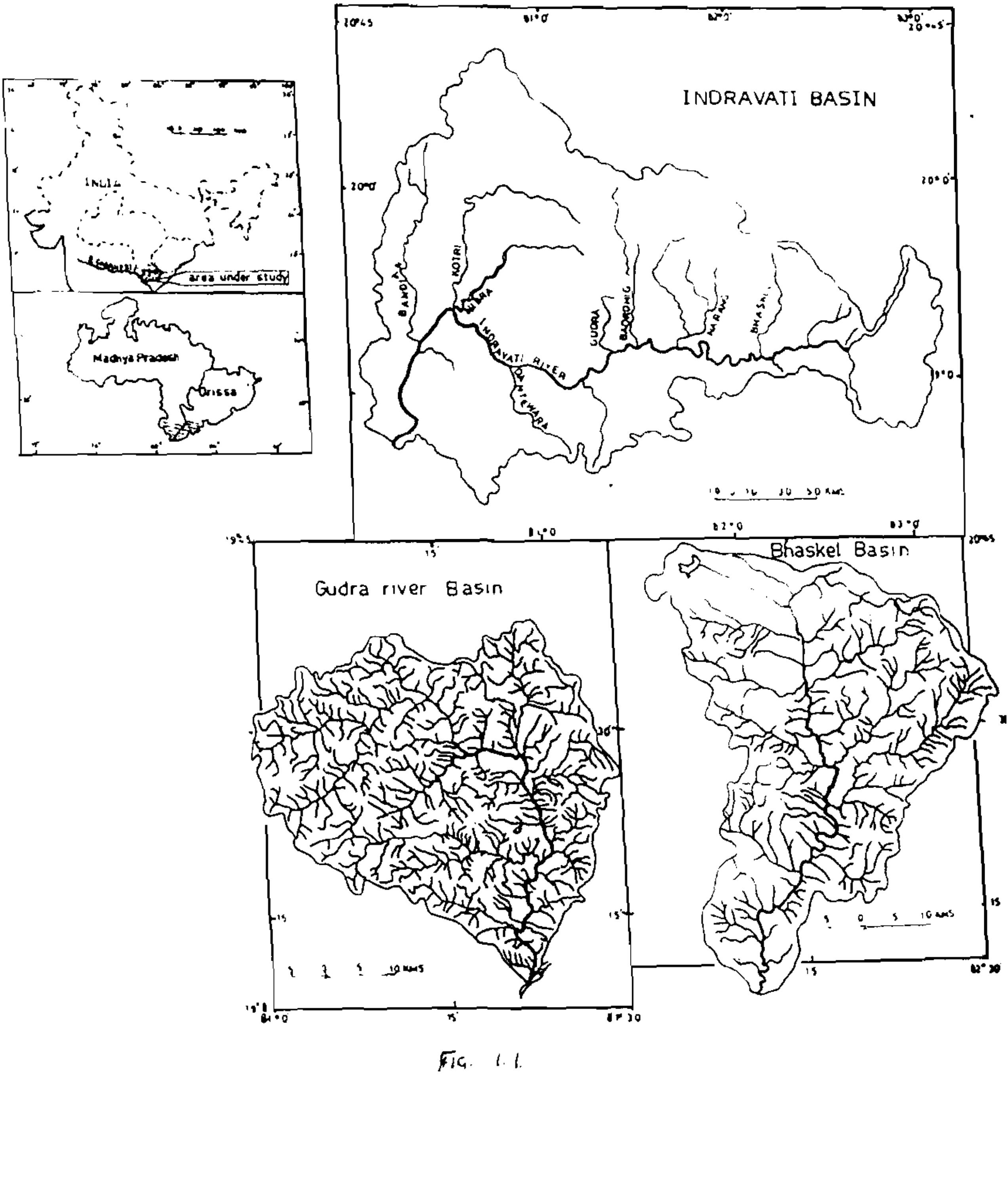

FIG. 1.1

Bhaskel extends from 82° 30'E of longitudes and 19° 13' N to 20° 25' N of lattitutes. Politically, these two basins covers an area of Bastar district of Madhya Pradesh (Gudra) and Korapatdistrict of Orisa (Bhaskel).

Geologically, Gudra river basin is composed of metamorphic rocks where gnesses and quartzites are in abundance, whereas Bhaskel river is composed of Metamorphic rocks in North and sedimentary in southern parts having lime stone in the east central parts.

1.5 PLAN OF THE WORK:

The present study is based on secondary data available literature.The work is divided into five chapters dealing with morphometric analysis of the study area.

Chapter I is an introductory chapter which gives an idea about the subject, review of literature, selection of the study, location, data base and maps. Methodology and hypothesis of the worh.

Chapter II consists of general information of geology, climate , vegitation and soils by the help of geological map and climatic date.

Chapter III deals with different linear, areal, relief aspects of the drainage basin which gives the calculation of different morphometric variables and their distribution of the selected basin.

Chapter IV deals with the comparative analysis of the behaviour of the morphometric parameters of two different (Geologically) tributaries of Indravati river basin selected for the study.

Last chapter V deals with the conclusion and summary.

1.6 HYPOTHESIS:

1. Area of a drainage basin is determined by various morphometric parameters viz stream frequency, drainage density, dissection index, ruggedness number, constant of channel maintenance, length of over land flow, relative relief, mean channel length , total channel length and number of stream segments.
2. Stream length is controlled by area.
3. Slope is directly related to the relief..
4. Drainage density and drainage texture are the function of relief,dissection index, ruggedness number and stream frequency.
5. All the morphometric parameters are dependent on each other directly or indirectly, giving a particular shape to the basin.

1.7 METHODOLOGY:

Drainage basin are selected according to the lithologically variations, where the formation of rocks is different. The major classification is hard rocks of Gudra (metamorphic) and soft rocks of Bhaskel(Sedimentary). It is attempted to find out how, different morphometric parameters behaves in different lithogies and tb support these results some correlation is calculated between these parameters.

Some of the parameters are chosen for this study to assess the drainage basin of Gudra and Bhaskel, their arel, linear, relief characteristics. These parameters are linear i.e.stream orders, numbers, patterns, bifercation ratio ; areal, shape, area, length and relief,relative relief, dissction index, ruggedness number, stream freqnancy. They have been represented in tables and maps.

The following morphometric parameters have been taken for the evaluation of the nature of lithology:-

TABLE 1.1

Sl. No.	VARIABLES	FORMULAE	UNIT	DERIVATION
1.	Number of stream orders	Nu	Enumerative	Strahler
2.	Total number of streams with basin order.	$\Sigma Nu = N1 + N2 + ..$	"	Strahler
3.	Bifercation ratio	$Rb = Nu/Nu+1$	-	Hortbn
4.	Total length of stream of order u	Lu	Kms	Hortan
5.	Mean length of stream of order u	$\bar{L}u = Lu/Nu$	--	Horton
6.	Area of the basin	Au	Sq. Kms.	Strahler
7.	Basin Circularity(Rc)	$Ax4\pi/P^2$	------	Miller

Sl. No.	VARIABLES	FORMULAE	UNIT	DERIVATION
8.	Basin Elongation (Re)	$2/\sqrt{\pi} \times \sqrt{A/L^2}$	--	Schumm
9.	Drainage Density (D)	$\Sigma Lu/Au$	Km/Km^2	Horton
10.	Texture Ratio (Tr)	$\Sigma Nu/\Sigma Pu$	No/Km	Horton
11.	Constant of channel (C) maintenance.	1/D	Sq. Km/Km	Schumm
12.	Stream frequency	$\Sigma N/A$	No/Sq.Km	Horton
13.	Absolute relief	H	Mtrs	Schumm
14.	Relative relief	Max-Min Absolute Relief	Mtrs	Schumm
15.	Ruggedness number	DxH/1000	----	Schumm
16.	Dissection index	$\frac{\text{Relative relief}}{\text{Absolute relief}}$	-	Schumm
17.	Basin slope	$\theta = \frac{\text{CI} \times \text{No. of contours}}{3361}$	-	Wentworth

1.8 DATA AND MAP BASE:-

The present study is totally based on the secondary data.The toposheets have been used on 1:50,000 scale published by servey of India.Toposheets of 65A/10,11, 13,14,15 and 65E/2,3,6,7 and 8 are used for Gudra river and 65I/2, 3, 4,6,7,8,11,12 and 14 are used for Bhaskel basin . For map work 65A, 65E and 65I on the scale 1:250,000.

Geological map of Indravati Bhaskel and Gudra are taken from the'Indravati project''Geological Servey of Indiaand from a unpublished project work from CSRD/ J N U .

C H A P T E R - II

GENERAL CHARACTERISTICS OF THE STUDY AREA

CHAPTER - II

GENERAL CHARACTERISTICS OF THE STUDY AREA

The Godavari basin extends over an area of 312,812 Square Kilometer which is nearly 10% of the total geographical area of the country. The basin lies between East longitudes 73°26' and 83°7' and north latitudes 16°16' and 22°36'. The basin lies in Deccan plateau and covers large areas in the state of Andhra Pradesh, Madhya Pradesh and Maharashtra in addition to smaller area in Mysore and Orissa. It is bounded on the North by Satmala hills and Ajanta Range and the Mahadeo hills on the South and East by Eastern Ghats and on the West by the Western Ghats. It is roughly traingular in shape & the main river itself runs practically along the base of the traingle. The entire basin of the river comprises rolling & undulating country a series of ridges and valley interspersed with low hill ranges.

The river Godavari rises in the North district of Maharashtra about 80 Kms. from the Arabian Sea at an elevation of 1067 Mtrs. After flowing for about 1465 Kms. in a generally South-East direction, through the Maharashtra and Andhra Pradesh it falls into the Bay of Bengal.

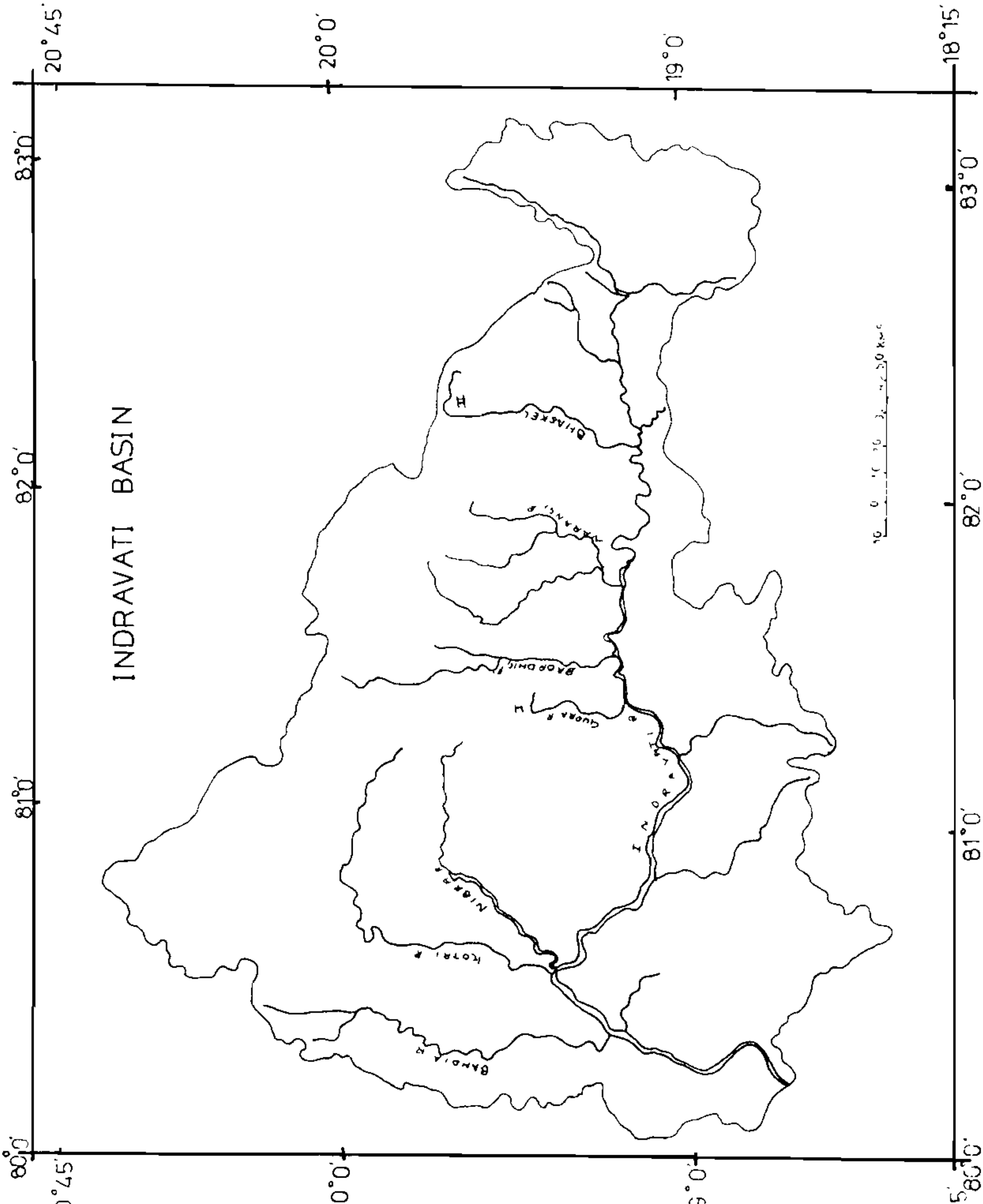
INDRAVATI BASIN
20°45'
20°0'
19°0'
18°15'
83°0'
82°0'
81°0'
80°0'
INDRAVATI
KOTRI R
BANDIA R
GUDRA R
BHASKEL

FIG. 2.1

About 64 Kms. from its source the Godavari receives the water of the Darua, on its right bank and a short distance lower down the Kadwa joins it from the left.

Indravati rises at an altitude of 914 Mtrs. in the Kalahandi district of Orissa on the Western Sloper of the Eastern Ghats. It flows West ward through the Korapur district of Orissa & the Bastar district of Madhya Pradesh, turns to South at about 531 Kms. from its source and joins the Godavari at an elevation of about 82 Mts. The largest and the longest river in South India is the Godavari of which the source is traceable to the Western Ghats. In its course through Maharashtra and Andhra Pradesh it is joined by then tributaries on the left and by eleven on its right. Among its important and major tributaries Indravati is one on which present study is based.

The Indravati, a major tributary of Godavari covers about 41,665 Square Km. of Catchment area of Madhya Pradesh and Orissa, rises at an altitude of 915 Mts. in the Kalahandi district on the Western Slopes of Eastern Ghats. It flows Westward through Korapur and Bastar districts, turns south and joins the Godavari about 530 Kms. from its source at an elevation of 82 Mtrs.

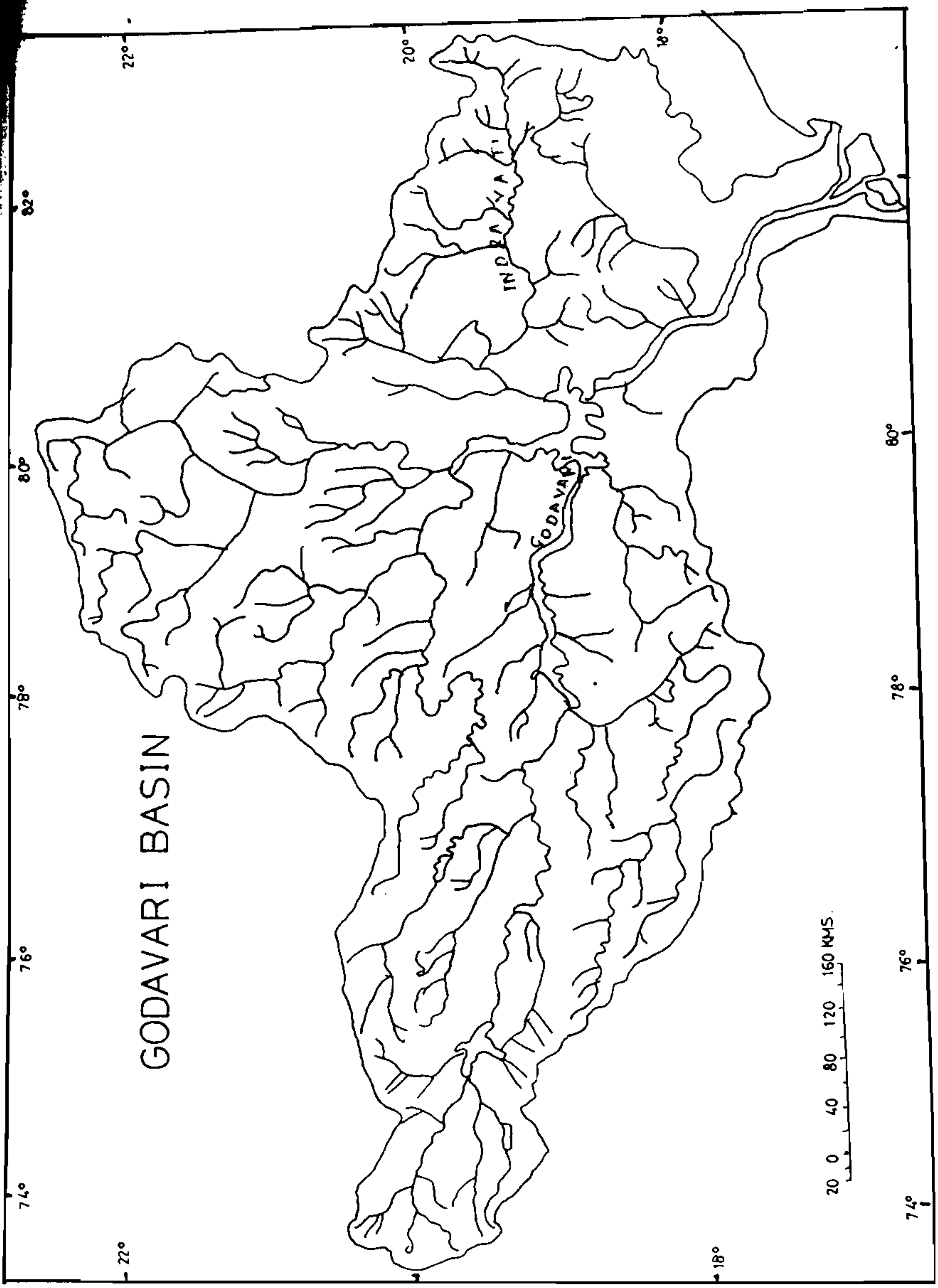
GODAVARI BASIN
INDRAVATI
GODAVARI
22°
20°
18°
82°
80°
78°
76°
74°
20 0 40 80 120 160 KMS.

FIG. 2.2

Bhopal pathanam. At chitrakot about 40 Kms west of Jagdalpurthe Indravati, while descending from the quartzitic sandstone, to the Archaean granite and gneisses makes 30 meter water fall. Also it makes a few rapidstowards further west from Chitrakot.

The majour tributaries of the Indravati river basin are Narangi, Baordhig, Kotri, Bandia, Nibra, Bhaskel flowing from its right Nandiraj as well as Dantewara from the left. The Abujhmar hills, lying between Indravati the Gudra and Nitra exhibit radial drainage pattern.

Bhaskel and Gudra are the two different tributaries of Indravati which have been taken for the present study as geologically they are of different origin.

GUDRA:

It is bounded with Kondagaon and Narayanpurin the North. Bijapur in south west, Dantewar in south. It stretches from 19° 10' Nto 17° 35' Nand 82°20' Eto 82° 30'E of longitude. It rises at an altitude of 853 meters. Its major tributaries are Madin Nadi , Orcha Nadi. Madin Nadi meets to Gudra at an altitude of 500 meters in south. After covering 17.25 Kms of the way another tributary Orchha nadi from left bank joins Gudra. Crossing various dense forest of Sal it joins

Indravati river 22 kms. aheadnnear Barsur village.The flow of Gudra is north to south.

BHASKEL :

It covers the districts of Kotpad, Nowrangpur and Umarkot of the Koraput (Orissa). It stretches from 82°10' to 82° 21' longitudes and 19°6' to 19°50' of latitudes It is bounded with Jeypore and Koraput district in the south Kashipur and Kalahandi in the east and Bastar district of Madhya Pradesh in the north, west. Its direction of flow is from north to south.Amar nadi joins on the right bank, and also Agua nadi, Chitrangi nadi, Kharakjori nadi, Belari nadi and Angi nadi . Singari nadi jpins in the left bank of the Bhaskel river basin. It covers an area of sq. km. It joins Indravati in south near Nagarnar village.

2.1: GEOLOGICAL SETTING:

The whole Indravati river basin, geologically, is found very heterogenous. Lithologically it can be divided into followings:

(i)- Indravati sedimentary sequence.

(ii) Pakhal sedimentary sequence.

(iii) Abujhmar volcano- sedimentary sequence.

(iv)- Dangargarh Granite complex.

(v)- Nandgaon volcanic complex.

(vi) Bailadila iron- ore group.

(vii) Bengpal gneissic complex.

(viii)Granulite charnockite complex.

(ix) Eastern Ghats complex.

A wider range of whole Indravati river basin consists of Bengpal Gneissic complex and Abujhmar volcano

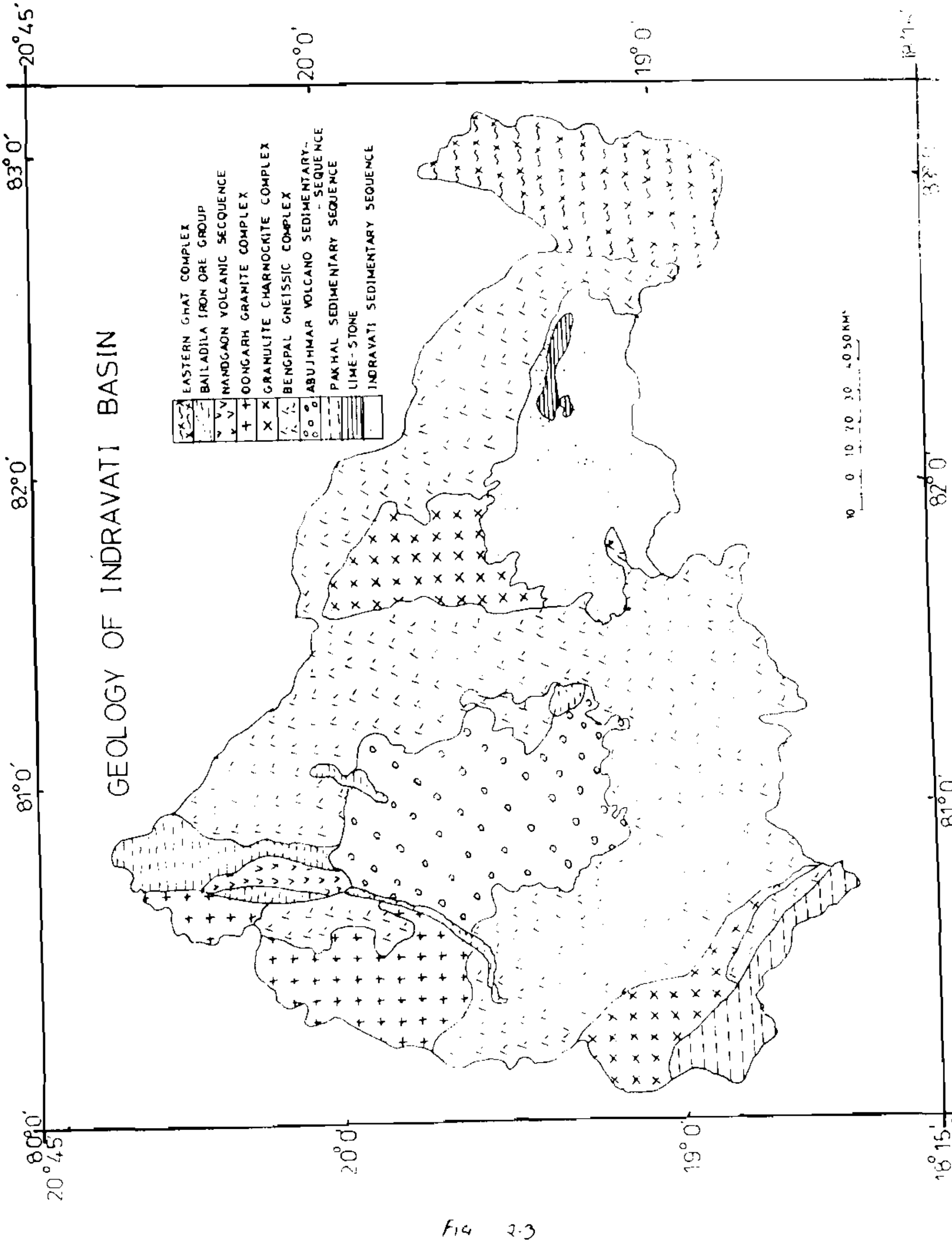
GEOLOGY OF INDRAVATI BASIN
EASTERN GHAT COMPLEX
BAILADILA IRON ORE GROUP
NANDGAON VOLCANIC SECQUENCE
DONGARH GRANITE COMPLEX
GRANULITE CHARNOCKITE COMPLEX
BENGPAL GNEISSIC COMPLEX
ABUJHMAR VOLCANO SEDIMENTARY-SEQUENCE
PAKHAL SEDIMENTARY SEQUENCE
LIME-STONE
INDRAVATI SEDIMENTARY SEQUENCE
20°45'
20°0'
19°0'
83°0'
82°0'
81°0'
80°0'
18°15'

Fig 2.3

2.1(a) GUDRA RIVER BASIN :

The main geological formations of the area belons to the Bengpal, the Bailadila, the Nandgaon and the Abujhmar groups and sub recent to recent deposits. The sequence of Rock type in this area is as follows:

TABLE 2.1

Purana		Arkose abd Quartzites	
Archaean		Quartz vein	
		Diorite, dolerite and amphibolite	
		Biotite Granite	
		Biotite Granite Gneisses.	
		Bailadila series	Banded hematite Quartzites Ferruginous shale
		Bengpal series	Quartzites, quart schist, phyllite, horn blende schist.
	BASIC LAVA		

BENPAL GROUP : This group comprises of metasediments including pyroxene, quartzites, quartz schist, banded magnetite, mica schist and hornblende schist occuring as enclaves with the granite gneisses ,migmatite and granite. The discontinuous exposures of these metasediments show a variation in strike from

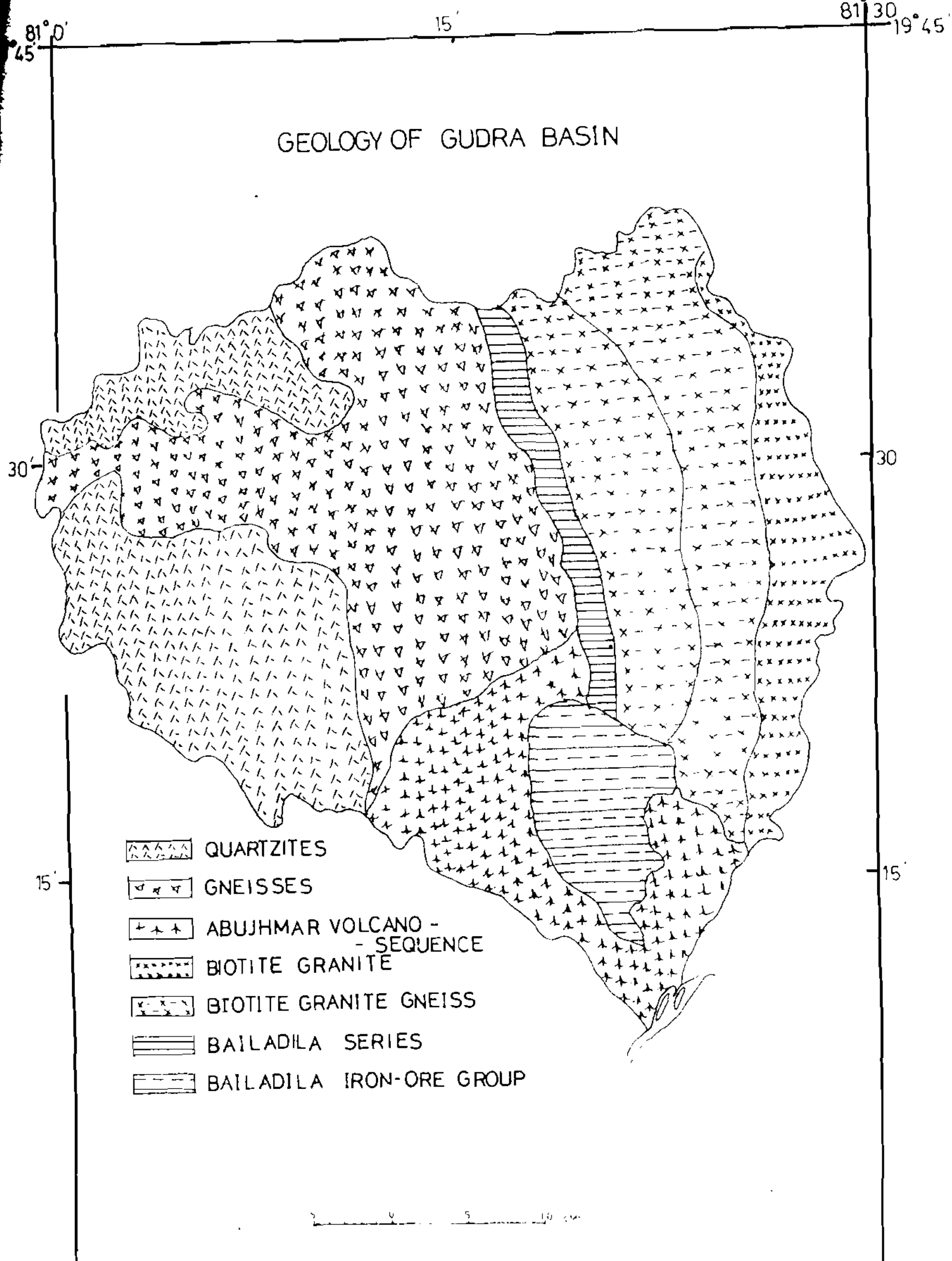
GEOLOGY OF GUDRA BASIN
81°0'
15'
81°30'
19°45'
45'
30'
30
15'
15
19°0
81°0
15'
81°30'
QUARTZITES
GNEISSES
ABUJHMAR VOLCANO - - SEQUENCE
BIOTITE GRANITE
BIOTITE GRANITE GNEISS
BAILADILA SERIES
BAILADILA IRON-ORE GROUP

FIG 2.4

North-east- south west to north west t- south west with dips varying from 30°-80° in either direction, at places becoming vertical. Granite gneiss, migmatite and granite are the product of the granitisation and anatexis of the above metasediments and predominantl ly occur in the north eastern part of the area. Metabasic dykes and quartz veins (at places sheared) and mylon itised intrude these rocks.

THE BAILADILA GROUP: This group of rocks forms a small in lier, occuring in the northern part and comprise banded magnetide and ferrugeous phyllites.

THE NANDGAON GROUP : The Nandgaon group of rocks include ferrugenous sand stone and shale ryolites and granophytes occuring in the north western finger of the area, forming a large in lier with in the younger Gundul sand stone-conglomerate. Their relation ship with the rocks of other groups and granite is observed by the overlying sediments of the Abujhmar group. Rhyolite and Granophyre occur in the north western part of the area around Mahla and east Pratappur. The intrusive relation of these rocks with ferrugenous sand stone and shale is seen at a few places. Pebbles of rhyolite occur in the Gundul conglomerate, indicating that the rhyolite is older than Gundul sand-stone conglomerate. The acid volcanic rocks in contribution with rhyolite in the north have been grouped as "Greenstone" by Chatterjee(1951).

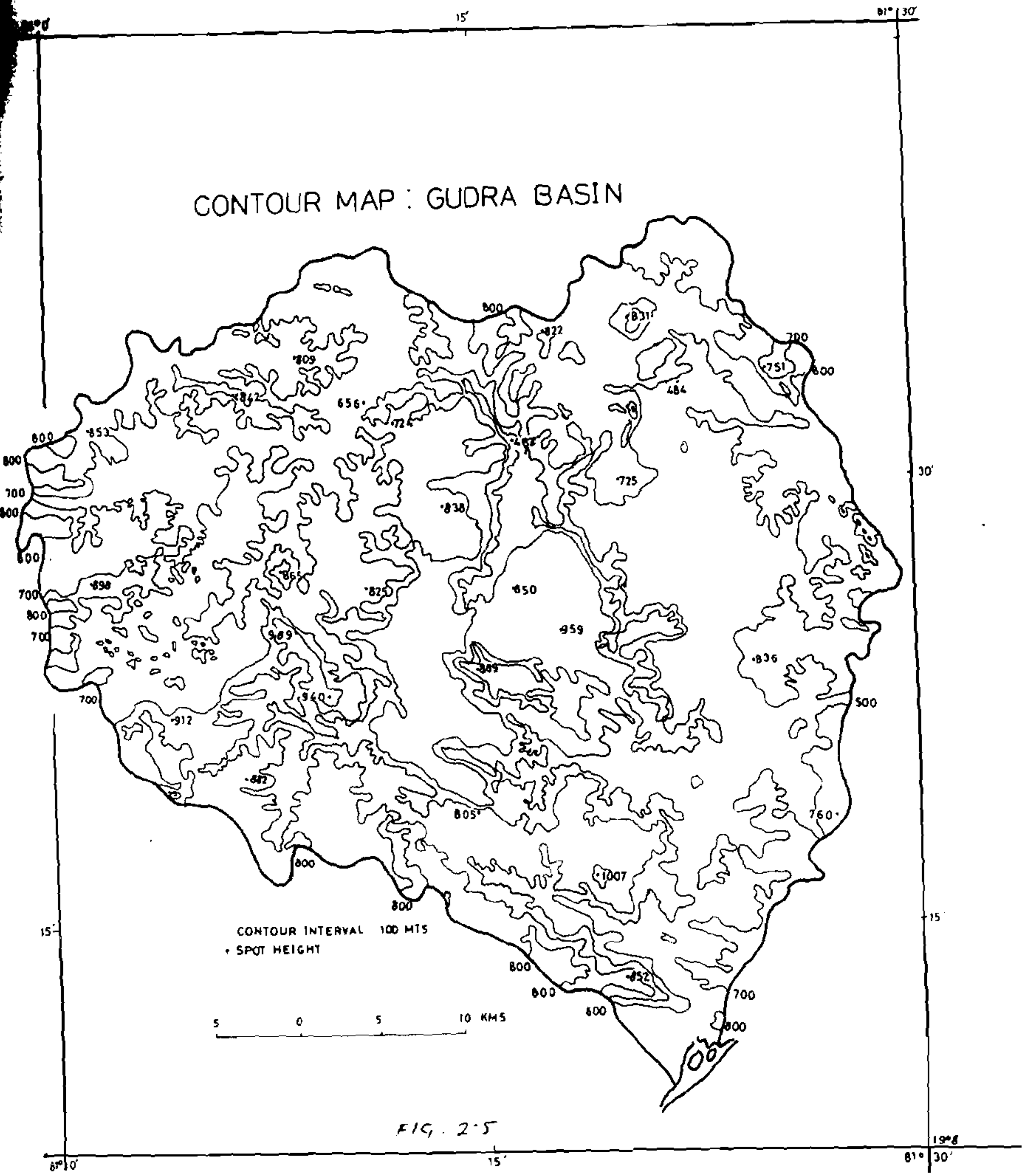
CONTOUR MAP : GUDRA BASIN
CONTOUR INTERVAL 100 MTS
+ SPOT HEIGHT
5 0 5 10 KMS
15'
81° 30'
30'
15'
19°8
81° 30'
81° 10'
800
700
600
500
809
862
853
656
724
822
831
751
484
462
725
838
898
865
825
850
959
989
849
836
940
912
882
805
760
1007
852

FIG. 2·5

NARAINPUR GROUP : The Narain pur group is also known as "Abujhmar Group", it include the lower Gundul formation of sand-stone, shale, conglomerate, unconformably overlain by the upper formation, Maspur trap (basalt) and intrusives.

FERRUGENOUS SAND STONEAAND SHALE : These form linear ridges trending NNE-SSW occuring to the east of Pratappur. Shale occurs as interscalation with in sand stone is laterised. Rhyolite and Granophyre exhibit intrusive relation with sed-mentaries and occur on all sides of the ridge. The bedding trend NW-SE to NNE-SSW, dipping 15°-30° towards east.Sand stone is greyish white to dark brown in color, medium graind in persistently banded and fragile to compact. Shale is purple colored well laminated and indurated in nature with small pockets of iron ore at places.

RHYOLITE AND GRANOPHYRES: These acid volcanics occur in the north western part. These are overlain directly by Gundul sand stones.Acid volcanic rocks at places exhibit prophyritic texture though generally crypto-crystalline and glassy. Rhyolite is light brown and pinkish to dark grey in color and breaks with equigranular texture.

GUNDUL FORMATIONS : Comprises an inter bedded sequence of sand stone is the most dominant of three and conglomerate occurs as large bands in it. Where as shale forms smaller pockets.

Sand stone is well bedded and form cliffs and high hills It shows variable composition being arkose at many places. The thickness and composition of the sand stone are variable as also thegrain size from grit to fine sill sizes. The sandstone is greyish white or pinkish to dirty white in color, well bedded and compact.Shale occurs as intercalation with in the sand stone and is noticed in differeht localities, but good exposures are present along the Dokrighat road section. Shale is purplish to greyish white in color, well laminated and at places slaty in places due to induration and compactness.

SUB RECENT DEPOSITS : Laterite capping developed over theMaspur trap forms the extensive plateau in the area. There are few pockets of bauxite with in the laterite. At other places the laterite is cavernes to pistolitic and ferrugeous to brown color.

2.1 (b) BHASKEL RIVER BASIN:

The cheif groups of the region are Archaeans, Cuddapah, Tertiary and recent formations like laterite and alluvium.

ARCHAEAN : The archaean of the region may be divided into two main rocks groups:

(i) Sedimentary rock and their metamorphic variants with which are associated basic igneous rocks

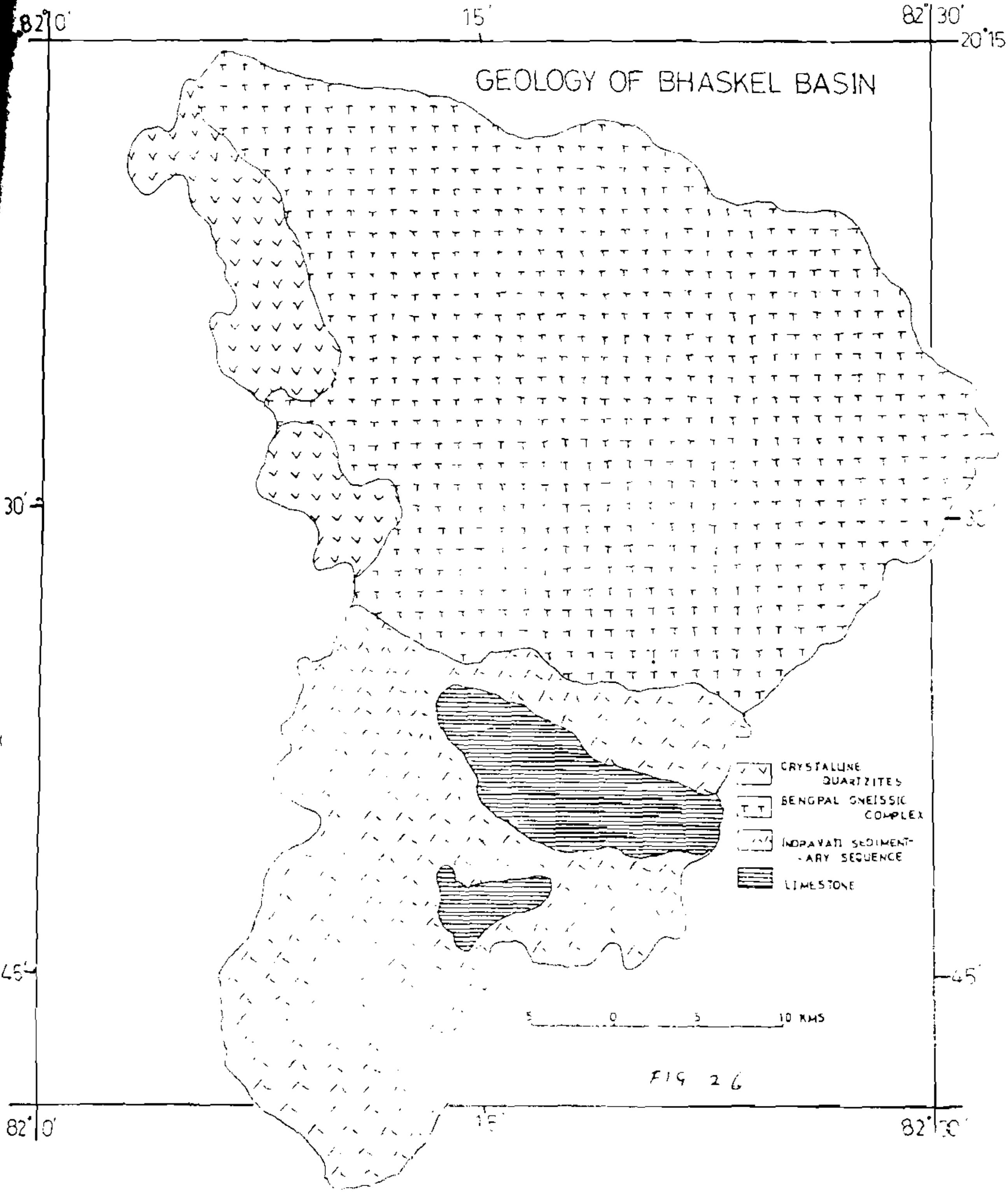
GEOLOGY OF BHASKEL BASIN
82°0'
15'
82°30'
20°15'
30'
45'
CRYSTALLINE QUARTZITES
BENGPAL GNEISSIC COMPLEX
INDRAVATI SEDIMENTARY SEQUENCE
LIMESTONE
5 0 5 10 KMS

FIG 26

CONTOUR MAP : BHASKEL BASIN

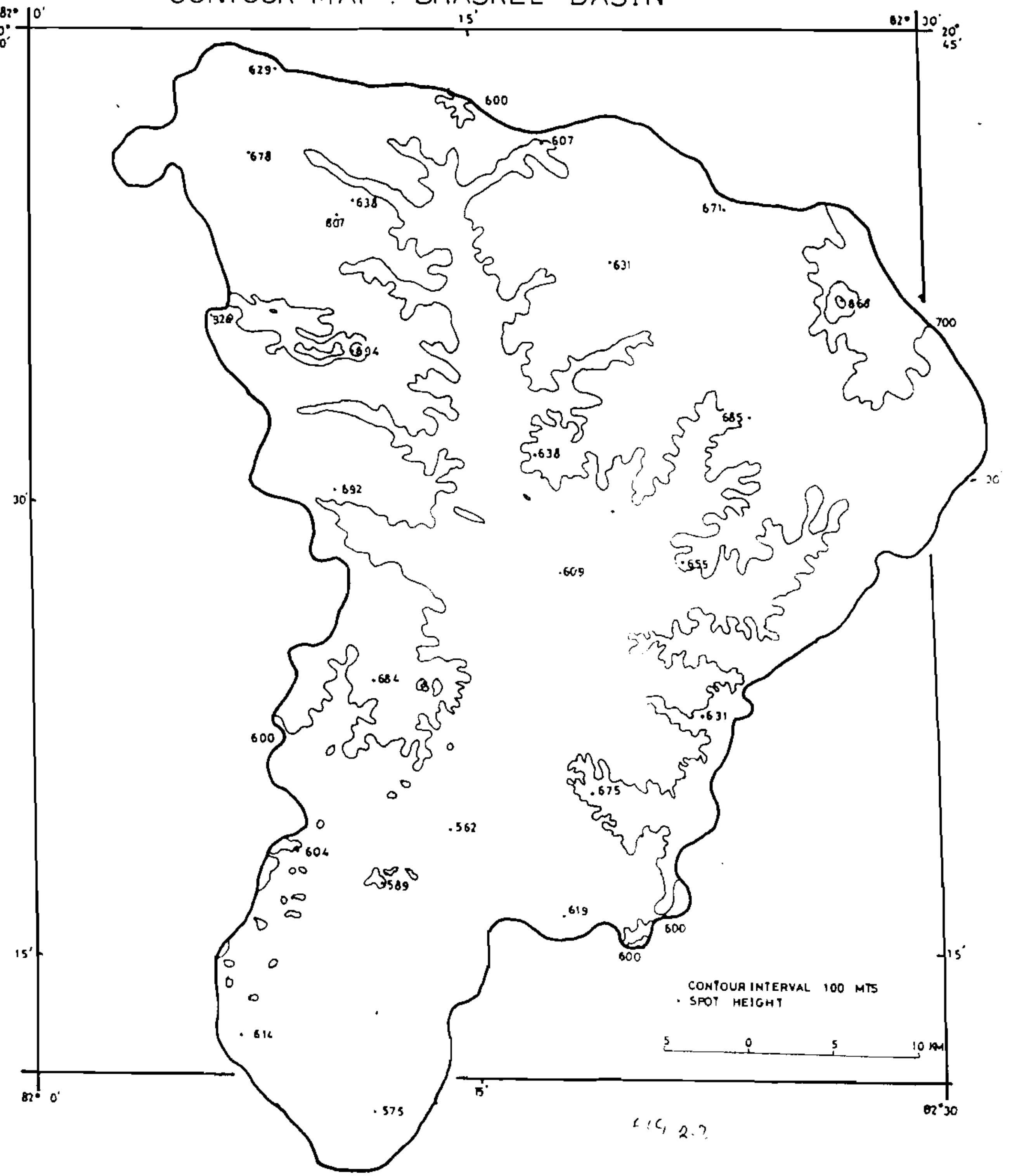

FIG 2.2

(ii) Widespread intrusions of granite and charnobites .

The sedimentary Archaean rocks ofthe region are highly metamorphosed, The cheif rock types consists of quartz garnet and sillimonitewith some feldspar and graphite and very often maganese, iron minerals(khondalites). In a few localities calc gneeisses, quartz veins ,limestone are associated withtypical khondalite rock forms a psrt of the Koraput plateau which passes south wards into the Vishakh--apattnam district of Andra Pradesh.

METAMORPHOSED ARCHAEAN : Archaean sediments is a different type which have not suffered such intense metamorphism as the Khondalites, occupy large areas of the western and southern parts of the Jeypore plateau and extends into the lower tracts of Malkangiri. These rocks are known as the Bengal series, extend westward into Bastar where they are better developed, included with in the Bengpal of the Koraput plateau region are Andalusite bearing grits and schist, biotite schist and crystalline quartzites,associated with them are haematite quartzites binded magnetide and grun esite quartzites.

The above Archaean sediments are associated with basic lavas and minor intrusions which are also present in gneisses. The basic rocks have been subjected to varying degrees of metamorphism and in all probabilty belong to more than one period. They consists of epidocites amphibolite non blendes diopside-chloride and talc-schist. The green stone intrusions in the Tulsi and Lokkhi hills assumes enormous proportions of rocks of this type.

The complex group of granitegneisses and metamorphic rock have been so much altered by regional metamorphism and different cycles of igneous activity, that the nature of the parent rock can't always be determined. Some of them may represent the crystalline product of true melts where as others appear to be hybrids or remnants of older rocks which have absorbed liquid or have been altered by liquid and gaseous emanations. Other types of gneisses found in the region are porphyritic granite gneiss,charnockites. They vary from coarse grained banded gneisses and typical injection gneisses to entirely massive granite and carry bands and patches of basic hypersthene and other dark colored rocks, Basic charnockite occurs in the form of minor patches or bands, associated with the granite gneisses.

2.2 CLIMATE:

The entire Indravati basin lies with in the tropics, is characterised by the hot and humid climate. The temperature varies from 19° in the coldest month,December to 31° in May, the hottest month showing a considerable annual range of 12°C. The rain fall in the region charac teristically occurs between June and September, ranging from

125 cm. and 150 cm. The periods between December - February remains generally dry. The region, however, suffers from uneven distribution, un reliabily and uncertainty of rainfall. The rainfall, fairly heavy though irregular and unevenly ditributed, mostly caused by the south west monsoon.

This variability of rainfall from normal is relatively high but since the annual precipitation is fairly high, floods are bigger menace than drought.

2.2(a) CLIMATE OF GUDRA:

Rainfall: Mean annual rainfall ranges from 13.75 Cm to 150 CM. It increses from west to east. Generally rainfall ocurs in the month of June to October, maximum reaches upto 30 to 40 Centimeters in the month of July to August.

Temperature: Annual mean temperature through out the year remains between 24°C to 26°C. December and January are the coldest months in the year. Thereafter the temperature goes on rising almost steadily till it attains Maximum temperature which takes place in the month of May. May is the hottest month of the year. After May the temperature starts decreasing till August. The drop being some what conspicious from June to July. In August the temperature is checked by heavy down pour. July and September are more or less equally warm. October is the month of transition from rainy to cold season and presents an interesting contrast of hot days and cool nights. From November again the mercury atarts declining constantly till it touches the minimum in the month of January.

2.2 (b) CLIMATE OF BHASKEL :

Rainfall : The climate of the region is more like that ofDeccan but milder than main Deccan plateau. The average annual rainfall is 152.2 CM. The spatial distribution of rainfall is largely influenced by the eastern Ghats which run roughly from south west to north east. Eastern side of Eastern Ghats get lesser rain fall that those on the West. 79% of the rainfall falls during the monsoon season. July and August are the rainiest months in the year.

Temperature: December is the coldest month of the year with the mean daily temperaure at 11.2°C (52.2°F). Both day and night temperatures progressively increases after January till May which is the hottest month.

2.3 NATURAL VEGITATION:

Although the implementation of agriculture extension programmes recently in many parts of this Indravati River basin has resulted in deforestation and decreasing of original forests with a view to increasing cultivable land. The region appears to be exceptionally rich in the forest wealth mostly confined on the upland hills and the Eastern Ghats.

The typical cover is of the mosist tropical deciduous forests of "SAL" being the most dominant species.About 57.8% of the area is under forests cover.

At present a high proportion of the forest in the region is either reserved or protected.Main trees are Teak, Sal, Sirsa, Bijasal, Kusum, Palas, Mahua, Tendu, Harsa, Salai and char etc

2,3 (a) NATURAL VEGETATION OF GUDRA:

Sal and Teak are the most common vegetation found here with. Sal forests aredeciduous forests. The Sal forest are found in the North North western parts of the region. Broader area consists of Teak forest which are found in the Northern, Central, Eastern tropical dry mixed deciduous forests and the tropical dry deciduous forsets. The dues region proceeds gradually towards North- western region and the proportion ofTeak also falls down in the same direction. The soil on the plateau and escapments are fit for dry deciduous forest with species like Hurra, Karra, Mahua, Sahaja, Palsa, Tendu Khair etc.

2.3 (b) NATURAL VEGETATION OF BHASKEL:

The vegetation is of considerable interest as although typically northern in character it has also affinities with the florad southern part.

The greater part of plateau was covered with 'SAL' of a moist peninsulas type and this forest still survives where it is under protection. The commonest trees are ShoreaRuusta (Sal), Asana, Dhama, Simili, Bagali, Atund etc. Bahoos are very rare. Scattered patches of teak occur as far west as 82°36' longitudes. Kusum is common in open cultivated tracts.

U Umarkot, Nowrangpur, Kotpad and part of Ramagin range are all situated on a plateau which is typically Sal of a moist peninsulas type. A few patches of teak occur locally. The whole crop was at one time under slufting cultivation and the forest now comprises pole crops in various stages of growth.

2.4 SOIL: Adequate and systematic record about the characteristics of soils of the region of Indravati river basin is hardly available. The soil types however vary widely depending on the configuration of surfaces while the peaks on the region have bare rocks almost devoid ofvegetative cover , the plateau and hill slopes contain rocky soil with thin veneer of loam and the plains and valleys are characterised usually by fertile alluvium. Majot part of arable land in Eastern Ghats contain mixed red and black soil deficient in humus nitrogen phosphoric acid potash and lime.

Extremely poious and gemerally sedentary type of soils are formed through the weathering of metamorphic rocks e.g. schists and gneisses and generally deficient in plant nutrients with low PH value (5.5 to 6.5). They are generally red with patches of grey color being too shallow with very fertile clay content. Being less moisture retentivity they are unableto sustain Ravi crops except under favourable conditions.

However the parent rocks slope and other factors produces greate variety of soils in different parts. The upland contain red soils rich in iron content and formed mostly due to the fact that soils are shallow ,exessively drained and non -calcareous, developed on 15 to 25% slope. The soilpedon exhibits brown sandy clay. A horizon grading to Ac horizon of dark brown color with gravelly clay underlain by weathered granite.

In the hilly tract of Abujhman are found that the soils are containing high concentration of iron oxides. Soils of Bodeli series are found to occur in this region . The soils are deep, well drained and non - calcareous developed on 1 to 3% slope, The soil pedon exhibits dark brown sandy clay. A horizon grading to Bt horizon dark brown to dark red in color having clay loam with thick patchy clay skin on ped faces underlain by massive unconsolidated lateritic materials in C horizon.

Being a hilly terrain with un dulating topography , flood plains occur in areas along this river at an elevation of 250 meters above Mean Sea Level. Soils of Khande series are found to occur in this unit. These soils have yellowish brown silty clay A horizon grading to B horizon of brown to olive grey clay with pressure faces and yellowish brown mottles underclain by clayey olive grey alluvium of 'C' Horizon.

2.4 (b) BHASKEL SOILS:

No systematic soil servey has been made yet the following soil classification is based on physical characteristics only.

COARSE TEXTURE SANDY SOIL:

Composed of a large percentage of coarse textured sand and a small amount of organic molten. Fine silty alluvial soil available on both sides of south Bhaskel river in Nowrangpur and Borigumns areas ,it is very rich in organic matter and contains silt and fine sand deposits of the river Indravati and Bhaskel.

RED LATERITE SOIL:

It is partly in this area.It is red in color and very clayey in nature, poor in organic matter contents and its fertility is low.

BLACK COTTON SOIL:

It occurs in Umarkot tehsil in North west part of Bhaskel river. It is slightly alkaline in nature. The soil stiffens and cracks when dry and grows sticky with a shower or two. Though black in color its humus contents is poor. The sub-soil is light yellow, impervious and forms a hard pan below the cultivated soil.

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CHAPTER III

AN ACCOUNT OF MORPHOMETRY OF GUDRA AND BHASKEL

CHAPTER III

AN ACCOUNT OF MORPHOMETRY OF GUDRA AND BHASKEL

The term morphometry is used in several disciplines to mean the measurement and analysis of form, characteristics, in geomorphology, it is applied to numerical examination of land forms. It provides, tool for analysis of surface configuration of a land scape. It evaluates the topological, geometrical areal, relief characteristics of the basin.

The present study is based on an evaluation of morphometric parameters. Bearing different lithologies Gudra and Bhaskel basins of, Bastar and Koraput districts, respectively, has been studied for geomorphological analysis based on Strahler's and Horton's method.

3.1 DELIMITATION AND SAMPLING OF THE BASIN :

Streams of various orders, following Strahlers' technique is marked and delimited the entire Indravati and sample basins. The geology of both, Gudra and Bhaskel have been superimposed on the drainage map and fourth order basins have been grouped according to different geological formations of the basins. These IV order basins have also examine according to Chorley's criteria as " Basins must be connected with the main stream network, must be ' permanent,' form a part of a distinctly bifurcating channel pattern and must conduct laterally concentrated surface runoff from a well defined drainage area.

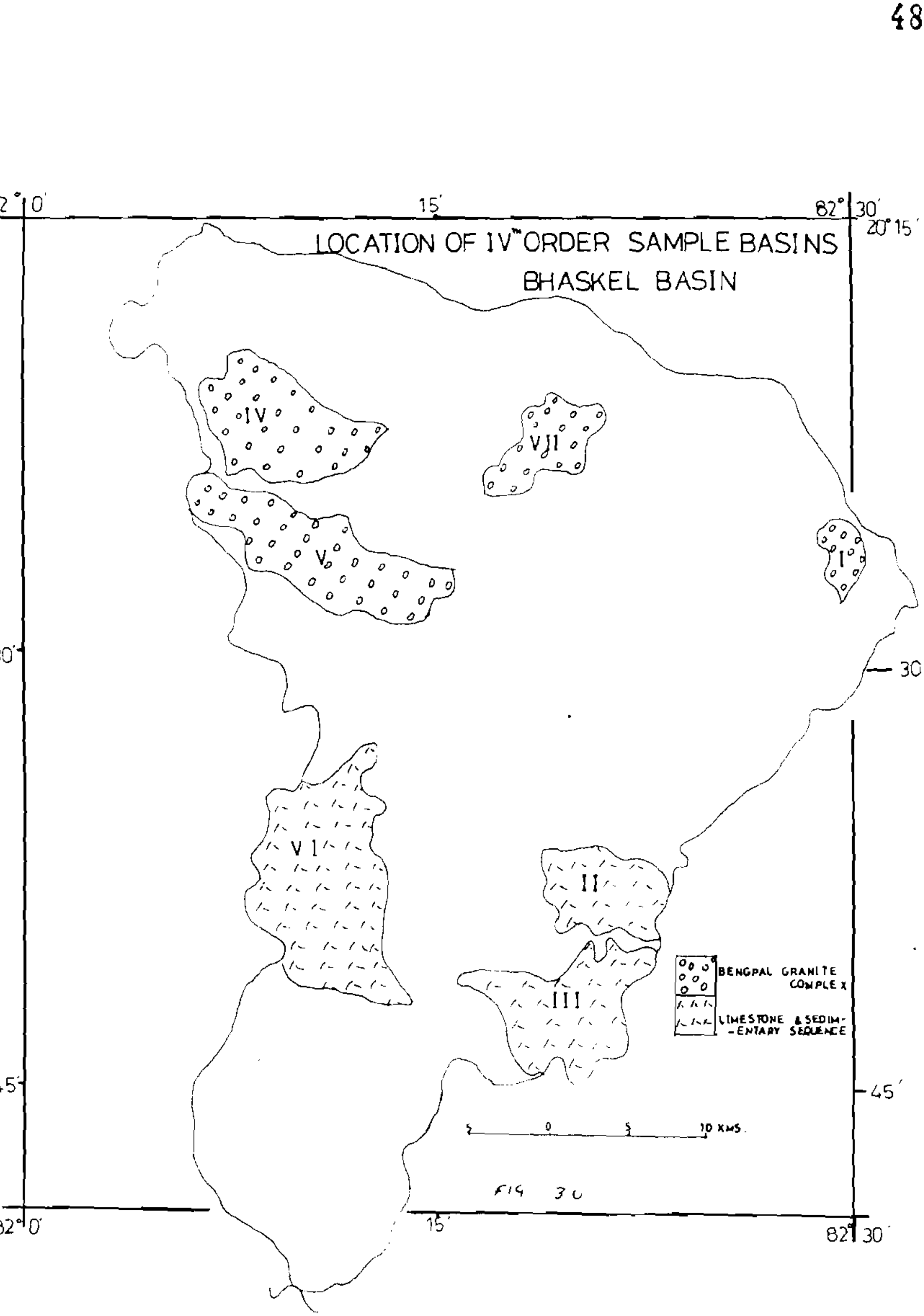

LOCATION OF IV th ORDER SAMPLE BASINS
BHASKEL BASIN
15'
82° 30'
20° 15'
30
45'
IV
V
VII
I
VI
II
III
BENGPAL GRANITE COMPLEX
LIMESTONE & SEDIMENTARY SEQUENCE
5 0 5 10 KMS.
15'
82° 30'
82° 0'

FIG 30

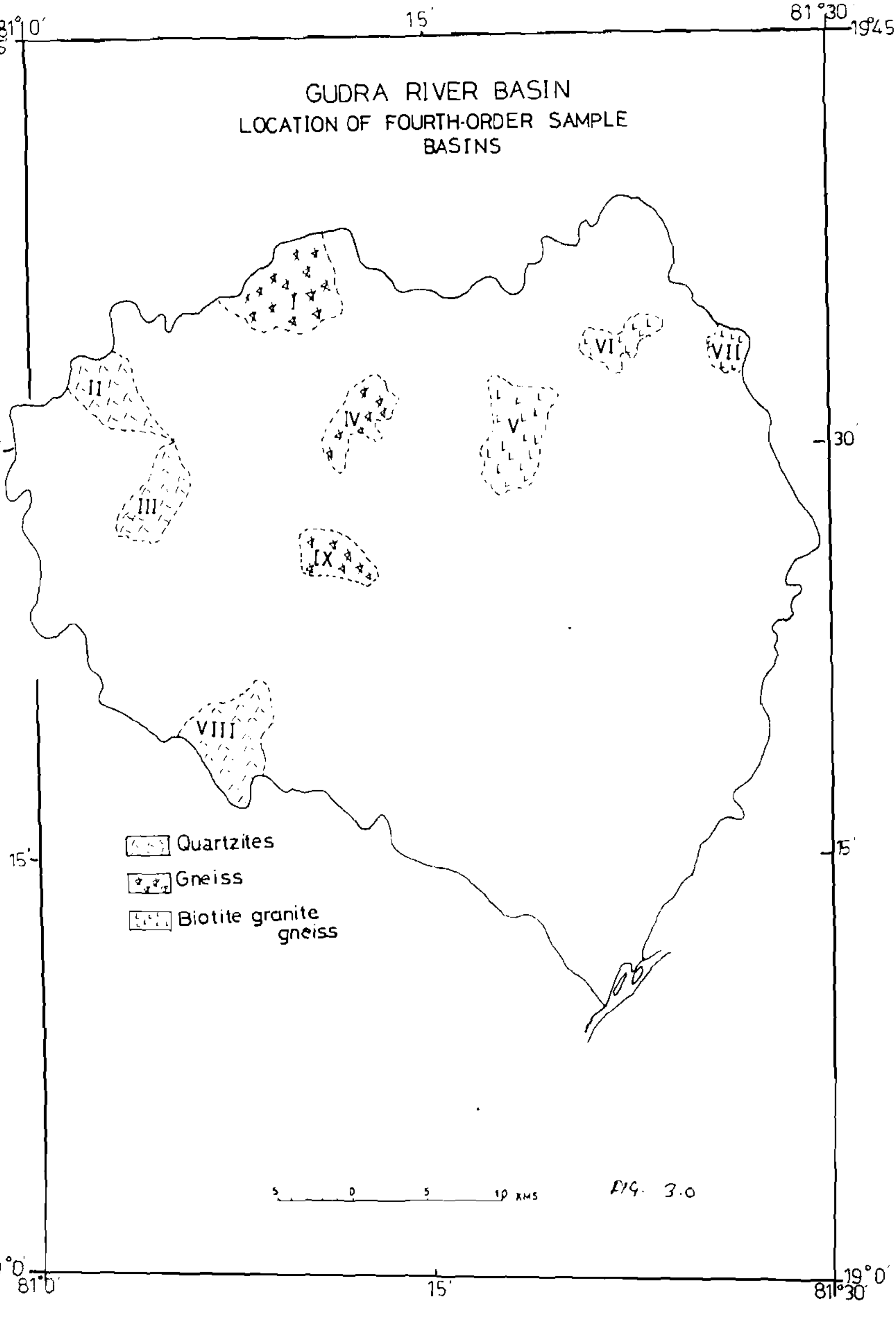

81°10'
15'
81°30'
19°45
GUDRA RIVER BASIN
LOCATION OF FOURTH-ORDER SAMPLE BASINS
I
II
III
IV
V
VI
VII
VIII
IX
30'
15'
Quartzites
Gneiss
Biotite granite gneiss
5 0 5 10 KMS
81°0'
15'
19°0'
81°30'

FIG. 3.0

These fourth order sample basins have been randomly selected. There are 16 fourth order basins selected from the different geological formations of the three tributaries of Indravati, broadly classified as hard rocks and soft rocks.

SELECTION OF THE BASIN :

TABLE 3.0

ROCK TYPE	GELOGICAL FORMATIONS.	MAIN DRAINAGE BASIN.	NO. OF IV ORDER STREAM
HARD ROCKS	Gneisses	Gudra	3
	Biotite Granite gneisses	Gudra	2
	Quartzites	Gudra	3
	Bengpal Gneissic complex	Bhaskel	4
SOFT ROCKS	Lime stone	Bhaskel	1
	Indravati Sedimentary sequence.	Bhaskel	3

In the present chapter some measurement of linear, areal, relief characteristics of Baskel and Gudra have been assessed. The first 2 categories of measurement i.e. linear and areal are planimetric, where as, the relief aspect have been treated vertically in equalities of the drainage basin form.

3.2 LINEAR ASPECTS OF DRAINAGE BASIN :

Linear characteristics of channels are defined in terms of, number, length and arrangement of the stream segments and can be assessed from 2 main view points:

(a) The topological, which considers the inter connectios of the system and include stream ordering.

(b) Geometrical, which considers the length, shape and orientation of the constituent parts of the network.

3.1 (i) STREAM ORDERS :

The initial step in drainage basin analysis is designation of stream orders. Streams are ordered after Strahlers'(1952, p. 1120)[1] adaptation of the Hortons' [2] scheme of classification. Melton (p.340 - 345)[3] has suggested the mathematical concept for ordering of the strem. Assuming a channel which includes all intermittent flow lines with well defined valleys gives the smallest finger tips designated as order 1. When 2 first order streams meet, forms a second order stream and so on. The trunk stream in which all discharge of water and sediments passes are therefore, the segment of higher order.

Stream order is useful in determination of the size of a strem channel as well as, hydrological potential. Intensity of erosion and sedimentation could also evaluated by the same technique. In a basin, streams are ordered to ascertain the dimension of the basin and to measure the amount of water and sediments which discharge through the tributaries with respect to trunk stream.

3.1 (ii) STREAM NUMBERS :

Horton developed a model of stream ordering and suggested that " The number of streams of each form an inverse geometric series with the order" Infers, as order

1. Strahler (1952), op. cit., ref. chapter I
2. Horton (1945), op. cit., ref. chapter I
3. Melton (p.340), op, cit. ref. chapter I

STREAM ORDERS : GUDRA BASIN

IV ORDER SAMPLE BASINS

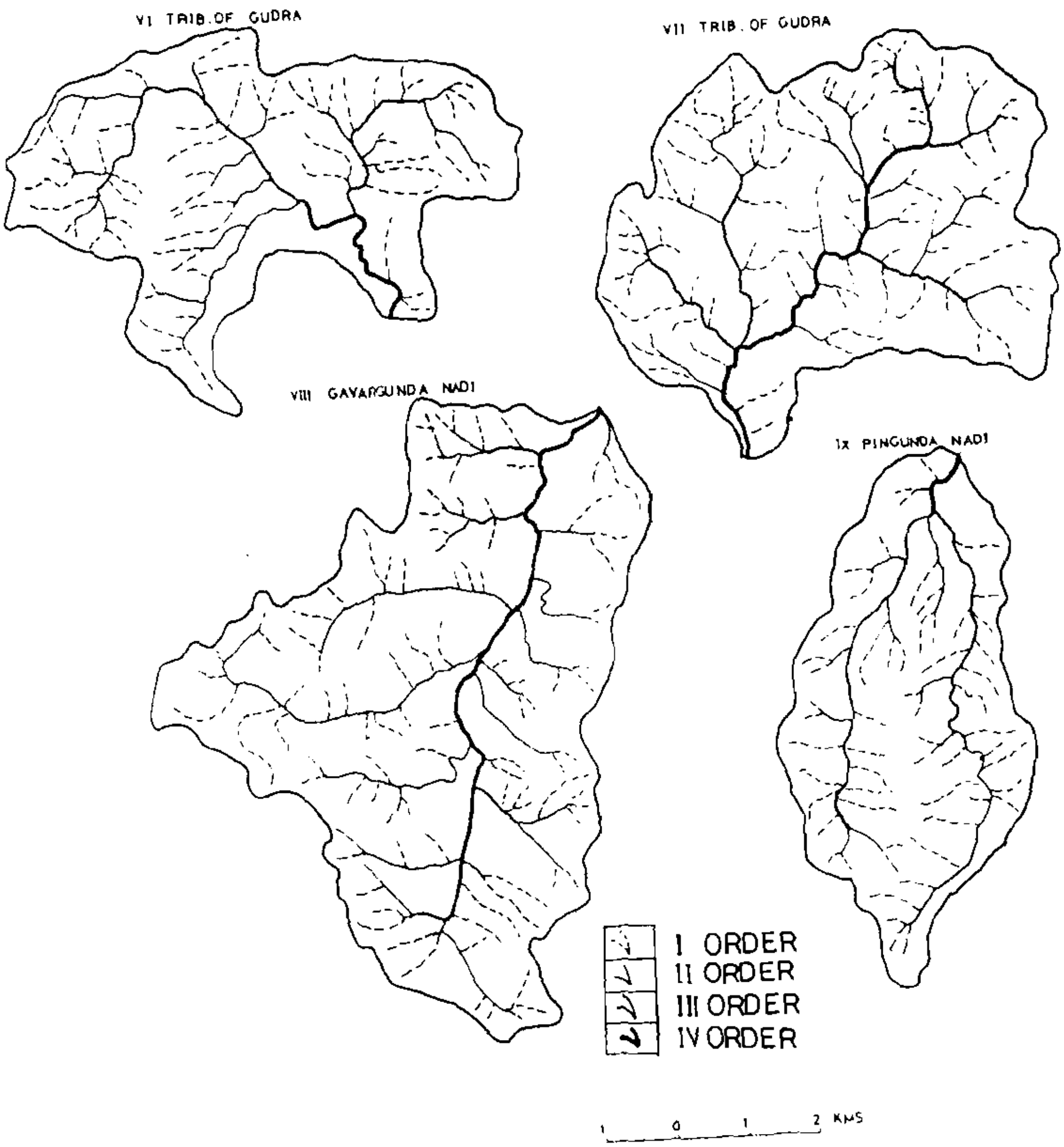


FIG. 3.1

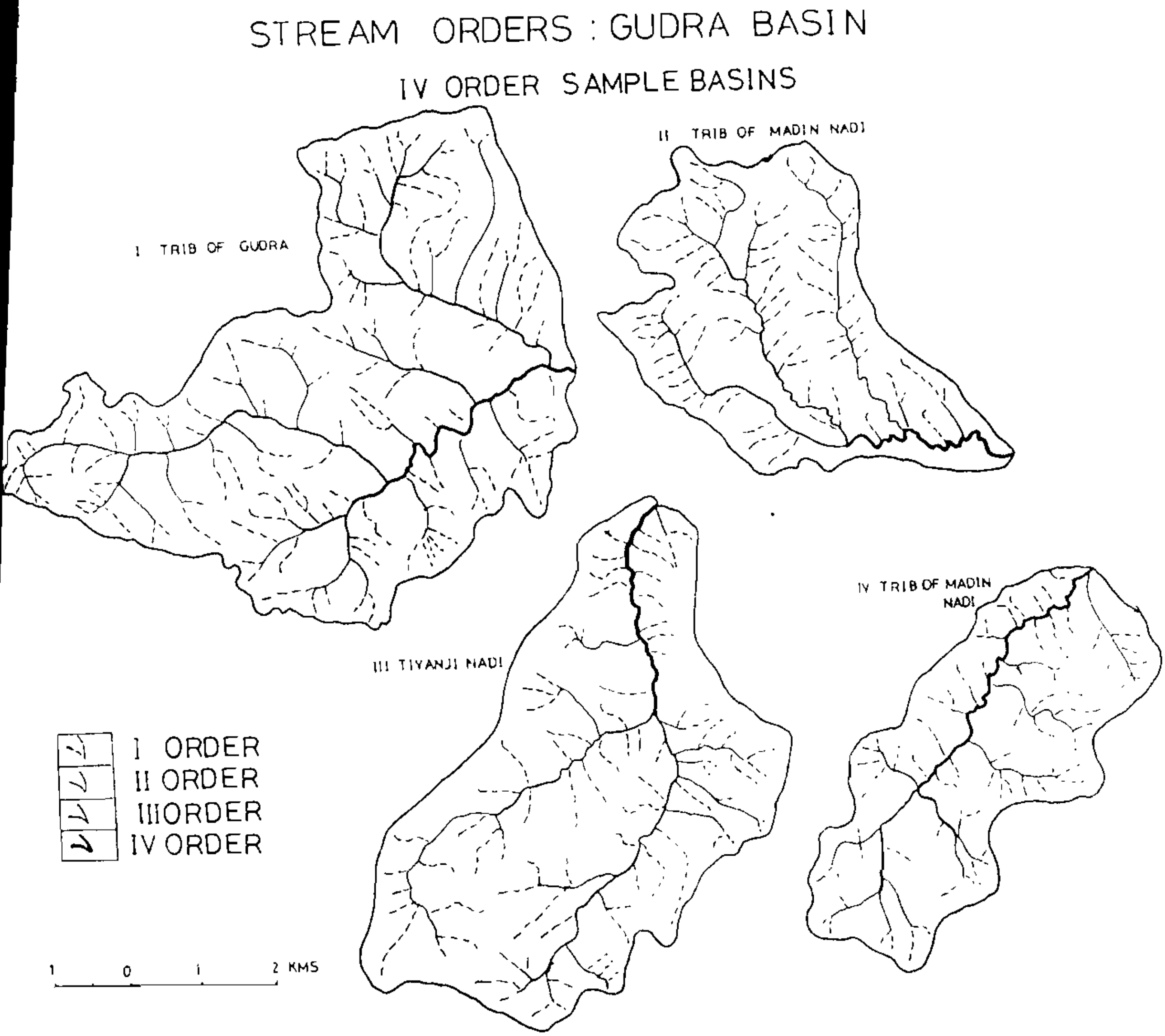

STREAM ORDERS : GUDRA BASIN
IV ORDER SAMPLE BASINS
I TRIB OF GUDRA
II TRIB OF MADIN NADI
III TIYANJI NADI
IV TRIB OF MADIN NADI
I ORDER
II ORDER
III ORDER
IV ORDER
1 0 1 2 KMS

FIG. 3.1

increases the number of streams of each order decreases. It is calculated as the number of finger - tips in a drainage basin, number of second order in a basin and so on. This has been termed as first law of drainage morphometry and has widely been tested.

STREAM ORDER AND NUMBER IN GUDRA BASIN :

TABLE 2.1

S.No.	Basin Name	Number of streams of individual orders Nu_1	Nu_2	Nu_3	Nu_4	Total no. streams
I	Tributary of Gudra	190	30	5	1	226
II	Tributary of Madin nadi	64	10	2	1	77
III	Tivanji nadi	85	16	2	1	104
IV	Tributary of Madin nadi	70	14	3	1	88
VI	Tributary of Gudra	64	19	3	1	87
VII	Tributary of Gudra	85	20	4	1	110
VIII	Gavargunda nadi	99	24	6	1	130
IX	Pingunda nadi	59	12	2	1	74

Gudra river is a seventh order stream. Number of streams of first order is higher in gneisses area (Basin I), 190, leading Quartzites (Basin VIII), 99, and Basin III, i.e. Tivanji nadi, 85. The first order streams is comparatively lower in Basin II of Quartzites, 64, Basin IV, 70 and Basin IX Pingunda nadi having gneisses as under - ground lithology.

The calculated mean value of first order streams give higher values in Quartzites i.e.82.67 and gneisses areas 83.00 than in Biotite granite gneisses regions 74.5. The number of second order is higher in the Basin I under gneissic lithology i.e. 30 than in Basin VIII of Quartzites and Basin VI and VII of Biotite granite gneisseic group i.e. 20 and 19, respectively.

The average stream number is calculated as in Biotite granite gneisses is 19.5 streams and gneisses 18.67, Quartzites as 16.67. In Basin I, VII, and VIII, the third order streams is more 5, 4, and 6, respectively, which is due to the hilly terrain and humid climate. Average value in Quartzites, Gneisses and Biotite granite gneisses is varying from 3.33 and 3.50. The total number of streams is highest in Basin I under Quartzites which is a hilly region and well dissected by streams.

STREAM ORDER AND NUMBER IN BHASKEL BASIN:

TABLE 3.2

S.NO	BASIN NAME	NO. OF STREAMS OF INDIVIDUAL ORDERS Nu_1	Nu_2	Nu_3	Nu_4	TOTAL NO. OF STREAM ORDERS
I	Angi nadi	28	8	2	1	39
II	Baliajori nadi	59	14	5	1	79
III	Tributary of Bhas--kel	133	32	5	1	171
IV	Nangi river	136	37	8	1	182
V	Singari nadi	139	35	11	1	186
VI	Tributary of Bhas--kel	75	17	5	1	98
VII	Agua nadi	32	9	2	1	44
VIII	Tributary of Indravati	37	6	3	1	47

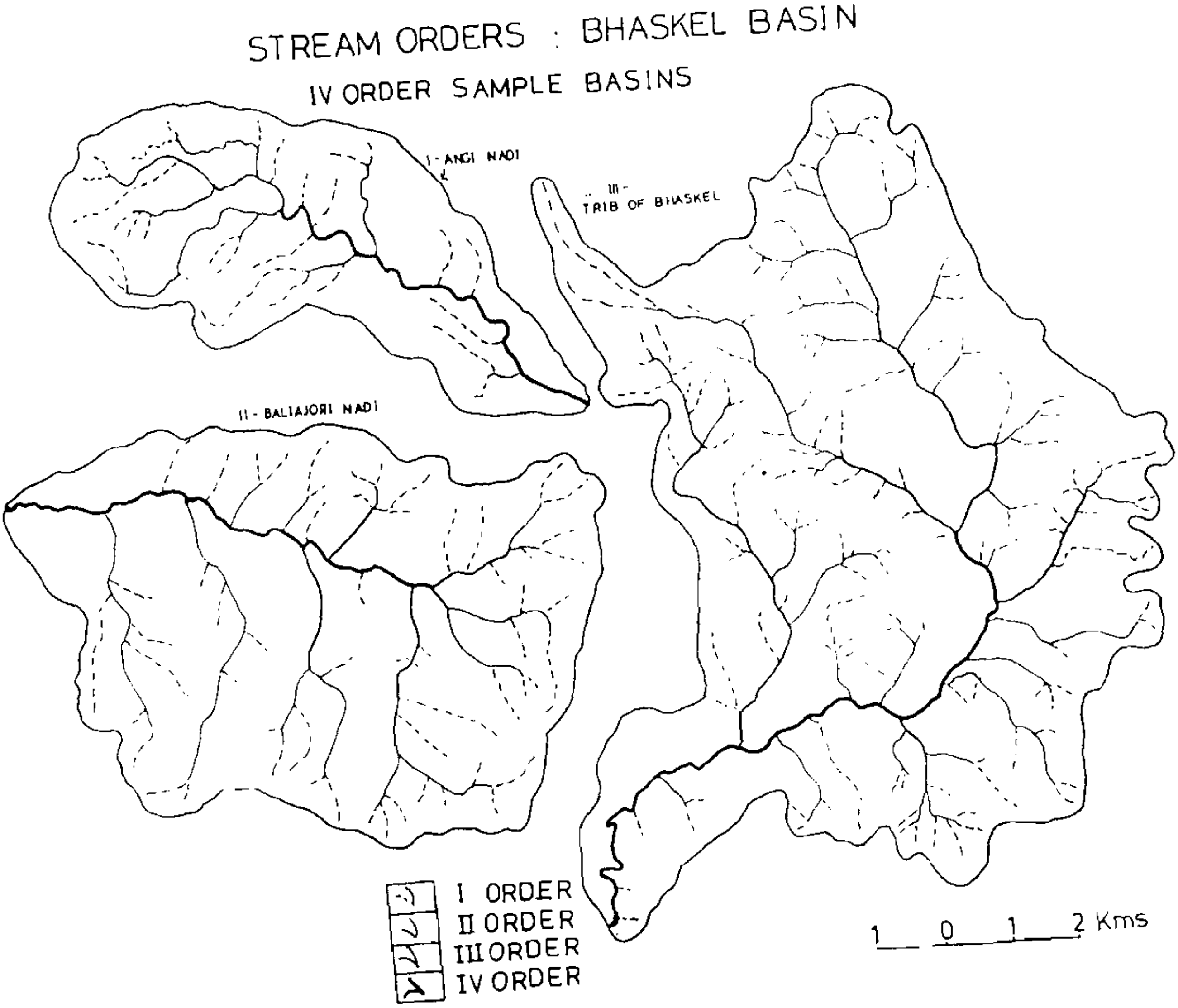

STREAM ORDERS : BHASKEL BASIN
IV ORDER SAMPLE BASINS
I - ANGI NADI
III - TRIB OF BHASKEL
II - BALIAJORI NADI
I ORDER
II ORDER
III ORDER
IV ORDER
1 0 1 2 Kms

FIG. 3.2

STREAM ORDERS : BHASKEL BASIN

IV ORDER SAMPLE BASINS

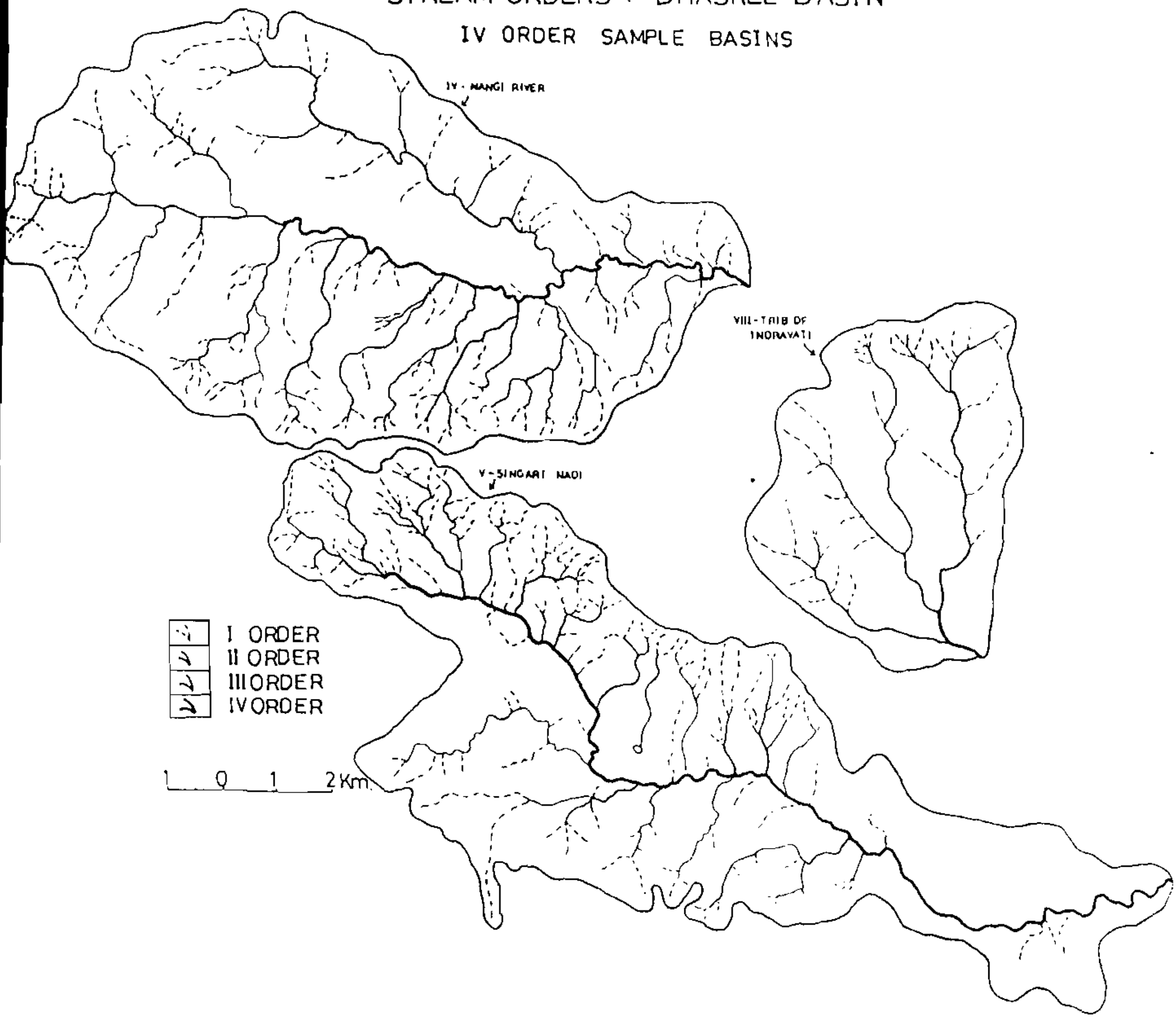


FIG. 3.2

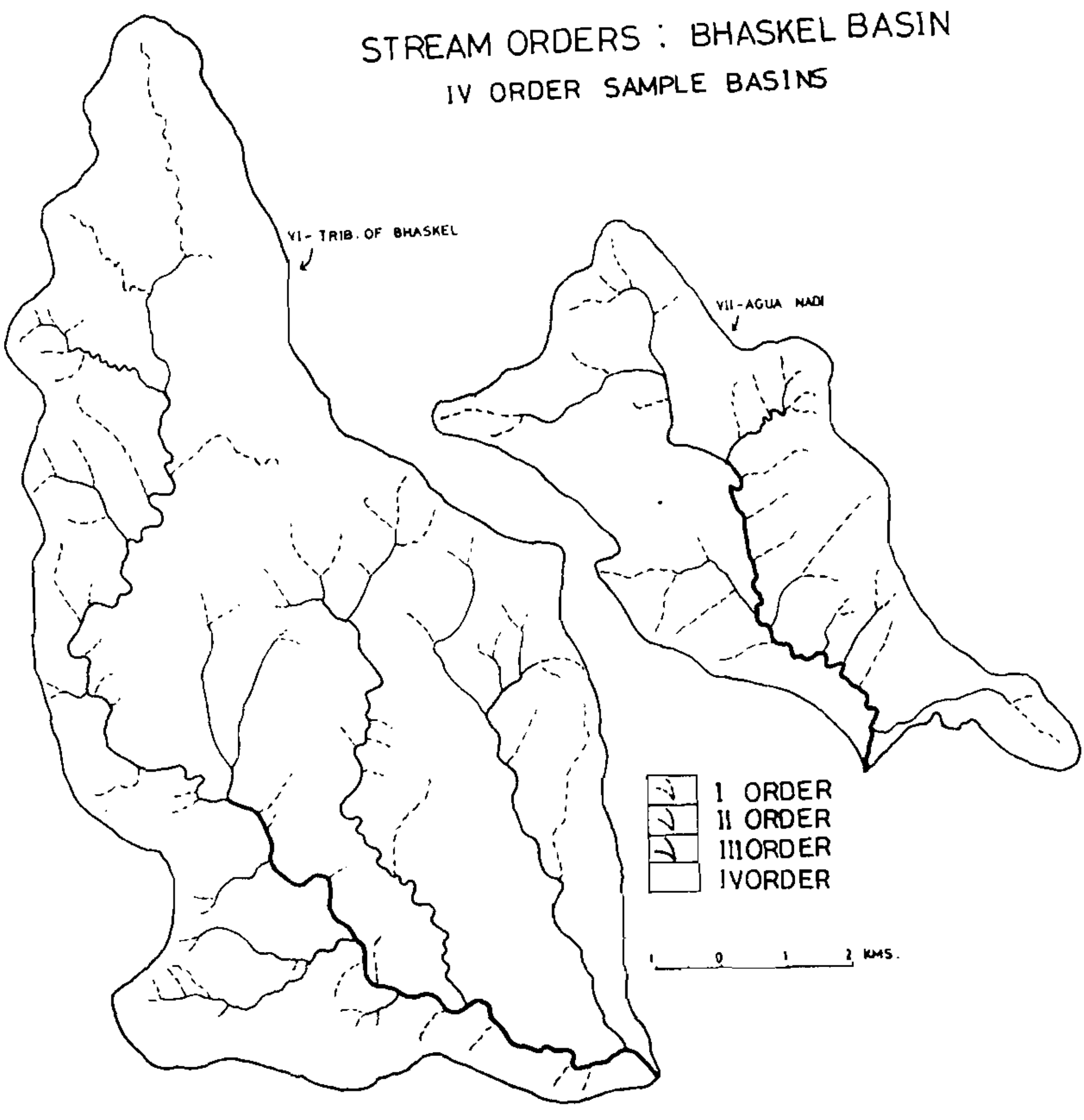

STREAM ORDERS : BHASKEL BASIN
IV ORDER SAMPLE BASINS
VI - TRIB. OF BHASKEL
VII - AGUA NADI
I ORDER
II ORDER
III ORDER
IV ORDER
1 0 1 2 KMS.

FIG. 3.2

The basin, selected for Bhaskel river comprises of sedimentary and limestone area and Bengpal Gneisses Complex. First order varies from 139 Of Singari nadi which comes under Bengpal gneissic complex to Angi nadi, 28, Of the same geology, where as, Basin III of sedimentary is also giving higher values for first order i.e., 133. The mean average value of first order in Bengpal group is higher i.e. 85.75 than that of sedimentary and limestone group, 76.

Streams order II in Bhaskel is higher in Bengpal group i.e. 37, leading 35 of the geological formation(Basin IV and V,respectively). Less numbers are found in basin I, Angi nadi, Basin VII;Agua nadi, and basin VIII; Tributary of Indravati, giving the values of 8, 9, and 6, respectively. The mean average for Bengpal is 22.25 numbers and for sedimentary is 17.25.

We can see exceptional cases in Bengpal group as the third order basins is concerned. It is having highest value of 11 in Basin V leading 8 in Basin VI. Even basin II, III,and VI is also giving higher values of 5. All these three basins are of sedimentary and limestone region.

3.3 (iii) BIFURCATION RATIO:

Horton considered the bifurcation ratio as an index of relief and dissection.It is designated as Rb. Due to the different lithological formations the value of bifurcation ratio varies. Generally many streams networks evolved out of the region of uniform climate, rock type and stage of development. Confirm to the principal of exhibiting relatively constant Rb. from one order to next value ranging from 3 to 5 in a natural stream system. Wats (1958)[1] observed that " The minimum possible value of 2.0 is rarely approached under natural conditions because the bifurcation ratio is a dimension less property and because drainage systems in homogenous materials tends to display geometrical similarity it is not surprising that the ratio shows only a small variation from region to region" High bifurcation ratio might be expected in region of steeply, differing rocks strata where narrow strike valleys are confined between hogback ridges.

BIFURCATION RATIO IN GUDRA BASIN :

TABLE 3.3

S.NO.	BIFURCATION RATIO Rb_1	Rb_2	Rb_3	MEAN Rb
I	4.125	4.00	6.00	4.71
II	4 .92	6.00	2.00	4.31
III	5.00	4.67	3.00	4.22
IV	5.31	8.00	2.00	5.10
VI	6.40	5.00	2.00	4.47
VII	6.33	6.00	5.00	5.78
VIII	3.36	6.33	3.00	4.23
IX	4.25	5.00	4.00	4.42

The value of Rb_1 is ranging from 3 - 6.33 having net much variation in the topography. High value of 5.31, 6.40 and 6.33 is in the Basin IV, Basin V and Basin VI of Quartzite Gneisses And Biotite gneissic group, resoectively.

Rb_2 is ranging from 4 - 8 where the highest values of 8 is in IV basin of Quartzites. Basin II, Basin VI, and Basin VII are varying in 6 - 6.33 seems to be in rugged topography of Abujhmar plateau.

Rb_3 is also giving the highest value of 6 in Basin I of the Quartzites. Mean value of Rb. is ranging from 4 - 6 having not much variations in the underlying topography over all.

BIFURCATION RATIO IN BHASKEL BASIN:

TABLE 3.4

S.NO.	BIFURCATION RATIO			MEAN Rb
	Rb_1	Rb_2	Rb_3	
I	3.95	4.75	2.00	3.56
II	4.21	2.80	5.00	4.00
III.	4.16	6.40	5.00	5.19
IV	3.56	4.62	8.00	5.43
V	3.94	3.18	11.00	6.05
VI	4.41	3.50	5.00	4.30
VII	3.56	4.50	2.00	3.35
VIII	6.16	2.00	3.00	3.72

The value ranges from 3 - 6 in Rb_1. Basin VIII (6.16)is having highest value under sedimentary sequence of Indravati river.In Rb_2 the highest value of 6.40 is exhibiting in Basin III of sedimentary areas. It infers that sedimentary group of Bhaskel river is having highest value in Rb_1 and Rb_2. The topography is somewhat homogenous and undulating. Rb_3 values are extreme in the case of Bengpal Gneissic group. It is a hard rock type and highly dissected, having hetero - geneity in the basin. Mean Rb value is ranging 3 - 6 where 6.05 is in the Basin Vcalled Singari Nadi.

3.4(iv) STREAM LENGTH:

Length of a stream channel segment is a dimensional property. The length of first order segments increases because the number of segments of finger tips is always higher than the number of segments of increasing orders. It is the second law of Horton(1945;p.291) as " The average length of streams of each order in a drainage basin tend closely to approximate a direct geometric series in which the first term is average length of streams of first orders."

STREAM LENGTH IN GUDRA BASIN:

TABLE 3.5

S.NO.	STREAMS LENGTH OF ORDERS Lu_1	Lu_2	INDIVIDUAL IN KMS. Lu_3	Lu_4	TOTAL STREAM LENGTH
I	59.00	24.00	12.00	5.00	100.00
II	31.00	12.25	8.00	2.25	54.00

(contd.)

(contd.)

III	47.00	38.00	8.75	4.50	72.25
IV	30.00	10.25	3.35	5.00	48.55
VI	37.50	11.25	9.50	7.50	61.50
VII	48.20	16.00	10.00	6.50	80.50
VIII	44.25	20.00	4.25	8.00	76.50
IX	30.00	8.50	9.50	1.15	49.15

The total length of all order is highest in basin Iof Gneisses area (100 kms.), others are 72.75kms. in basin III, 80.50 kms. in basin VIIunder Biotite granite group. The lowest value is in Basin IV under gneisses group i.e., 48.55 kms.

The higher value of 59.00 kms. in Basin V of gneisses region shows that there are more finger tips in this area. It is true , having 190 initial tributaries, is the highest. This area is a high land which develop finger tips.

Average length of streams is higher in Quartzites, 19.35 kms. and,comparatively,lower in gneisses area, 16.48 kms.

STREAM LENGTH IN BHASKEL BASIN :

TABLE 3.6

1 S.NO.	2 LENGTH OF INDIVIDUAL STREAM ORDERS IN KMS.				3 TOTAL STREAM ORDERS
	LU_1	LU2	LU_3	LU_4	
I	21.62	10.50	1.50	4.88	38.50

(contd.)

(contd.)

1	2				3
II	34.85	21.65	15.25	11.25	83.00
III	58.75	34.65	17.25	13.35	117.25
IV	69.50	36.75	17.30	21.50	145.00
V	59.75	33.50	27.52	10.75	112.30
VI	41.00	20.50	22.62	10.35	94.00
VII	22.50	9.75	4.50	6.75	43.00
VIII	18.75	9.50	8.00	2.38	37.00

The total length of all order is highest in Basin IV of Bengpal granite gneisses area, 145 kms. others are basin V, 123 kms.;Basin III, of sedimentary,1175 kms. The lowest length is of the basin VIII in sedimentary sequence of Indravati basin,i.e.,37.00 kms.

Average length of stream is almost same in sedimentaries as well as, Bengpal region.

3.4 AREAL ASPECTS OF DRAINAGE BASIN :

The shape and area of the drainage basin is considered as an areal characteristics of a basin. In this study, area of the basin, elongation ratio, circularity ratio, drainage density, drainage texture, constant of channel maintainence and stream frequency has been taken into consideration. The systematic interpretation is as follows :

3.4 (i) BASIN AREA :

Drainage basin area is an independent variable. It is most sensitive and controls texture, shape and direction of the basin. Drainage basin area is defined as the total area projected upon a horizontal plane, contributing flow to channel segment of a given order and including all tributaries of lower order. Horton inferred that " mean drainage basin areas of progressively higher orders should increase in a geometric sequence as do stream length " Schumm (p. 606)[1] expressed this relationship in a law of stream areas as " the mean basin area of stream of each order tend closely to approximate a direct geometric sequence in which the first term is the mean area of the first order basin."

AREA OF GUDRA RIVER BASIN :

TABLE 3.7

S.NO.	TOTAL AREA IN KM^2
BASIN I	53.84
BASIN II	19.63
BASIN III	43.29
BASIN IV	29.59
BASIN VI	33.78
BASIN VII	44.81
BASIN VIII	47.20
BASIN IX	22.40

The large area is covered by basin I of Quartzites, leading basin VIII and basin VII

Quartzites and Biotite granite group. In all Quartzites are covering average area of 36.71 sq. kms. and Biotite granite is covering 39.29 sq. kms. The lowest area is covered by Gneissic group i.e. 22.87 sq. kms.

AREA OF BHASKEL RIVER BASIN :

TABLE 3.8

S.NO.	TOTAL AREA IN SQ. KMS.
BASIN I	20.75
BASIN II	62.25
BASIN III	65.81
BASIN IV	73.65
BASIN V	81.18
BASIN VI	95.25
BASIN VII	33.75
BASIN VIII	27.00

The higher value of sedimentary region is 95.25 sq. kms. leading Bengpal group as 81.18 sq. kms. of the basin V and 73.65 sq. kms. of basin IV. The lowest area is covered by Bengpal gneissic complex i.e. Basin I. The average area is higher in recent alluvial sedimentary region of Bhaskel than in Bengpal geisses of metamorphic type(52.33sq. kms.).

3.4 (ii) BASIN SHAPE :

The shape is also considered as an out line form of a drainage basin and is projected upon the horizontal datum plane of a map. It is a dimension less property and controlled by stream discharge characteristics and under lying lithology. Horton described " the out line of normal drainage basin as pear - shaped ovoid " as a proof thatdrainage basins are foremed largely by sheet erosion process acting uponan initially inclined plane, or / and surface. These dimensionless properties can be termed as shape parameters. In the present study two shape parameters - elongation and circularity ratio- have been taken to assess the shape of Gudra and Bhaskel. El ngation ratio is defined as " The ratio of a diameter of a circle of the same area as the basin to the maximum basin length " and designated as Re'.Circularity ratio designated as Rc, can be defined as " the ratio of the basin area divided by area of a circle with two same basin perimeters."

Value of unity shows thatbasin is perfectly circular/ elongated and any change indicates distortion of basin shape.

BASIN SHAPE OF GUDRA RIVER :

TABLE 3.9

S.NO.	ELONGATION RATIO	CIRCULARITY RATIO
BASIN I	0.92	0 .70

(contd.)

(contd.)

BASIN II	0.75	0.59
BASIN III	0.90	0.94
BASIN IV	0.78	1.00
BASIN VI	0.97	0.65
BASIN VII	1.08	0.90
BASIN VIII	0.69	0.95
BASIN IX	0.73	0.97

Basin elongation and circularity ratio ranges from 0 - 1. Here Basin Vii of Biotite granite group shows a basin to be perfect elongated.The higher values of elongation ratio is shown in Gneisses, Basin I (0.92) Quartzites, basin II (0.90), Basin VI,Biotite granite (0.97).

Higher values of circularitycan be seen in the Basin IV of gneisses, where it is giving perfect circular shape, but, elongation ratio is also higher which distorts the cicularity of the basin. Basin III, of Quartzites, Basin VII of Biotitegranite, basin VIII of Quartzites and basin IX of gneisses are also giving high value in Rc as well as, in Re. The Rc of these above basins are 0.94, 0.90, 0.95, and 0.97, respectively.

The mean value in Quartzites is showing 0.78 (Re), and 0.83(Rc); in gneisses 0.81(Re), 0.89(Rc) and in biotite gneisses as 1.02(Re), and 0.78(Rc).It can't be derived perfectly whether the basins are of circular shape or elongated. May be it is distorted by the nature of undulating topography in this region.

BASIN SHAPE IN BHASKEL RIVER :

TABLE 3.10

S.NO.	ELONGATION RATIO	CIRCULARITY RATIO
BASIN I	0.53	0.62
BASIN II	0.85	0.93
BASIN III	0.65	0.39
BASIN IV	0.66	0.68
BASIN V	0.50	0.36
BASIN VI	0.52	0.66
BASINVII	0.62	0.56
BASIN VIII	0.78	0.77

The higher value of elongation ratio is shown in basin II of limestone region (0.85), and basin VIII of sedimentary region of Indravati(0.78). The lower values of 0.50, basin V of bengpal gneisses region; and 0.53, Basin I, of same geology can be seen, showing somewhat elongated shape. No sample basin is having high value of elongation.

The higher value of circularity ratio can be seen in the limestone region (0.93) of basinII and the lower value can be seen in Bengpal group- Basin V (0.36)

The average value of elongation and circularity in Bengpal gneisses complex is 0.58 and 0.56; sedimentary and limestone region is 0.70 and 0.69, respectively.

3.4 (iii) DRAINAGE DENSITY :

Introduced by Horton as "The ratio of total channel segments lengths cumulated for all orders with in a basin to the basin area (projected to the horizontal).It is the length per square unit area. It is highly influenced by the structure of rocks, distribution of rainfall and density of vegetation cover.

3.4 (iv) CONSTANT OF CHANNEL MAINTAINENCE:

Schumm used the inverse of Drainage density as a property termed as constant of channel maintainence This constant, in units of square/kilometers, has the dimension of length.

GUDRA RIVER BASIN :

TABLE 3.11

S.NO.	DRAINAGE DENSITY PER SQ. KM.		CONSTANT OF CHANNEL MAINTAINENCE
BASIN I	1.86	Moderate	0.54
BASIN II	2.75	High	0.36
BASIN III	1.68	Moderate	0.59
BASIN IV	1.82	Moderate	0.55
BASIN VI	1.82	Moderate	0.55
BASIN VII	1.80	Moderate	0.56
BASIN VIII	1.62	Moderate	0.62
BASIN IX	2.17	High	0.46

Drainage density is ranging from 1.62 - 2.75 km./km.^{2} This means that the lower value shows in Basins VIII of quartzites which having 1.62 km ./kms^2 of channel maintainence and higher value is in Basin II having same geology 2.75 kms. of channek for every sq. kms.The average drainage density in quartzites are 2.02 km./kms^2, gneisses is having 1.96 km. /kms^2 and Biotite granite as 1.81 km. /kms^2

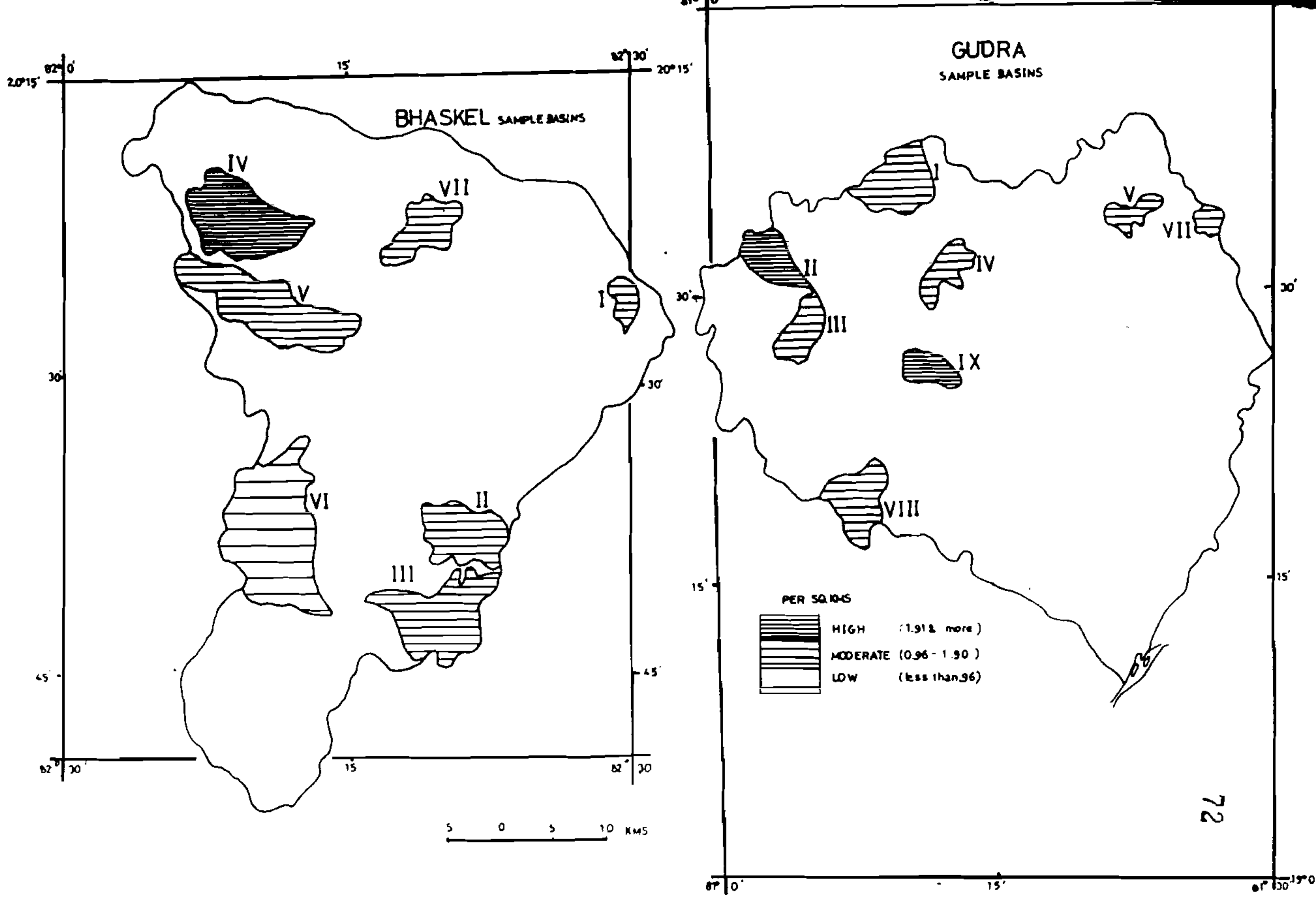
Constant of channel maintainence shows higher values in Basin VIII of quartzites is 0.62. This means that 0.62 sq. kms. of surface is needed to support one km. of channel. The lower value is of Basin II in quartzites is 0.36 km./kms^2,

The average value in quartzites is 0.52 km^2/km, in gneisses 0.52 km^2/km. and Biotite granite gneisses area is 0.55km^2/km.

BHASKEL RIVER BASIN :

TABLE 3.12

S.NO.	DRAINAGE DENSITY KM. PER SQ. KM.		CONSTANT OF CHANNEL MAINTAINENCE SQ.KM./KM.
BASIN I	1.86	Moderate	0.54
BASIN II	1.14	Moderate	0.88
BASIN III	1.89	Moderate	0.53
BASIN IV	1.97	High	o.51
BASIN V	1.52	Moderate	0.66
BASIN VI	0.92	Low	1.01
BASIN VII	1.27	Moderate	0.79
Basin VIII	1.39	Moderate	0.72


BHASKEL SAMPLE BASINS
GUDRA
SAMPLE BASINS
I
II
III
IV
V
VI
VII
VIII
IX
PER SQ.KMS
HIGH (1.91 & more)
MODERATE (0.96 - 1.90)
LOW (less than .96)
5 0 5 10 KMS
82° 0'
15'
82° 30'
20°15'
30'
45'
81° 0'
81° 30'
15'
19° 0'

In Bhaskel river basin (sample) drainage density varies from 0.92 - 1.97 km./ km^2 from Basin VI of sedimentaryarea to Basin IV of Bengpal group. This means that in sedimentary part 0.92 km. of channel is needed for a unit area of 1 sq. km. to 1.97 km./ km^2 in metamophic.

The average drainage density in sedimentary is 1.35 km/sq. km. and in Bengpal gneisses group is 1.66 km/sq.km. Higher value of constant of channel maintainence can be seen in sedimentary region of basin VI having 1.01 sq. km./ km. TH The lower value is of Basin IV in Bengpal group i.e., 0.51 sq. km. / km.

Average value in sedimentary sequence is 0.79 sq. km./km. and in Bengpal gneissic complex is 0.62 sq.km./km. The drainage density is the basin ranges from 0.92 - 2.75 The total range of drainage density has been divided into 3 categories wbth an interval of 0.95 sq.km./km.

3.4(v) DRAINAGE DENSITY :

Texture ratio of a drainage basin gives an idea about the individual element of the underlying topography in a basin. As drainage density increases, texture ratio also increasesfrom coarse to ultrafine.

TEXTURE RATIO IN GUDRA BASIN :

TABLE 3.13

SNO.	TEXTURE RATIO	
BASIN I	7.29	Fine

TEXTURE RATIO IN SAMPLE BASINS

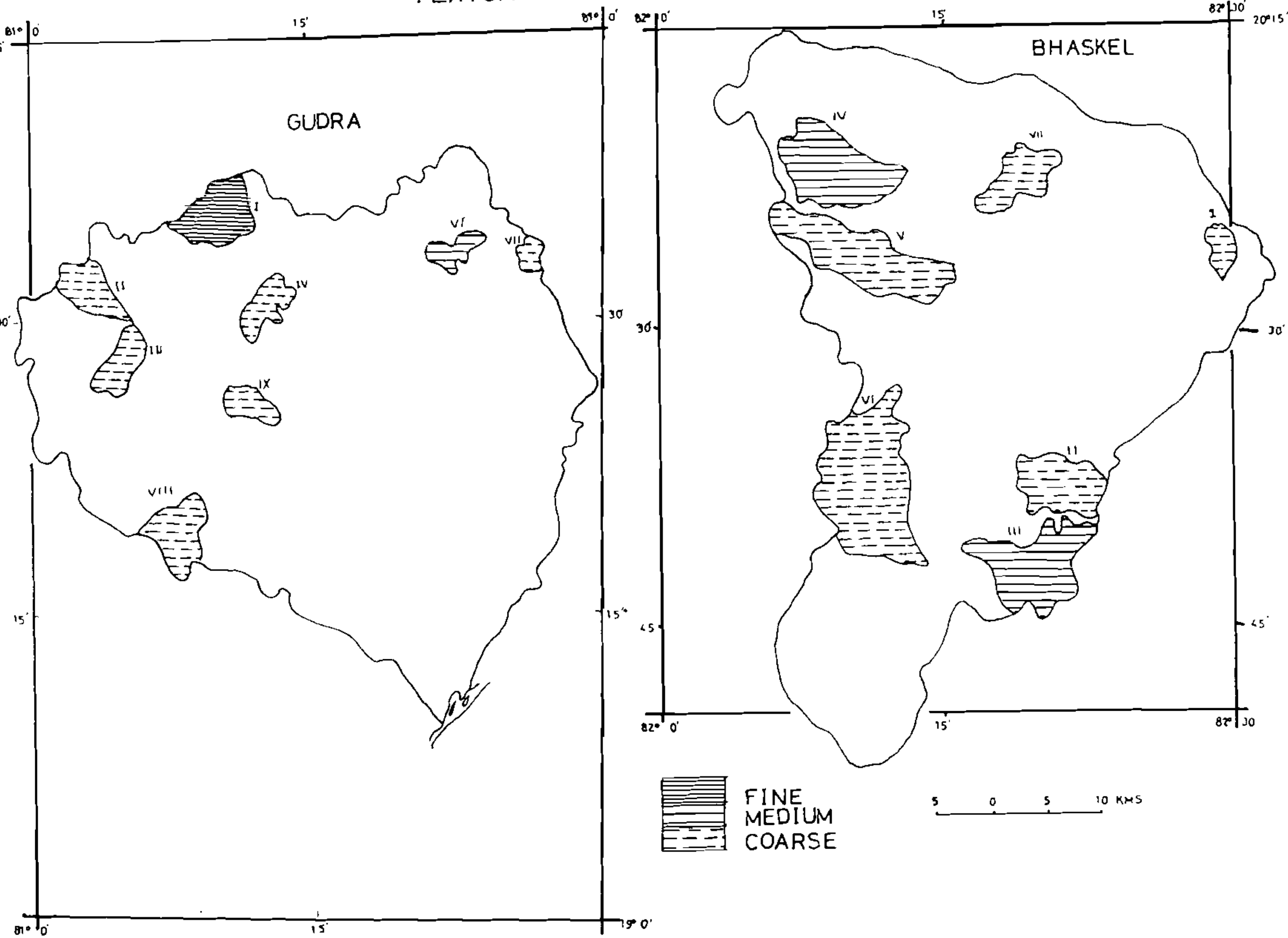


FIG. 3.4

(contd.)

BASIN II	3.76	Medium
BASIN III	4.33	Medium
BASIN IV	4.82	Medium
BASIN V I	3.41	Coarse
BASIN VII	4.40	Medium
BASIN VIII	5.20	Medium
BASIN IX	4.35	Medium

Texture ratio in gneisses of basin first is higher than other basins. Here, texture is comparatively finer in contrast to the Biotite granite gneisses area, it is having lower value of ratio i.e. 3.41 which gives coarser texture to the basin. These all regions comes under metamorphic rocks. The average texture is 5.49 in quartzites, 4.43 in gneisses and 4.80 Biotite group.

TEXTURE RATIO IN BHASKEL :

TABLE 3. 14

S.NO.	TEXTURE RATIO	
BASIN I	1.90	Coarse
BASIN II	2.72	Coarse
BASIN III	3.76	Medium
BASIN I V	4.95	Medium
BASIN V	3.48	Coarse
BASIN VI	2.30	Coarse
BASIN VII	0.93	Coarse
BASIN VII	2.24	Coarse

From the above table we can find that comparatively higher ratio is in basin IV of Bengpal granite i.e. 4.95 can be termed texture. The lowest value of Bengpal granite is 0.93 basin VII having same texture. In the same geology we can see the variations.

Average texture ratio is 2.76 in sedimentary and 2.82 in Bengpal gneissic complex. On an average this area is having coarser texture.

3.4 (vi) STREAM FREQUENCY :

Horton 1945, (p. 285) introduced stream frequency or channel frequency as the number of streams segments per unit area.

STREAM FREQUENCY : GUDRA BASIN :

TABLE 3. 5

S. NO.	STREAM FREQUENCY No./Km^2
BASIN I	4.21
BASIN II	3.92
BASIN III	2.40
BASIN IV	3.31
BASIN V	2.57
BASIN VI	2.45
BASIN VII	2.75
BASIN VIII	3.30

The highest stream frequency is shown in Basin I, and basin II, i.e., 4.20/sq.km. and 3.92/sq.km. both of gneisses and quartzites areas, respectively. In other words we can say that 4.20 streams are draining these two basins per square kilometer. The lowest is in basin III of quartzites having 2.40 / sq, km.Mean stream frequency are 3.02 / sq. km. in quartzites, 3.06 / sq. km. in gneisses and 2.5 / sq. km. in biotite granite gneisses regions.

STREAM FREQUENCY IN BHASKEL BASIN :

TABLE 3.16

S.NO.	STREAM FREQUENCY NO./SQ.KM.
BASIN I	1.88
BASIN II	1.27
BASIN III	2.59
BASIN IV	2.47
BASIN V	2.29
BASIN VI	1.03
BASIN VII	1.02
BASIN VIII	1.25

The highest value is showing in basin III of recent alluvial and Basin IV, V in Bengpal gneissic complex having 2.59/sq. km., 2.47/sq. km. and 2.29/km.^{2} frequency, respectively. The lowest is exhibiting in

Bengpal Gneissic complex having the value of 1.0 /km^2 (BASIN VIII).Average stream frequency in bengpal group is 1.99/sq. km. and in Indravati sedimentary sequence is 1.54/sq.km.

3.5 RELIEF ASPECTS :

Relief is a continuous function of processes working under different climatic conditions over different lithologies. Several agents are continuously shaping the relief characteristics of a region such as geology, stratigraphy, climatic weatheribg, mass wasting, runoff, etc. From the study we will see the climate is same is same in Gudra and Bhaskel but different relief features are developed, this gives the reflection of the underlying rock. Different rock types plays an important role in the development of land forms.

Different aspects of relief for Gudra and Bhaskel is studied under sub-heads as follows :

3.5 (i) ABSOLUTE RELIEF :

Absolute relief is the maximum height taken, base , as a mean sea level. Absolute relief is more stable in nature as it changes with time. It determines the climate and natural vegetation. The absolute relief may be defined as "the vertical elevation of a point or surface above the datum plane." Here, spot

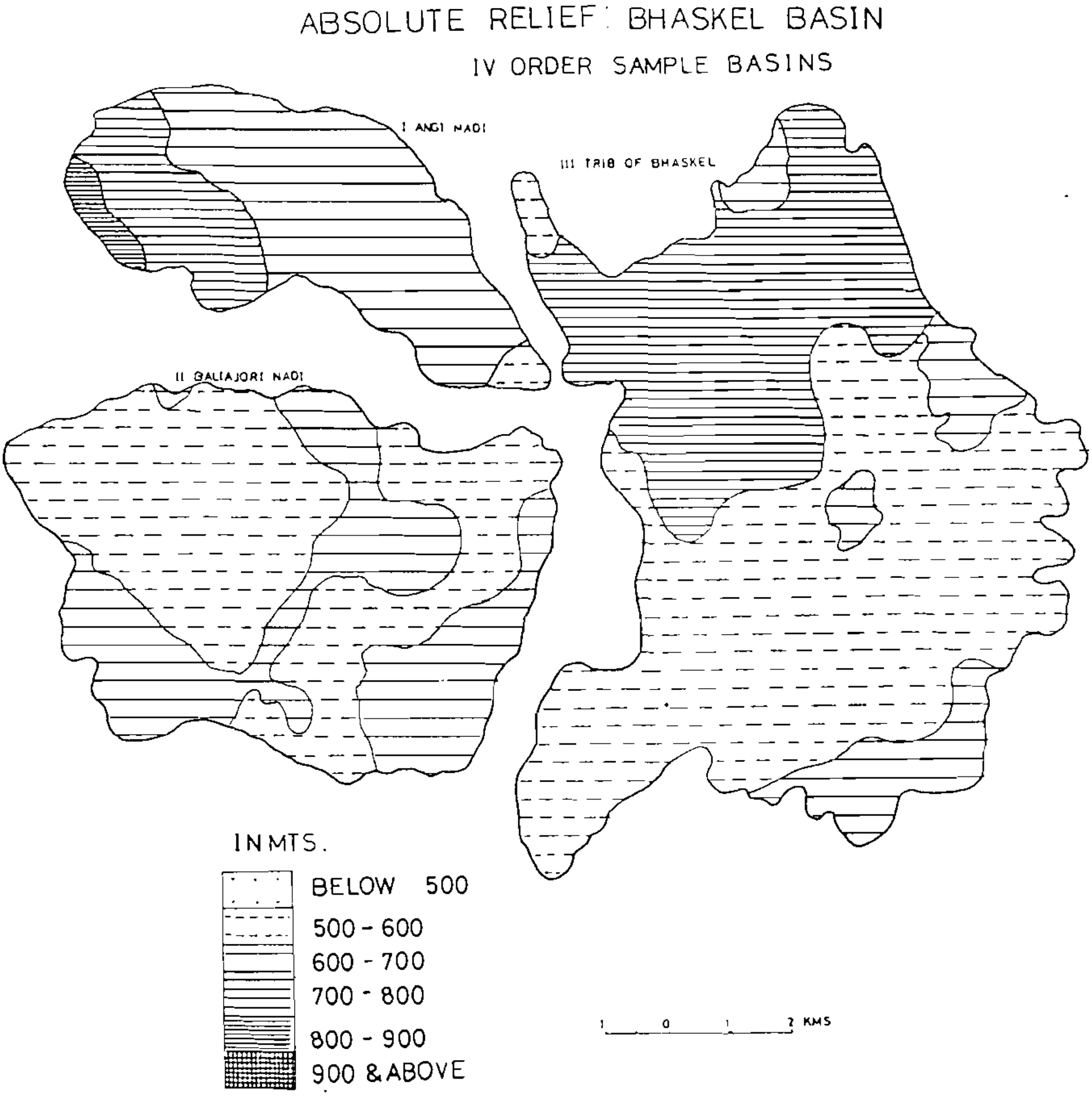

ABSOLUTE RELIEF: BHASKEL BASIN
IV ORDER SAMPLE BASINS
I ANGI NADI
II GALIAJORI NADI
III TRIB OF BHASKEL
IN MTS.
BELOW 500
500 - 600
600 - 700
700 - 800
800 - 900
900 & ABOVE
1 0 1 2 KMS

Fig. 3-4

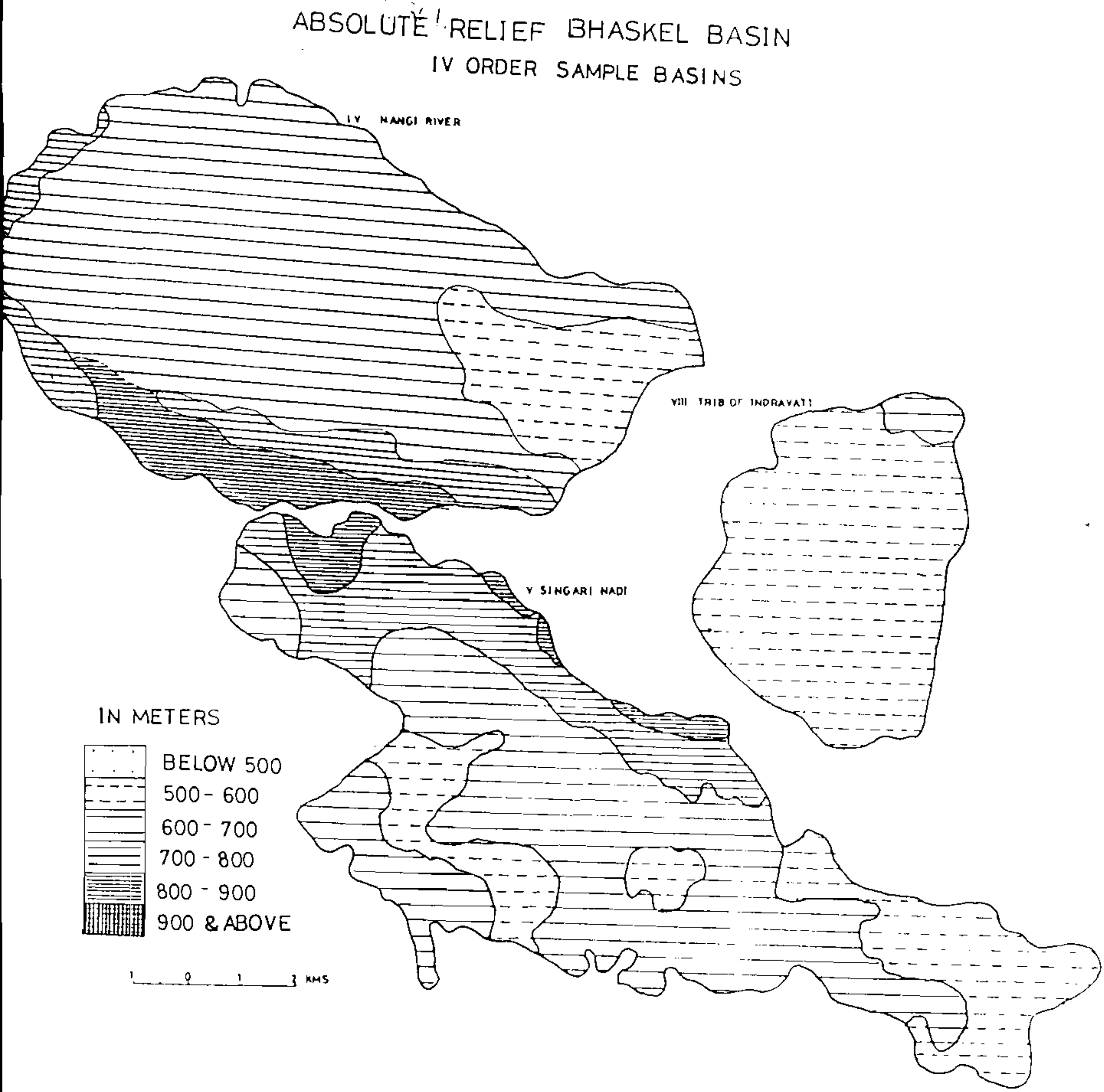

ABSOLUTE RELIEF BHASKEL BASIN
IV ORDER SAMPLE BASINS
IV NANGI RIVER
VIII TRIB OF INDRAVATI
V SINGARI NADI
IN METERS
BELOW 500
500 - 600
600 - 700
700 - 800
800 - 900
900 & ABOVE
1 0 1 3 KMS

FIG. 3.4

ABSOLUTE RELIEF : BHASKEL

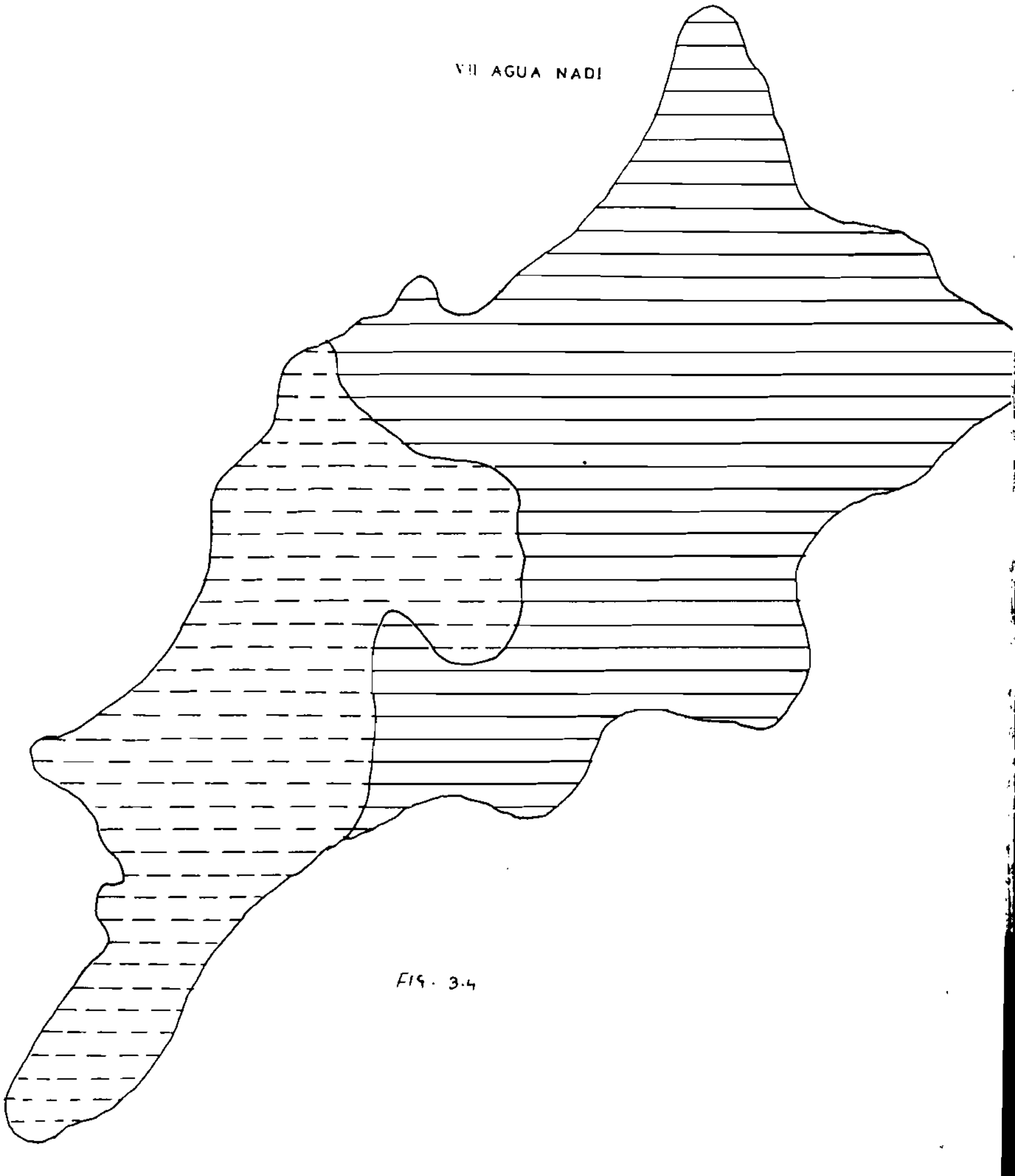


FIG. 3.4

ABSOLUTE RELIEF: GUDRA

IV ORDER SAMPLE BASINS

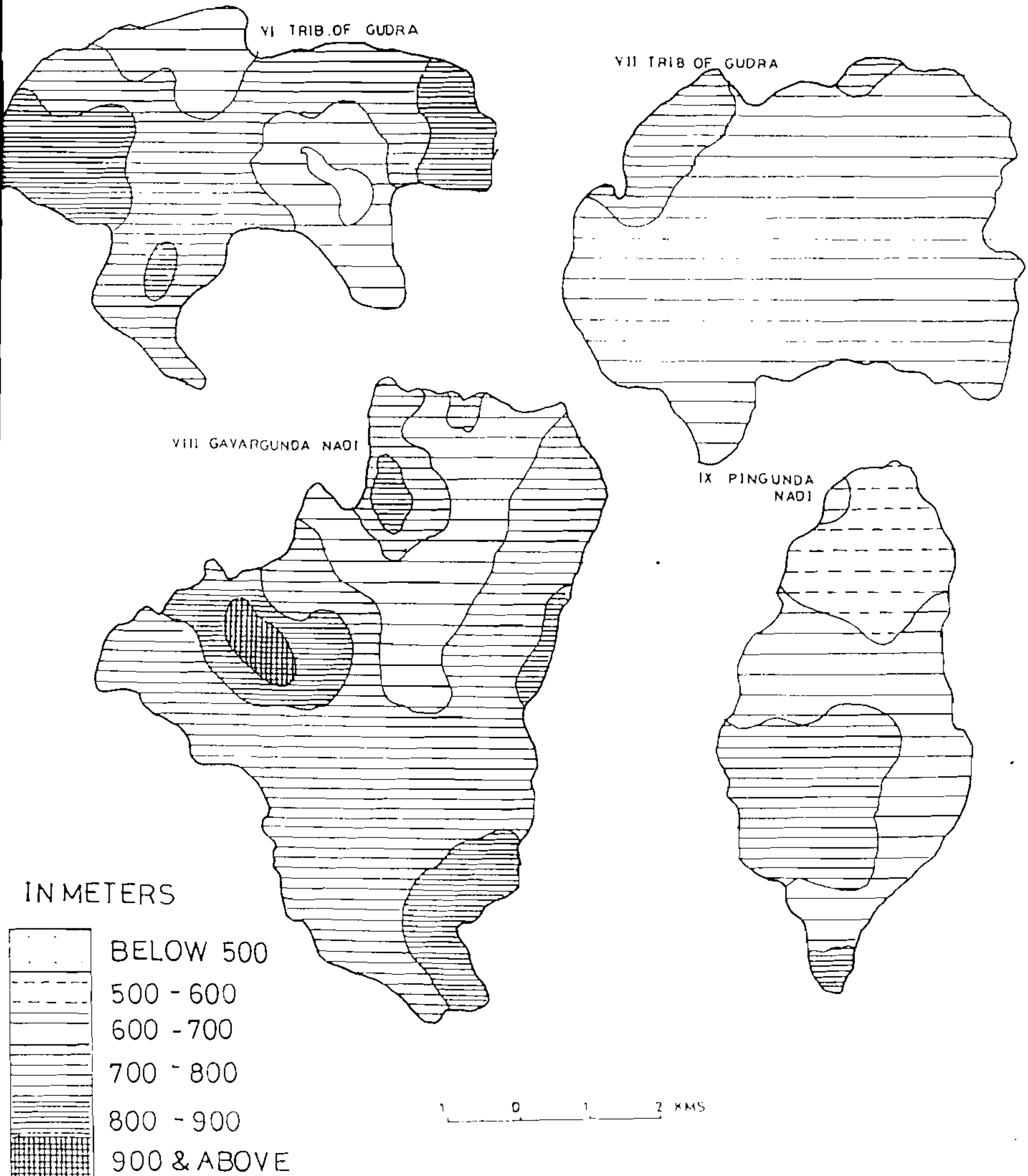


FIG. 3.5

height has been taken into consideration as an absolute relief, but, where spot height is not available it has been measured by contours.

3.5 (ii) RELATIVE RELIEF :

Relative relief is a basic morphometric property. It is defined as the difference of elevation between the highest and the lowest points of any region. It gives an idea of gradient of a terrain. In the present study relative relief is measured on an average by calculating maximum and minimum absolute values.

RELIEF : GUDRA BASIN :

TABLE 3. 17

S.NO.	ABSOLUTE RELIEF IN MTS.	RELATIVE RELIEF IN MTS.
BASIN I	840	180
BASIN II	853	193
BASIN III	897	257
BASIN IV	787	207
BASIN VI	837	257
BASIN VII	715	175
BASIN VIII	882	282
BASIN IX	848	328

Absolute relief is highest in Basin III , which is under quartzites. This quartzites area is situated in the North-Western part of the basin and is higher than other regionin the Gudra Basin.* The lowest value is found in basin VII of Biotite granite gneisses which lies in the North - Western part of the Gudra basin.

Absolute relief varies from 553 mts. in biotite group to 1007 mts. in quartzites. Relative relief is higher in basin VIII of quartzites and basin IX of gneisses i.e., 282 mts. and 328 mts. respectively. The lowest value is found in the basin ofbiotite group,VII 175 mts. Average height is 832.38 mts. and mean relative height is 234.88 mts

RELIEF : BHASKEL BASIN

TABLE 3.18

S.NO.	ABSOLUTE RELIEF IN MTS.	RELATIVE RELIEF IN MTS.
BASIN I	825	225
BASIN II	654	94
BASIN III	654	93
BASIN IV	927	327
BASIN V	920	320
BASIN VI	684	122
BASIN VII	660	80
BASIN VIII	614	74

*In the selected basins of Gudra.

The absolute relief is higher in Basin IV of Bengpal gneissic complex i.e.,927 mts. leading under same geology in basin V i.e., 920 mts.The lower relief is found in basin VIII, a tributary of Indravati and totally comes under sedimentary sequemces accumulated by the river.

Relative relief also ranges from 74 mts. to 327 mts., in basins VIII and IV respectively, of Bengpal group. Average absolute relief for the basin is 745.25 meters and mean relative relief is 166.88 meters.

3.5 (iii) RUGGEDNESS NUMBER :

Ruggedness number is a function of drainage density and relative relief of the area. It is a unit less measurement which gives the degree of roughness of underlying rocks. It is the ratio of the product of drainage density and relative rekief and divided by the constant.

RUGGEDNESS NUMBER OF GUDRA BASIN :

TABLE 3. 19

S.NO.	RUGGEDNESS NUMBER	
BASIN I	0.33	Low
BASIN II	0.53	Medium
BASIN III	0.43	Low
BASIN I V	0.37	Low

(CONTD.)

(CONTD.)

BASIN VI	0.47	Medium
BASIN VII	0.32	Low
BASIN VIII	0.47	Medium
BASIN IX	0.72	High

Ruggedness number is ranging from 0.32 - 0.72 Basin I, III, IV and VII are having lower values and hence ruggedness number is comparatively low. It is ranging from 0.52 - 0. 43. Basin II of quartzites, VI of Biotite granite gneisses and VIII of quartzites are having medium ruggedness number ranging from 0.46 - 0.53 Basin IX of gneisses is having comparatively higher value of 0.72. Average ruggedness number in quartzites is high 0.47 and also in gneisses 0.47, and lower in Biotite granite gneisses, 0.39.

RUGGEDNESS NUMBER IN BHASKEL :

TABLE 3. 20

S.NO.	RUGGEDNESS NUMBER	
BASIN I	0.42	Low
BASIN II	0.11	Low
BASIN III	0.18	Low
BASIN IV	0.64	High
BASIN V	0.49	Medium

(CONTD.)

(CONTD.)

BASIN VI	0.12	Low
BASIN VII	0.10	Low
BASIN VIII	0. 10	Low

Ruggedness number is varying from 0.10 - 0.64 Basin I, II ,III, VI, VII, and VIII are showing lower values having low ruggedness number. Basin V is having medium ruggedity and Basin IV is having high ruggedity. On an average sedimentary and limestone areas are showing low ruggedity 0.13 than in Bengpal gneissic complex, 0.41.

3.5 (iv) DISSECTION INDEX :

It is another morphometric parameter to illustrate the relief properties of the region. It is the measurement of dissected topogeaphy in mathematical terms.

DISSECTION INDEX IN GUDRA :

TABLE 3.21

S.NO.	DISSECTION INDEX	
BASIN I	0.21	LOW
BASIN II	0.23	MEDIUM
BASIN III	0.38	HIGH
BASIN IV	0.26	MEDIUM

(CONTD.)

(CONTD.)

BASIN VI	0.31	HIGH
BASIN VII	0.21	MEDIUM
BASIN VIII	0.32	HIGH
BASIN IX	0.39	HIGH

Basin IIIof quartzites , Basin VI of biotite granite gneisses, Basin VIII of quartzites are comparatively highly dissected than other basins.Basin I of gneisses is having low dissected underlying topography. In an average q uartzites and biotite granite gneisses group are highly dissected, values ranges from 0.276 - 0.28.

DISSECTION INDEX IN BHASKEL :

TABLE 3.22

S.NO.	DISSECTION INDEX	
BASIN I	0.29	MEDIUM
BASIN II	0.14	LOW
BASIN III	0.14	LOW
BASIN IV	0.35	HIGH
BASIN V	0.34	HIGH
BASIN VI	0.18	LOW
BASIN VII	0.121	LOW
BASIN VIII	0.120	LOW

DIssection Index value is varying from 0.12 - 0.35 basin VIII is having lowest value and Basin IV of Bengpal group is having the highest values. Both basins, IV and V are highly dissected than Basin I which is medium, others are low dissected. Mean value of dissection index is high in Bengpal gneissic complex 0.27 and low in sedimentary and limestone areas.

CHAPTER IV

A COMPARATIVELY ANALYSIS OF THE MORPHOMETRIC VARIABLES IN GUDRA AND BHASKEL RIVER BASINS.

CHAPTER IV

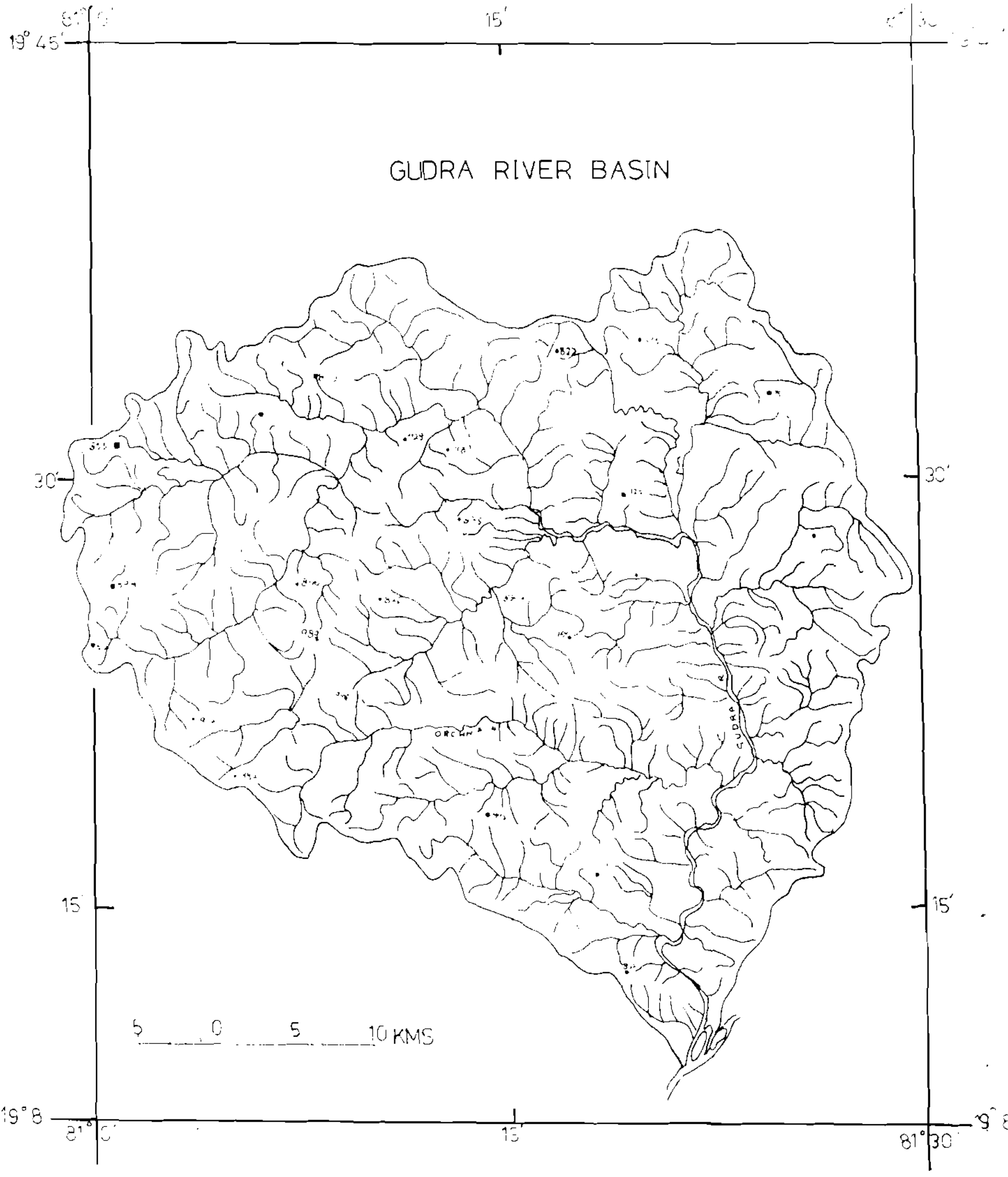
A COMPARATIVE ANALYSIS OF THE MORPHOMETRIC VARIABLES IN GUDRA AND BHASKEL RIVER BASINS.

For the study of the behaviour of morphometric parameters in hard rock and soft rocks; Gudra and Bhaskel have been selected due to different lithological conditions.

In Gudra, basin II,III and VIII are from quartzites and IX are from gneisses area has been selected for the study purpose. These come under metamorphic rocks and in Bhaskel Basin II, VI, III, and VIII are taken for study. First basin comes under limestone region and rest comes under recent alluvial deposits of Indravati and Bhaskel- soft rocks. The comparison is done for both the basin :

4.1. DRAINAGE PATTERN :

The pattern which stream forms are determined by inequalities of surface slope and inequalities of rock resistence. Firstly, pattern produced by the stream is dependent on the slope of the initial surface. At a glance, we can vaquely determine the under lying lithology of the basin, by the help of its pattern.


GUDRA RIVER BASIN
19° 45'
15'
30'
15'
19° 8
81° 0'
81° 30'
5 0 5 10 KMS
ORCHHA R
GUDRA R

FIG

1.1- DRAINAGE PATTERN IN GUDRA BASIN :

Gudra is showing dendritic as well as sub - parallel pa ttern in its basin. " Dendritic pattern is characterised by irregular branching in all directions with the tributaries joining the main stream at all angles. The streams are insequent in origin ".* Gudra basin shows this type of pattern in its southern part in the tributaries of Orchha river, which joins from West. Here, true dendritic pattern is not developed may be because of zones of weakness and is determined by valley growth by subsequent streams. Some of the tributaries are by chance parallel in its source mainnly, Orchha. Rocks are offering uniform pattern of Abujhmar volcanic sequence. This area is a flat lying beds of plateaus and crystalline rocks. The north eastern part of Gudra i.e. gneisses has under gone intense metamorphism and hence developed dendritic pattern. The appropriate dendritic pattern can be seen as " Pinnate " type. The more or less parallel and rythmical arrangement of the small tributaries is found here due to the uniformity of slopes on the sides of Gudra valleys and it is having almost homogenous type of resistence of rocks i.e. metamorphics.

1.2- DRAINAGE PATTERN IN BHASKEL :

The drainage pattern which can be seen by the map is of sub - parallel type. Radial pattern

* Zernitz E.R.(1932), Drainage patterns and their significance. Journal Of Geology Vol. 40, PP.498-521

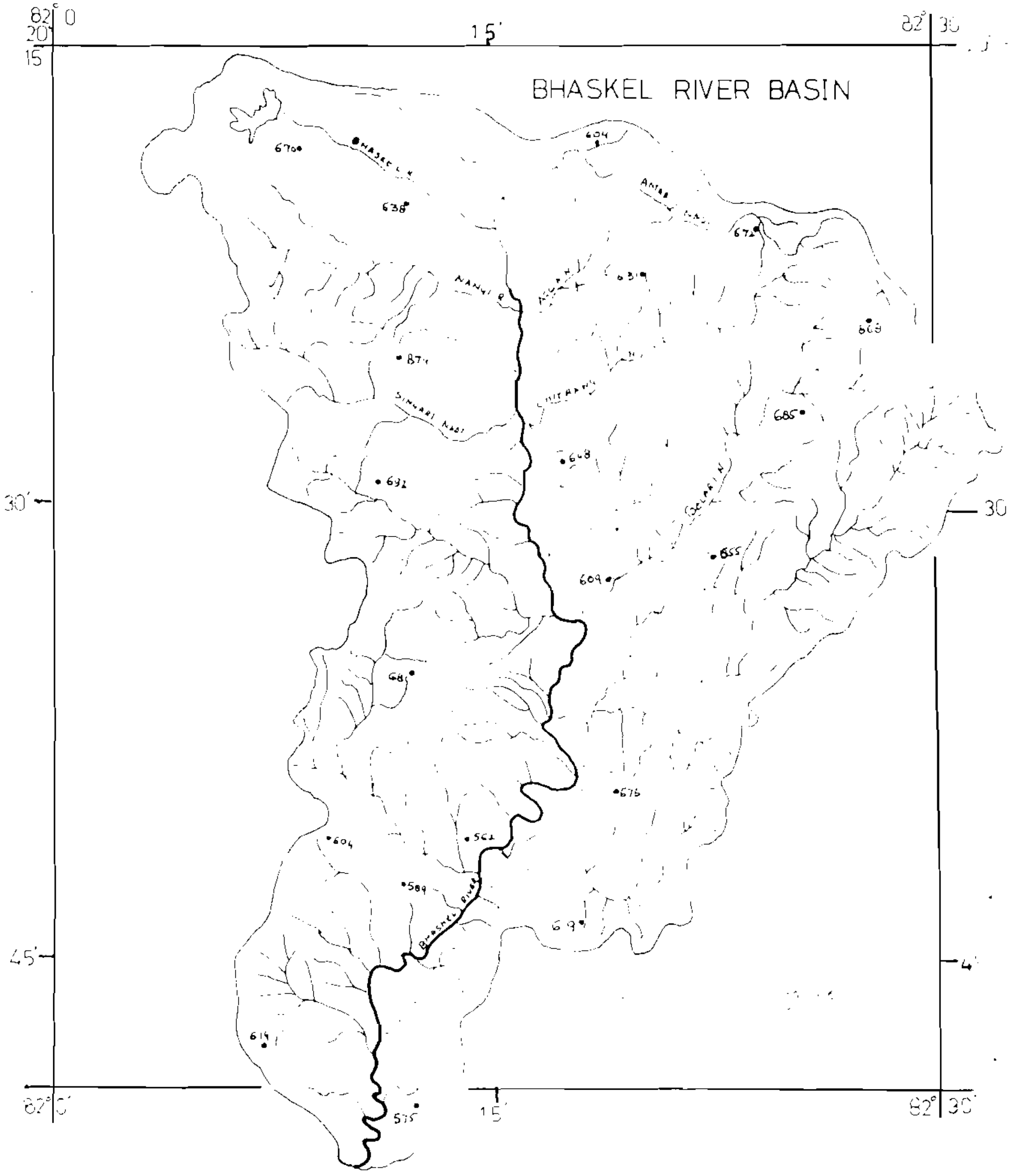

BHASKEL RIVER BASIN
82° 0
20'
15
15'
82° 30
30'
45'
82° 0'
82° 30'
670
638
604
672
631
669
674
685
692
648
655
609
681
675
604
561
589
614
575
BHASKEL RIVER

FIG 42

is also visible in north-western part and southern parts of Bhaskel:Nangi river, Singari river are having radial pattern and their height is comparatively, more than other part of the basin. It lies in the crystalline quartzites and Bengpal Gneissic complex. Irregularities in the initial slopes of domes has given birth to this type of pattern. Head ward erosion and formation of gullies are well developed here. The sub - parallel pattern is also seen due to slope control.

4.2. LINEAR CHARACTERISTICS OF A BASIN UNDER DIFFERENT LITHOLOGY

Stream order and stream number are related to each other in a geometric progression. Inverse relation ship is found in both the variables,from the table we can see that there is no marked difference in stream number whether it is hard or soft:

TABLE 4.1

ORDER NO.	METAMORPHIC	SEDIMENTARY
	ROCK TYPE	
I	78	76
II	15.5	17.25
III	3	4.5
IV	1	1
MEAN	32.17	32.58

Stream number is independent. In soft rocks streams flow freely and give rise to the number of streams in each order. Hard rocks under humid conditions give birth to several streams which also increases numbers. The average value is coming more or less same which determines that geology is not playing much role in the development of stream numbers. There may be another factors like, slope, climate, and vegetation which is more important than underlying lithology.

The coefficient of variation in soft rocks is 46.10% (appendix II) and non - resistence rocks is 22.30% It means that there is no homogeneity between the stream numbers of each order may be because of undulating topography In quartzites and gneisses, well known for their non- resistancy, are having less variations with in the basin giving rise to the inference that underlying topography is more or less same in the whole basin of Gudra.

" If a geometric series exists in a straight line series of points results where numbers of streams are plotted on a logarithmic scale on the ordinate against order numbers of an arithmatic scale on the abscissa"(Schumm). But it is not for any basin except for over all hard rocks of Gudra and VI basin of Bhaskel. All other graphs are showing a marked up - concavity at the lower end, which infers that geometric progression is not closely observed in higher orders whether under lying topography is hard or soft.

MEAN BIFURCATION RATIO

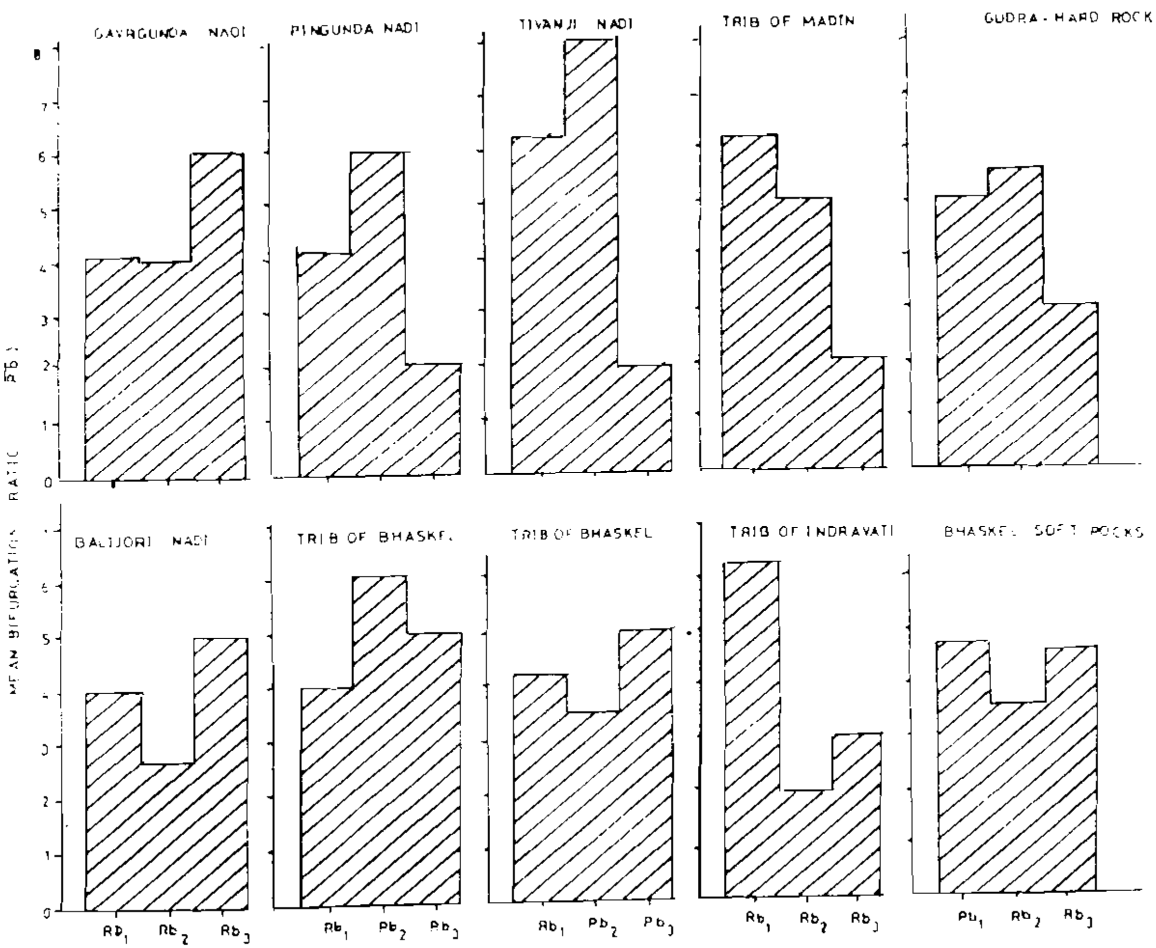


FIG 4.3

4.3 BIFURCATION RATIO :

Bifurcation is varying from 3 - 5 according to underlying topography. The table is showing mean bifurcation ratio for two difeerent rock types :

TABLE 4.2

BIFURCATION RATIO	GUDRA HARD ROCKS	BHASKEL SOFT ROCKS
Rb_1 (I - II)	5.18	4.73
Rb_2 (II - III)	5.75	3.67
Rb_3 (III- IV)	3.00	4.00
MEAN Rb	4.64	4.13

In Gudra, the hard rocks are having undulating and rugged topography,there is heterogenity with in the basin. In southern parts of Bhaskel which is comprised of soft rocks are showing not much variations with in under lying lithology.

Non - resistant rocks exhibit high value of bifurcation ratio in contrast with sedimentary. The values of coefficient of variation (appendix II)are 12.83% in Gudra and 6.40% in Bhaskel. Variations are more in Gudra river than in Bhaskel. As we can see the values of Rb, with in a basin, which is ranging from 5.19 - 5.72 in Gudra and 4.31 - 5.10 in Bhaskel. The Gudra is having ruggedness and

CORELATION
BIFURCATION RATIO & AREA

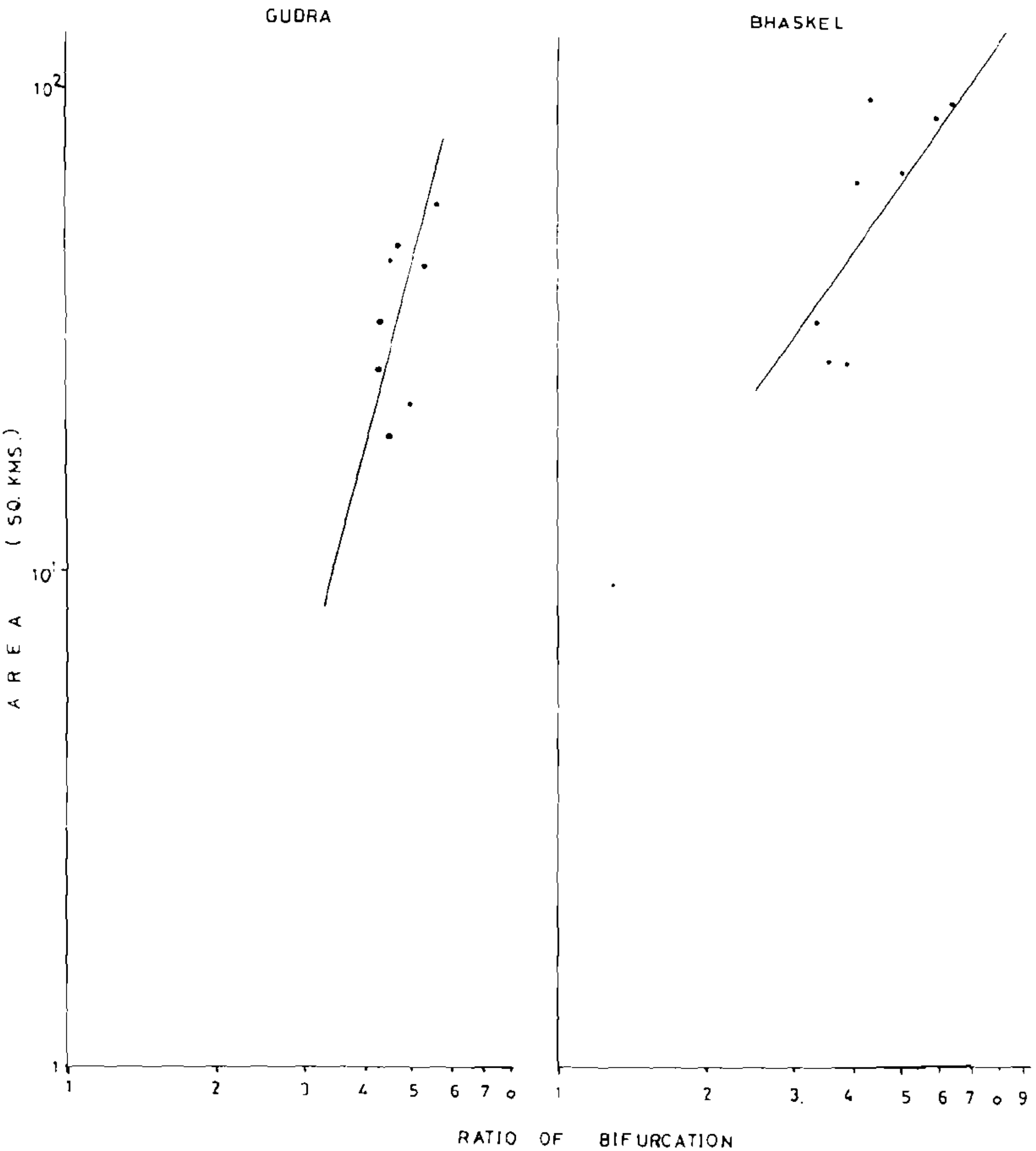


FIG 4.4

in its underlying lithology.

According to Giutsi and Schneider's hypothesis the Rb with in a basin decreases with the increase of stream ordes:[1]

$$Rb_1 > Rb_k$$

where, k, is successive increasing order. But it is not supporting this hypothesis in Gudra and Bhaskel basins. Basin I, II, and Iv of Gudra are havinghard underlying rocks. But the above equation ($Rb_1 > Rb_k$) it is not fitting on sedimentary rocks also. It can be seen easily from the graph.

4.2 RATIO OF BIFURCATION AND AREA :

Bifurcation ratio reflects the branching phenomena of drainage net work. The coefficient of correlation between bifurcation ratio and basin area is standing at +0.725 in Gudra and + 0.708 for Bhaskel, which indicates that higher value of mean bifurcation ratio are associated with the bigger areas of the basin and vice versa. The value of metamorphics and sedimentary rocks are showing + 0.31 and +0.44 respectively, confirming positive correlation between area and bifurcation ratio. But in some cases i.e. basin VIII of Gudra is having 47.20 square kilometers of area and mean Rb is 4.71, where underlying lithology is quartzites in contrast with basin III, where area is comparatively lesser i.e. 43.29 square kilometer

MEAN LENGTH

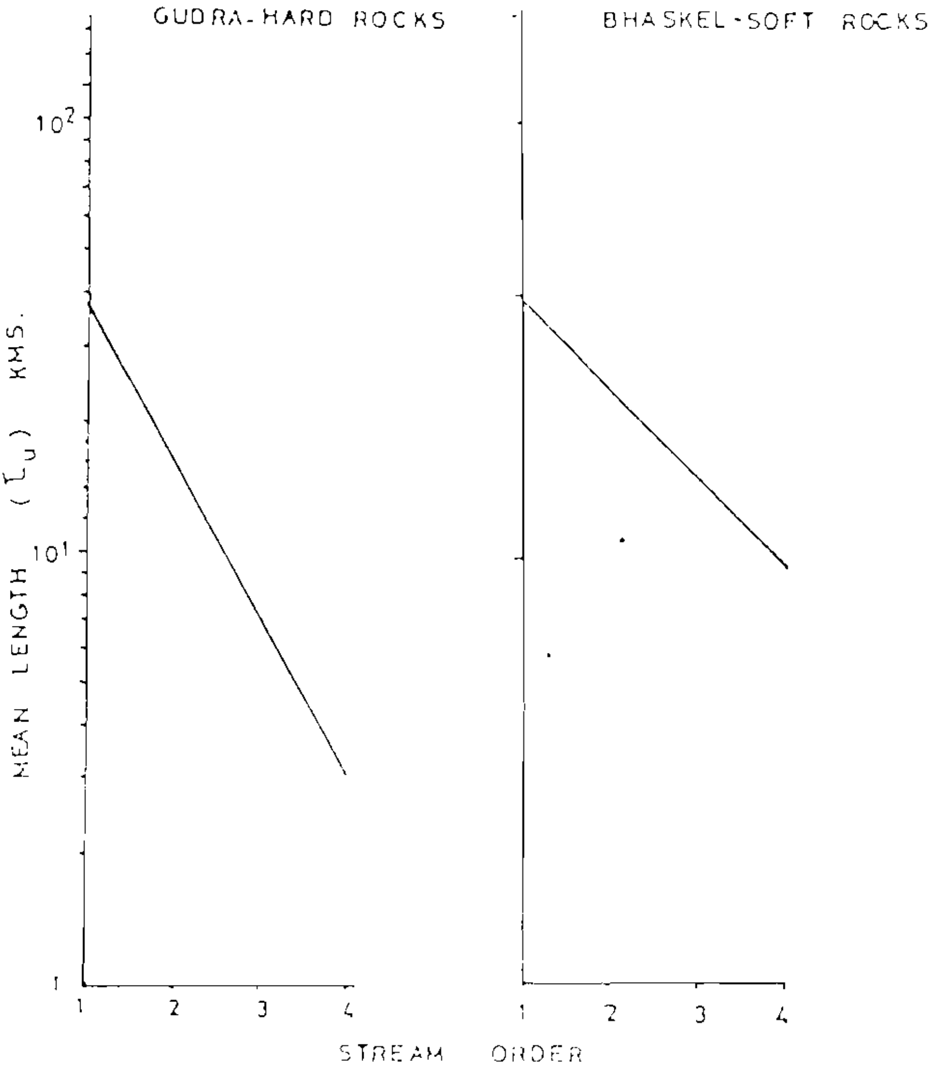


FIG 4.5

and mean bifurcation ratio is 5,10, this may be by chance or due to local variations.

4.4 VARIATIONS OF STREAM LENGTH:

The length of streams of each order were obtained by measuring all the drainage channels with in a basin of a given order, the length of the fourth order of the selected basins of Gudra and Bhaskel is the total length of all the channels in the basin. Here, streams are varying from basin to basin :

TABLE 4.3

S.NO.	STREAM ORDERS	HARD ROCKS IN KILOMETERS	SOFT ROCKS
1.	I	38.06	38.21
2.	II	19.69	21.58
3.	III	7.62	15.78
4.	IV	3.97	9.31
5.	MEAN L_u	17.335	21.220

Average length is greater in resist -ant rocks than in non - resistant. Mean length is higher as order increases in soft rocks of Bhaskel basin which infers that stream length reduces as the massiveness and compactness of rock, increases from the figure it is clearly evidenced that the increase in mean length do not form the geometric series as the points are deviating from the line.

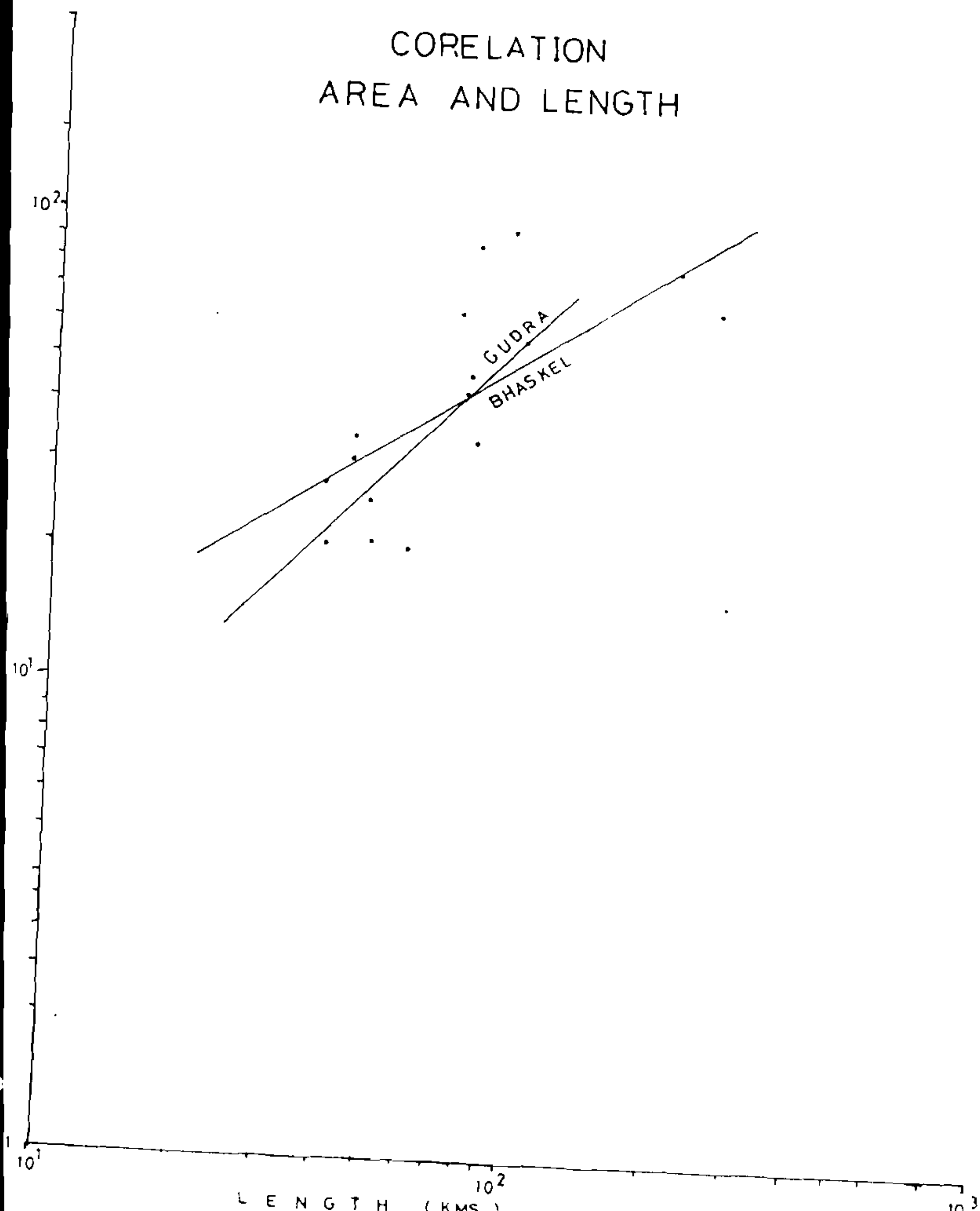

CORELATION
AREA AND LENGTH
GUDRA
BHASKEL
10^2
10^1
1
10^1
10^2
10^3
LENGTH (KMS)

FIG 4 6

The coefficient of variation is higher in soft rocks,lithology as 40,67% than in hard rocks i.e. 18.58% It means that there is higher variation with in the length of the basin in each order of selected basins of Bhaskel.

According to Schumm, the curve of stream length should be in linear pattern i.e. gentle sloping curves but in some cases we find gentle sloping curves up to III order and then slightly increase because the higher order streams occupy relatively low lying plain area forming meandering courses which create comparatively low difference in higher order streams where as, lower order streams are situated over dissected parts of Abujhmar group of uplands which create sudden increase in the length due to the higher frequency.

4.5 AREA AND LITHOLOGY :

It is an important geomorphic parameters. The differences of mean area in different lithologies are as follows :

table 4.4

ROCK TYPE	AREA IN SQ. KMS.
METAMORPHIC	33.13
SEDIMENTARY	62.58

Basin area of any drainage basin depends upon the degree of headward erosion which is directly related to climate lithology etc. The area per square kilometer is larger in resistant rock.

According to Horton[1] "mean drainage basin areas of each order should form a geometric series. The coefficient of correlationvalue is high in selected basins of Bhaskel river having underlying topography as cohesive and non- resistant i.e, 38.86%

Gudra is having 36.92% of the variation. Both whether hard or soft topography, the ruggedity and undulation as well as, slope increases,the area of a basin.Basin area is governed by climate also. Variations with in the basin area for each order is more or less same in any lithology.

Total stream length having higher value of coefficient of correlation(r= 0.94) in Gudra basin and in Bhaskel (r = 0.80) shows strong control over thebasin area. The positive relation ship can de seen in the graph which shows the trend of distribution. Basins area is directly proportional to stream length, but, some variations may be there either due to local irregularities, or by chance.

4.6 SHAPE INDICES AND LITHOLOGY :

Shape is a geometric structure of drainage and is related to the external shape of the drainage basin.

As drainage basin is governed by geological form tions relief, slope and lithological factors, it is never in extremes i.e., straight line shape or complete circular. The ideal shape is cinsidered to be pear shape.

The coefficient of variation is 10.37% in Gudra basin and 12.63% in Bhaskel. In basin III of Gudra it is having elongation ratio as 0.94, but it cannot be categorised as perfect circular or perfect elongated as it is having both the values higher. Similarly for basin III of Bhaskel river under sedimentary rocks the value of Re = 0.65 and Rc = 0.39, the basin falls into the category of elongated shape but if we look at the map (chapter III) we will find its shape is not perfectly elongated. The basin passes to elongated shape in metamorphic rocks (BASIN, V, IV ,I) where the streams are in initial stage and head ward erosion is dominant. Rest of the basin are giving, comparatively, higher value of circularity denotes early mature stage of the stream.The deoositbon is more and water is moving freely. Latter type of shape is generally found in sedimentary region of south Bhaskel.

In Gudra basin, over all value of circular ratio is higher 0.86 but the variation in each basin exhibits that no basin is perfectly circular or elongated. The basin in higher relief is having more elongated shape than in lower relief. Basin II, III, IV and IX of Gudra are showing higher values of elongation than circulay. Basin

IV is showing perfect circular shape giving circularity ratio as one(1), But it is not so in the map. There is a slight deviation of the shape may be due to local variation. Basin IX is also showing high value of circularity ratio(0.96) and Re (0.73). These both values are not giving shape to this basin as perfect circular.

It is inferred that underlying lithology is dominant in determining the shape of the basin. Climate and relief are also important factors which modifies the shape.

4.9 DRAINAGE DENSITY :

Chorley[1], states that drainage density is directly related to amount and intensity of precipitation and inversely related to the amount of vegetative cover.

The following table shows the variation of drainage density in two different rock types:

TABLE 4.5

DRAINAGE DENSITY IN KM./SQ. KM.

S.NO.	GUDRA	S.NO.	BHASKEL
BASIN II	2.75	BASIN II	1.14
BASIN III	1.68	BASIN III	1.89
BASIN VIII	1.62	BASIN VI	0.99
BASIN IX	2.19	BASIN VIII	1.39
MEAN	2.06	MEAN	1.35

The resistent rocks are showing higher drainage density than the non- resistant one. The mean value is standing at 2.06 km./sq.km.in sample basins of Gudra and 1.35km./sq.km. in Bhaskel. The variation is giving higher values od 22.13%in compact and massive formation in contrast with 8.54% in sedimentary sequence of Indravati, which shows greater variation of drainage density in the basin of Gudra. The is due to the local changes of the underlying rocks in metamorphics.

4.8 DRAINAGE TEXTURE :

Drainage texture which is the influence of underlying lithology, slope, climate and drainage density is ranging from basin to basin. Hard rocks are having coarse texture as the value is low, but ,sedimentary rocks are having values lower than hard rocks. In Bhaskel basin the texture is coarser than Gudra basin. The table shoes the drainage texture in the basins of Gudra and Bhaskel :

TABLE 4.6

S.NO.	HARD ROCKS GUDRA		S.NO.	SOFT ROCKS BHASKEL	
BASIN II	4.33	MEDIUM	BASIN II	2.72	COARSE
BASIN III	3.76	MEDIUM	BASIN III	3.73	MEDIUM
BASIN VIII	5.20	MEDIUM	BASIN VI	3.30	COARSE
BASIN IX	4.35	MEDIUM	BASIN VIII	2.24	COARSE
MEAN	4.41	MEDIUM	MEAN	2.76	COARSE

The mean value of texture is 4.41km./sq.km. is in the resistant rocks and 2.75km./sq.km. in non - resistant rocks. Coarser texture is found where erosion is dominant and overland flow is high.

As the stage of a river increases texture also increases from coarse to fine. Slope also influences texture ratio. Coarser texture are generally found in gentle sloped areas as in the case of basin VI of Gudra where slope is gentle and itis having the value of drainage texture 3.41. Steep slopes can have the fine texture as it is in the case of basin I of Gudra i.e. 7.29 showing highest value than other basin, and lies in the hilly region having the height of 837 meters.

The coefficient of variation is showing 11.65% in Gudra basin and 22.60% in Bhaskel. This exhibits that there is not much variations in the texture of Gudra as they are more or less of medium to fine. In Bhaskel the texture is coarser to medium. There is less uniformity with in the Bhaskel basin.

Drainage texture is related to drainage density. As the drainage density increases texture also increases from coarse to fine. From the coefficient of correlation calculated for the sample basins, Gudra is having r: - 0.076, a negligible negative value because of basin III and IX i.e. Pingunda nadi and Tivanji nadi. Bhaskel is showing perfect positive correlation, + 0.58 infering high drainage density increases the texture, to medium

In Gudra negative value of 'r' is because of dense forest cover and gentle slope. Hard resistant rocks such as quartzites and gneisses tends to give low drainage density and coarse texture. This is because stream erosion is difficult and only arelatively large channel can maintain itself. Therefore, the first order basins are large and provide large amount of runoff to the channels. In Indravati sedimentary sequence of Bhaskel, weak rocks such as limestone(BASIN II, Baliajori nadi), even smaller water shed can beenough to supply runoff for channel erosion. This type of lithological formations are having higher drainage density and fine texture.

4.8 CONSTANT OF CHANNEL MAINTAINENCE AND LITHOLOGY:

It is the measure of drainage texture similar to the drainage density and expresses the distance for the development and maintainence of stream lines as well as the intensity of surface erosion. Values of constant of chan nel maintainence in metamorphics of sample basins ranges from 0.34-0.62sq.km.and in Bhaskel it is from 0.53-1.00sq.km.

It shows that hard rocks are having lower average values(0.52) which gives medium to fine texture. Here drainage densityis also high. Theconstant of channel maintainence are higher in sedimentary area having low drainage density which shows that drainage texture is coarse to medium.It can be inferred from above study that the metamorphic rocks in Gudra and North of Bhaskel are not totally resistant. Quartzites, crystalline quartzites, gneisses are and thus making this area highly. So, the streams are not bound to flow along joints. Constant of channel maintainence is inversely proportional to drainage density and stream frequency.

4.10 STREM FREQUENCY AND LITHOLOGY :

Stream frequency gives character of under lying lithology, climate and control of vegetal cover in a particular region. Mean stream frequency is 3.09/sq.km. in Gudra and 1.54/ sq. km. in Bhaskel. It is low in recent alluvial deposits of Indravati basin and higher in quartzites of Gudra. Stream frequency is governed by rain fall intensity, runoff, percentage of bare rock area, erosional proportional rate of evaporation and infilteration capacity. From the table above factor are sinificant, determining the stream frequency.

Stream frequency is maximum in Basin II of Gudra river i.e. a tributary of Madin nadi, and in Tivanji nadi, basinIIIof Gudra, 4.02/sq, km.and 3.92/sq.km. respectively. This area is of higher relief and mixed dense forest exists.In contrast withlower stream frequency 0.99/sq.km. of alluvial deposits of Bhaskel river , where relief is low, sparse vegetation can be seen. Seepage of water through the pores is one of the reason giving rise to less stream frequency.

Coefficient of variation being 18.60% in Hard rocks and 40.15% in soft rocks, in the present case indicates that the standard deviation is 18.60% and 40.15% of the mean which further supports great range of deviation. There is less uniformity of the distribution of stream frequency with in the basin of Bhaskel than in Gudra.

4.16 BEHAVIOUR OF RELIEF IN DIFFERENT ROCK PATTERN:

ABSOLUTE RELIEF:

Absolute relief is more stable in nature than other morphometric parameters. It influences these parameters, indirectly.The map (chapter III) of selected basins of Gudra and Bhaskel reveals that height of the basin decreases from source to mouth. The area of maximum height lies in quartzites of Gudra basin, 897 meters i.e. Tivanji nadi which lies in the western part of the Gudra basin. The lowest value of 614 meters lies in the tributary of Indarvati basin which is having recent alluvial deposits in its beds.

The mean value of absolute relief is 870 meters(appendix II) in Gudra and 651.5 meters in Bhaskel. The standard deviation being the best measuse of dispersion is used in the present study to measure the exact degree of variation from the normal distribution. The calculated standard deviation is standing at 20.285 shows slightly smaller degree of variation in Gudra than in Bhaskel, 24.87. Coefficient of variation being 2.33 % for Gudra and 3.18% for Bhaskel reveals that the stabdard deviation is 2.33% and 3.18% of the mean which supports the low degree of variation of absolute relief with in thw sample basins.

The analyses of absolute relief depicts that most part of the basin lies in a medium altitude, which quite obvious because entire basin lies in a plateau and is highly dissected.

4.9 RELATIVE RELIEF :

Another important parameter, relative relief is higher in the Pingunda Nadi of Gudra(BASIN IX) having the value of 328 meters. The lowest value is found in the BASIN VIII of Indravati tributary having only 74 meters of relative relief. Relative relief gives an idea about the inclination of terrain, which reflects the nature of configuration. Relative relief is higher in river valleys and lower near the mouth. It has great degree of variation due to the varying nature of configuration. It varies from 74 - 328 meters.Variation in the relative relief values from the normal distribution has been measured by standard deviation. The values show 52.85 and 17.123 in the Gudra and Bhaskel respectively. Gudra is showing comparatively higher variation of relative relief than Bhaskel. Coefficient of variation being 21.42% in Gudra and 17.88% in Bhaskel further supports the higher degree of variations in Gudra.

4.10 SLOPE ANLYSIS AND LITHOLOGY:

The computation of average slopes from the topographic maps using contours have been attempted by several scholars. In the present study the scheme of Wentworth is used for the slope analysis. The degree of slope in the area is ranging from minimum Of 0° to maximum of 8.55°. The slopes values of all grids in the entire basin has

AVERAGE SLOPE GUDRA
IV ORDER SAMPLE BASINS

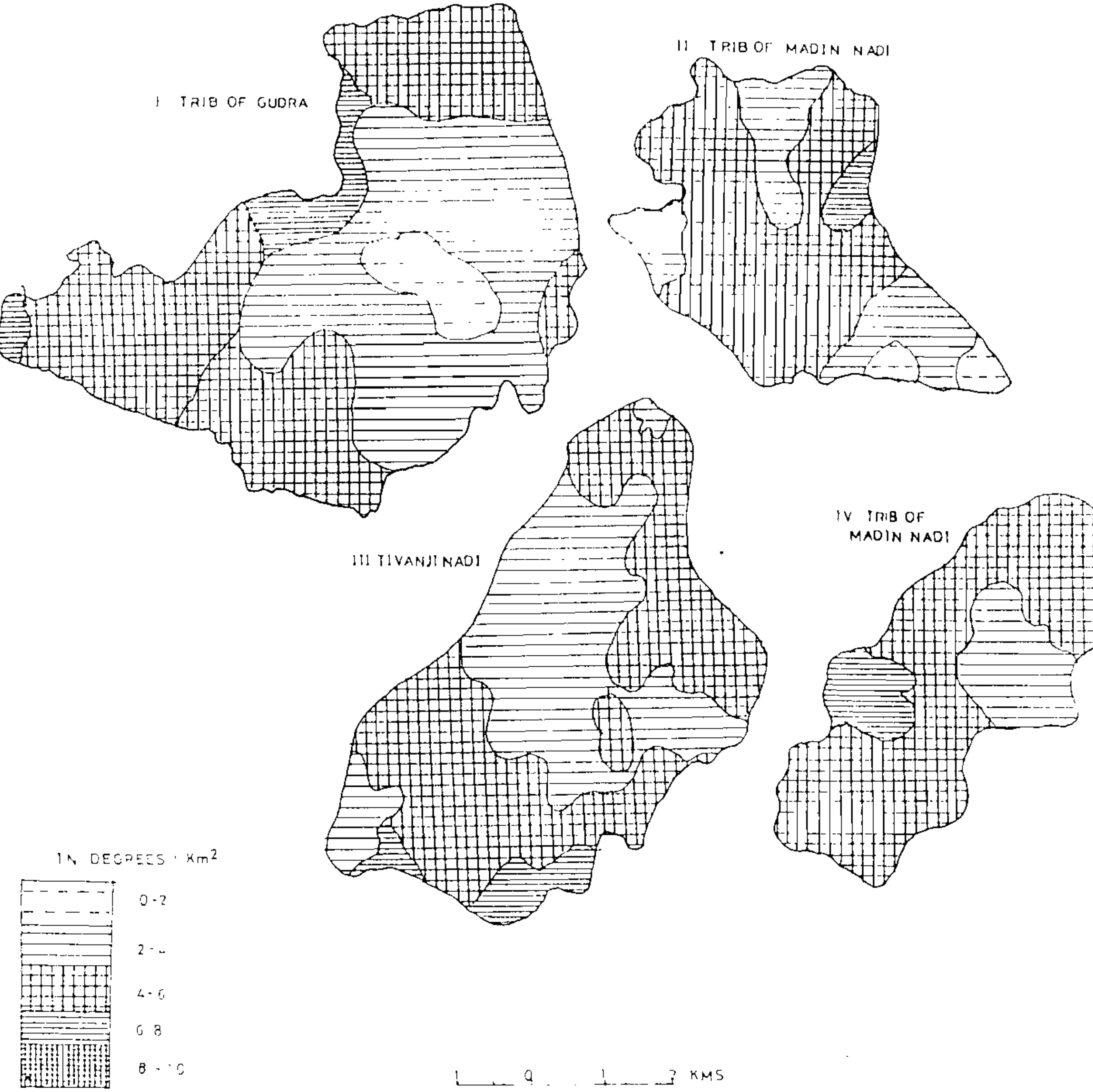


FIG. 47

AVERAGE SLOPE : GUDRA
IV ORDER SAMPLE BASINS

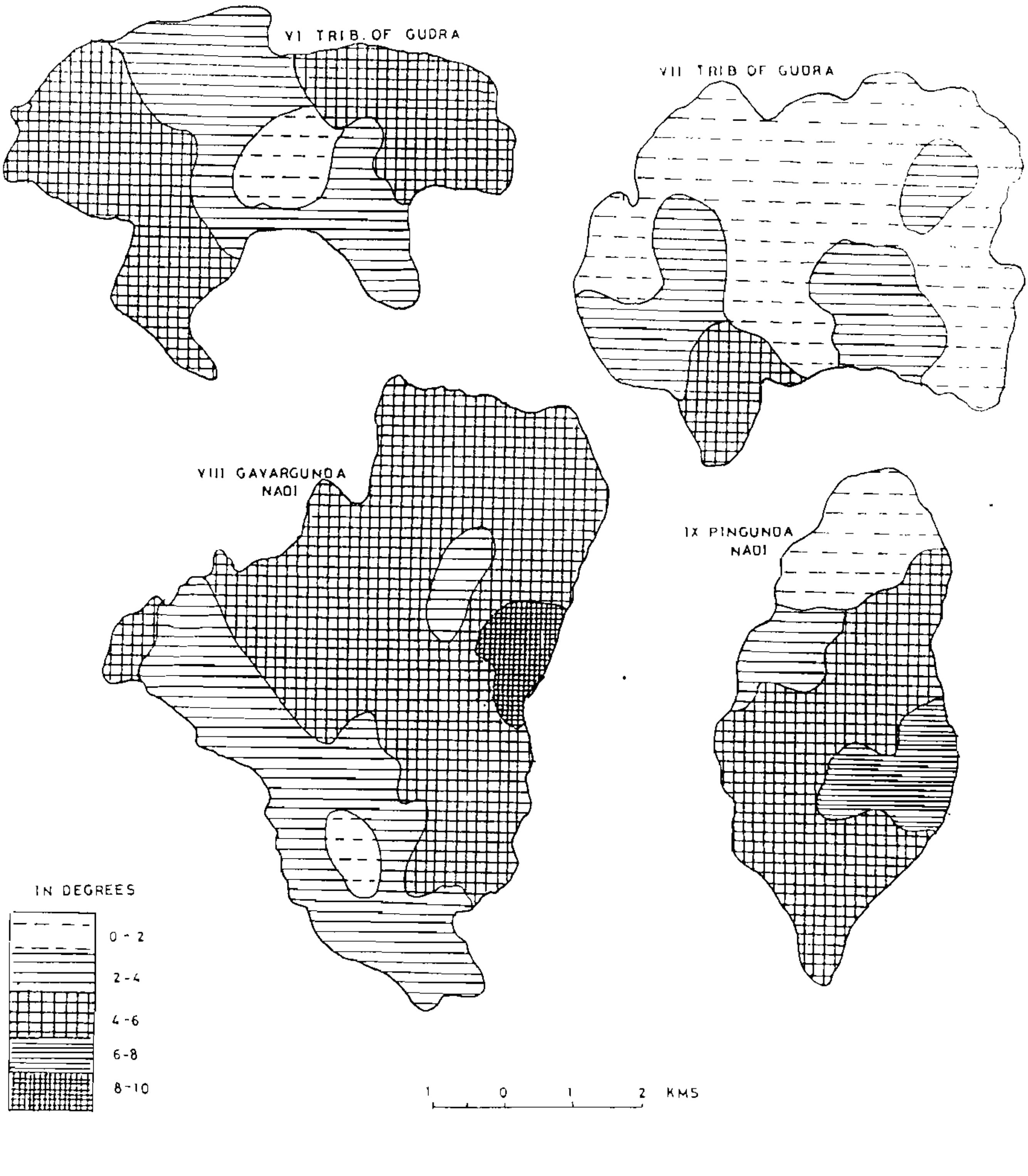


FIG 4.8

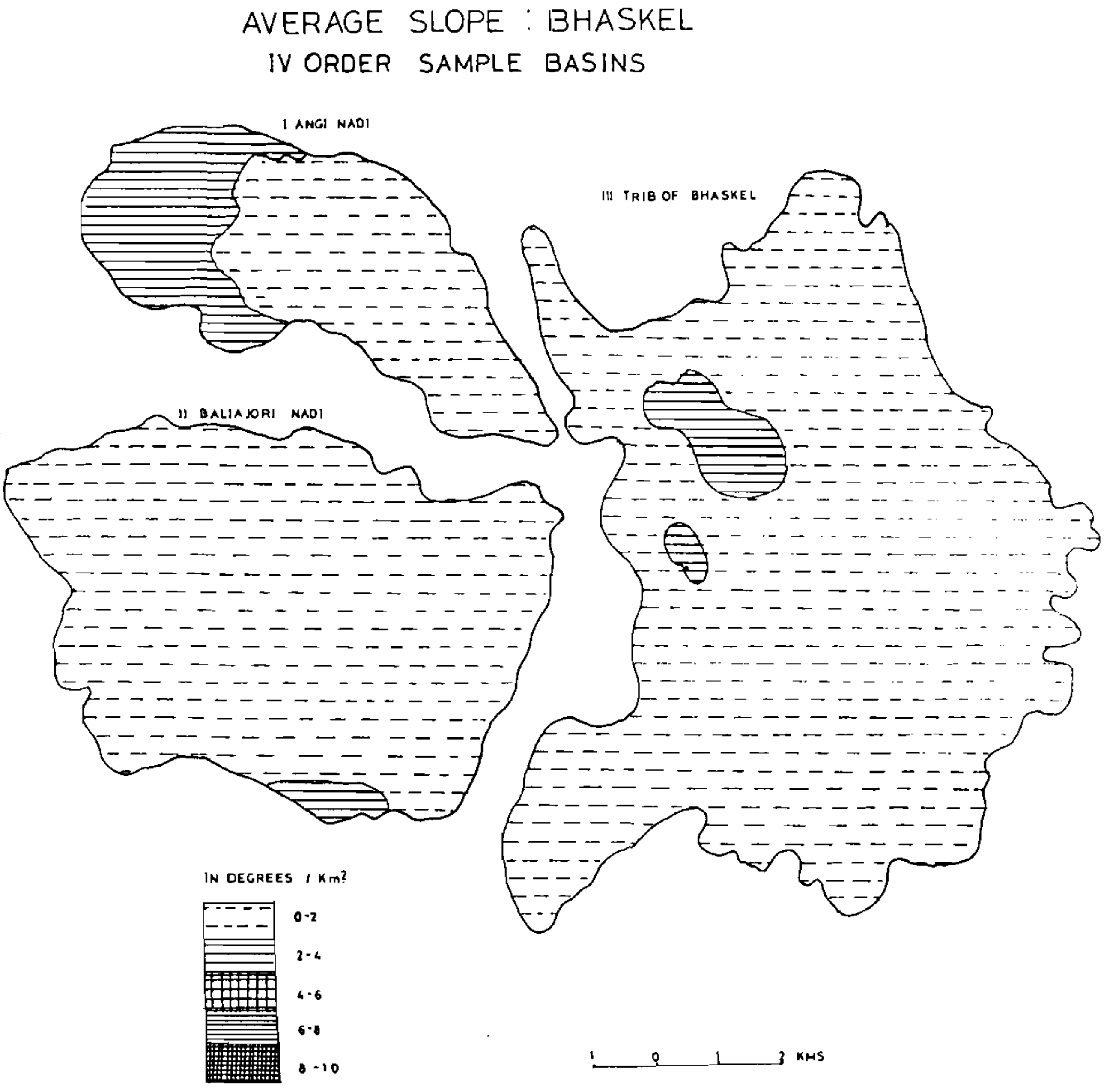

AVERAGE SLOPE : BHASKEL
IV ORDER SAMPLE BASINS
I ANGI NADI
III TRIB OF BHASKEL
II BALIAJORI NADI
IN DEGREES / Km²
0-2
2-4
4-6
6-8
8-10
1 0 1 2 KMS

FIG. 4.9

AVERAGE SLOPE : BHASKEL
IV ORDER SAMPLE BASINS

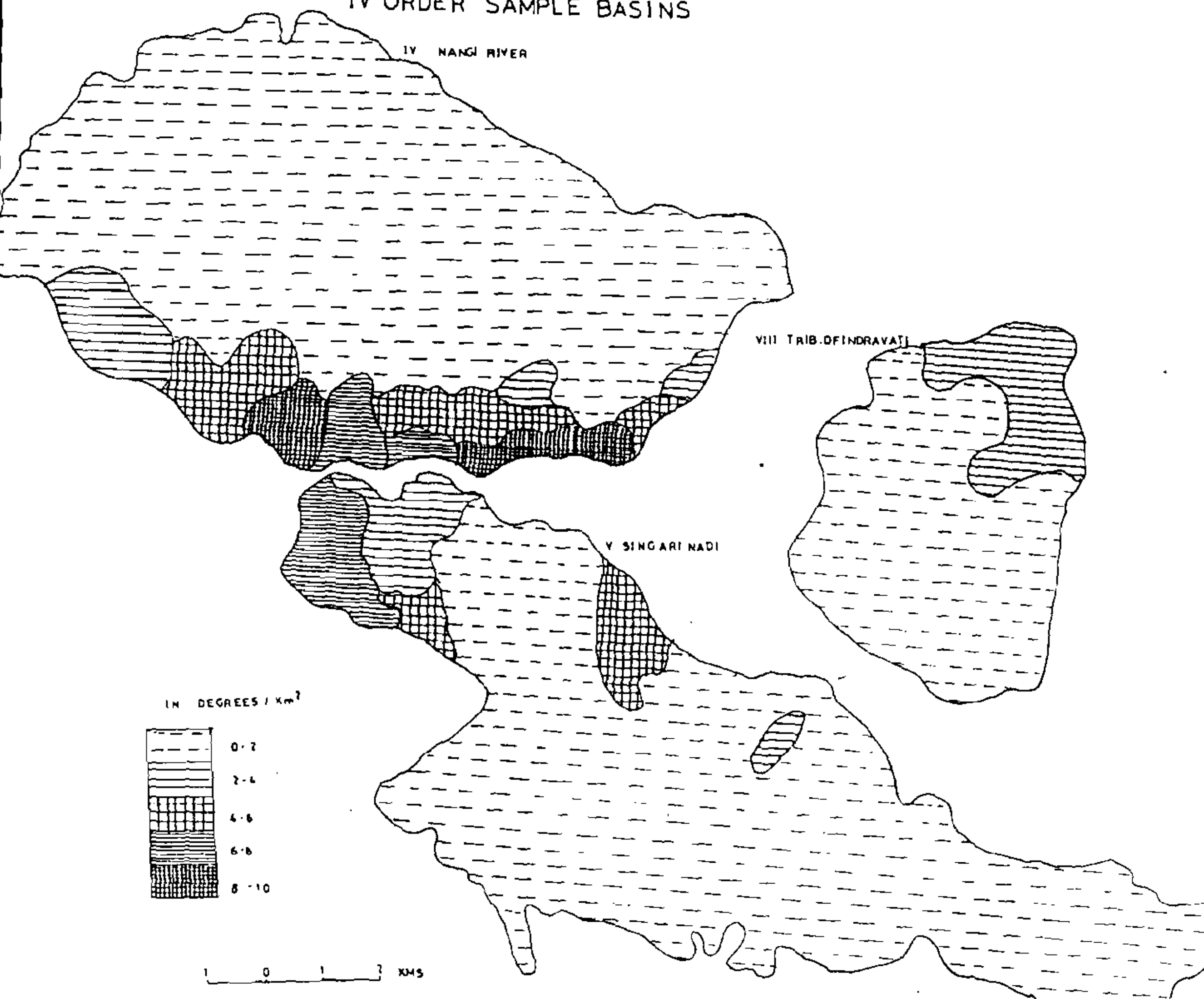


FIG 4.10

been classified into five categories of 2° interval.

AVERAGE SLOPE IN HARD ROCKS OF GUDRA:

Table 4.7

S.NO.		AVERAGE SLOPE
BASIN II	Tributary of Madin Nadi	2°-5°
BASIN III	Tivanji Nadi	1°-5°
BASIN VIII	Gavargunda Nadi	1°-5°
BASIN IX	Pingunda Nadi	0.54°-8°
<u>BHASKEL BASIN:</u>		
BASIN II	Baliajori Nadi	0.54°-3°
BASIN III	Tributary of Bhaskel	0.54°-3°
BASIN VI	Tributary of Bhaskel	0.54°-4°
BASIN VIII	Tributary of Indravati.	0.54°-4°

All the selected basins of Bhaskel and Gudra lies in gentle slope. Slope is the ratio of vertical drop to horizontal distance, measure from the upper end to the lower end of a single stream segment of given order.

Slope of Gudra is Ranging from 0.54°-8° giving, comparatively steep slope in contrast to Bhaskel which ranges from 0.54° to 4°, only. The Basin Gudra is situated on an elevation comparatively, higher than Bhaskel.Bhaskel* lies in lower elevated region. It makes meandering pattern in its mouth, where, it joins the Indravati river. The whole basin of Bhaskel is in initial stage and the classification stages is only ,comparative, to each other.

4.13 DISSECTION INDEX :

Dissection Index is a measurement of dissected topography in mathematical terms. By dissected topography we mean topography characterised by a definite pattern of incised hills on mountains separated by low lying areas i.e. cut by erosion into a net work of valleys and interfluves.

The calculated mean value of the dissection index stands at 0.305 and 0.148, for the sample basins of Gudra and Bhaskel respectively. Standard deviation of calculated dissection index values standing at 0.0005 and 0.058 for Bhaskel and Gudra, which indicates greater degree of variation in Bhaskel. Coefficient of variation being 19.19% and 14.86% in resistant and non resistant rocks respectively gives greater degree of variations in sedimentary region of Bhaskel. Gudra, though, comparatively lower value, it is also showing high dissected terrain of Abujhmar group and gneisses having large variations with in the basin.

This analysis brings out that Bhaskel river in general, experienced moderately dissected terrain.

4.14 RUGGEDNESS NUMBER :

Ruggedness number gives an idea about the nature of variation of erosional features of erosional agents engaged in sculpturing the land mass and resulting configuration.

Mean values of ruggedness number of the selected basins are 0.53 for G dra and 0.1725 for Bhaskel Ruggedity is high in resistant rocks comprised, og gneisses Quartzites in Gudra than in the recent alluvial deposits of Bhaskel Basin.

The measure of degree of dispersion i.e. standard deviation is calculated for both of the selected basins. The values are 0.055 for Bhaskel and 0.1129 for Gudra shows a greater of variation in the latter basin. The coefficient of variation being 21,30% for Gudra and 31.72% of Bhaskel further supports a greater degree of variation in Gudra.

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

Morphometry from early forties is playing a vital role in evaluating the characteristics of river basins in terms of quantification. A similar attempt has been made for the two selected basin of Indravati river. The main emphasis of the present study is on the evaluation of the land surface with the help of selected morphometric parameters.

Several processes are engaged in sculpturing the land forms in a long period of time and under different environmental conditions. Not only lithological conditions but also climate, slope, play an important role.

Lithology as a major factor, though dependent directly or indirectly on other factors has been taken into account to explain the variation in morphometric parameters. The conclusion derived from the study of earlier chapters can be organised as follows ;

A)- The Indravati is the second largest river which covers 13.32% of the area of the largest and the longest river in South India i.e., Godavari. Its catch ment area is about 41,665 square kilometers, of Madhya Pradesh and Orissa. It rises at an elevation of 915 meters in Kalahandi. It flows west wards The two tributaries, namely, Gudra and Bhaskel of Indravati being of differebt geological formations has been selected for the study.

Gudra stsetches from 19°10' North to 19°35' and 82°20' east to 82°30'east of longitudes. It rises at an elevation of 853 meters. It comes under metamorphic rocks.

Bhaskel stretches from 82°10' to 82°21' east and 19°6' to 19°50' north of latitudes It joins Indravati in South near Nagarnar village.

Six lithological formations have been taken into account for the study of the structure and its influence upon selected morphometric parameters. Lithological formations are broadly divided into two groups i.e. sedimentaries and metamorphics.

Sedimentary includes, Indravati sedimentary sequence or the recent alluvial deposits and limestone region situated in South central portion of Bhaskel river.

Metamorphics includes quartzites crystalline quartzites, gneisses, Bengpal gneissic complex and Biotite granite gneisses.

B)- Gudra is showing dendritic and sub- parallel pattern in its course andBBhaskel shows sub - parallel and radial pattern, where dome is found giving birth to several finger tips in centripetal form.

C)- Lithology and linear properties: The fourth order basins are selected for the present study and the diff-ernt morphometric parameters are applied. The metamor-phic lithology produces high values of the stream numbers of first order. In contrast, with sedimentary particularly, recent alluvial deposits and limestone But the mean stream number is more or less same which concludes that climate and vegetation is also important for thr development of stream number.

Bifurcation ratio is high in the metamorphics in comparision to the sedimentaries but the length is more in soft rocks than in hard. Massive has higher variations among the observations like in Gudra.

Ratio of bifurcation and area shows positive corralation among them. Sedimentary and limestone regions of Bhaskel basins are showing high bifurcation ratio and bigger areas than Gudra.Mean length of the basin is more in soft areas. Stream length reduces as the massiveness and compactness of rock increases. Co-efficient of variation shows higher variations in sedimentaries.

D)- Lithology and areal property: Areas of sedimentary rocks are more than in metamorphics. Basin areas depend upon the degree of headward erosion which is high in soft rocks. There is a positive correlation between length and area. Basin area is directly proportional to stream length.

Shape of the drainage basin is governed by the geological formations,relief, slope aspects, and lithological factors. No shape is perfectly circular or elongated due to the variation of different factors. Same is in the case of the present selected basin.

Drainage density is higher in hard rocks than soft rocks. It shows high variations in sedimentary rocks. The mean drainage density is 2.06 km./sq.km- in metamorphic and 1.39 km./sq.km. in sedimentary region Drainage density is not only governed by lithology but also by relief, slope, ruggedness number and dissection index.

Drainage texture associated with density. It is high in hard rocks showing medium texture in Gudra than in Bhaskel. There is much more variations in texture in resistant rocks than in non - resistent. Drainage texture is having positive correlation with drainage density, As density increases texture of a basin also increases from coarse to ultra- fine. Stream frequency is high in metamorphic rocks. It is governed by rain fall intensity, infilteration capacity. rate of evaporation and run off. Second factors are dominant in the lime stone region, decreasing the stream frequency.

Constant of channel maintainence is high in sedimentary rocks than in metamorphics. There is a negative correlation between constant of channel maintainence and drainage density. As drainage density increases constant of channel maintainence decreases.

E)-Lithology and relief characteristics: The absolute relief of the basin varies from 715 meters to 897 meters in Gudra and 614 - 927 meters in Bhaskel basin. The whole region lies in plateau region of Bastar and Abujhmar plateau. Average absolute relief is higher in Gudra than in Bhaskel.

Relative relief of the area has a less degree of variation ranging from 175 - 328 meters in Gudra and 74 - 320 meters in Bhaskel. It indicates the develoment of broad river valleys.

Average slope varies from 0°-8° in Gudra and 0° to 4° in Bhaskel. The area lies in very gentle slopes. The development of slopes in these two basins is a resultant of combination of drainage density stream frequence, relative relief, absolute relief and underlying lithology.

Dissection index stands at 0.305 and 0.148 for hard rocks and soft rocks, respectively. Which denotes the down ward erosion of the bed, predominant. Ruggedness number of the basin provides the roughness of the land surface. It is more in Gudra basin than in Bhaskel. It concludes that in resistant rocks than in non - resistant. There is more ruggedness in Gudra than Bhaskel.

It is concluded from the above study that other environmental conditions being constant lithology controls the distributional aspects. of morphometric characters of the two river basins selected for the present analyses.

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APPENDIX II

AVERAGE QUANTITATIVE GEOMORPHIC CHARACTERISTICS. BHASKEL & GUDRA BASIN

OF THE 4th ORDER BASINS OF INDIRAVATI

S.NO.	Hard rock Gudra			Soft Rock Baskel		
	X		C.V. in %	X		C.V. in %
Stream number	97.5	21.74	22.30	98.75	45.52	46.09
Stream length	63.1	11.73	18.58	82.81	33.68	40.87
Stream area	33.13	12.23	36.92	62.58	24.32	38.86
Bifurcation ratio	4.65	0.24	5.28	4.30	0.55	12.84
Drainage Density	2.06	0.46	22.13	1.35	0.34	25.04
Drainage texture	4.41	0.51	11.65	2.76	0.61	22.07
Stream frequency	3.09	0.58	18.62	1.54	0.62	40.02
Elongation ratio	0.77	0.77	10.68	0.70	0.13	12.63
Circularity ratio	0.86	0.15	17.92	0.68	0.19	28.62
Absolute relief	870	20.28	2.33	645.5	18.35	2.84
Relative relief	265	48.75	18.39	95.75	17.12	17.88
Dissection Index	0.305	0.06	19.19	0.145	0.02	15.03
Rudggedness Number	0.56	0.12	20.63	0.13	0.03	24.41

Abbreviations

X = Mean of variable
= Standard deviation
C.V. = Coefficient of Variation.

APPENDIX - I

Gudra

S.No.	Basin
I	Tributary of Gudra
II	Tributary of Madin Nadi
III	Tivanji Nadi
IV	Tributary of Madin Nadi
VI	Tributary of Gudra
VII	Tributary of Gudra
VIII	Gavargunda Nadi
IX	Pingunda Nadi

Bhaskel

S.No.	Basin
I	Angi Nadi
II	Baliagori Nadi
III	Tributary of Bhaskel
IV	Nangi River
V	Singari Nadi
VI	Tributary of Bgaskel
VII	Agua Nadi
VIII	Tributary of Indravati