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Tectonic Geomorphology of West Bangalore by analysing the Chick Tore river basin, Karnataka, India, Using ASTER DEM

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Abstract- **The study of tectonic geomorphology and morphometry is considered as a valuable tool in active tectonic studies. The present study carry out geomorphologic analysis in an area where a historic earthquake was reported. The study area is a small river (Chick Tore) basin, broadly showing a dendritic pattern, covering an area of 116 km^2 and having four 4th order tributaries. The area is crisscrossed by NW-SE, N-S and NE-SW trending lineaments. For morphometric analysis, the area is demarcated into 43 sub basins. Two pockets of anomalous basin asymmetry are observed southwest of the main trunk of the river. Transverse topography factor indicates that on either side of the NW-SE trending lineament, through which the Chick Tore river is flowing, are deflected on opposite directions. Valley floor width to valley height ratio along the NW-SE and NE-SW trending drainage segments also shows varying values (0.27 to 2.31) however, relatively higher values are observed along the NW-SE trending main trunk close to the junctions where N-S and NE-SW lineaments are crossing. The study observed that the area falls in uniform lithology and ongoing tectonic adjustments along the main NW-SE trending lineament are reflecting as drainage anomalies.**

I. INTRODUCTION

Bangalore city is the fastest growing city and fifth biggest city in India. The city is vulnerable even to average earthquakes, because the buildings of all kinds from mud buildings to RCC (Reinforced Cement Concrete) framed structures are constructed without proper building codes and with increasing population [1]. However, the occurrence of damaging earthquakes in various parts of similar intraplate tectonic settings indicates reactivation of pre-existing structural weaknesses/faults [2]. Indian plate is one of the complexly deformed parts in the world which had also become the source of various devastating earthquakes in the past along the pre-existing zone of weakness. However, the information on historic earthquakes are also lacking in such terrain to determine the long-term activity of the faults. Over the years, studies across the globe indicate that careful geomorphologic analysis can identify potentially active faults even from areas of moderate seismicity [3, 5, 6, 7, 8, 9, 10, 11, 12, 13]. Numerous geomorphic indices are formulated for quantitative assessment of the tectonically active area [3, 4, 6, 14, 15]. The present study is based on the fact that the geomorphology of a terrain indicates an amount of interaction between surficial and tectonic processes and also the control of climatic conditions over them [16]. Thus, the present study deals with the quantitative evaluation of structures falling with in the study area, using the elements of tectonic geomorphology.

II. STUDY AREA

The study area forms NNE- SSW trending Chick Tore basin of 5th order lies in the west of Bangalore, Karnataka (Fig. 1). This area is broadly falling under Seismic zone II of seismic zonation map of India a Low Damage Risk Zone [17]. However, an average earthquake nearby can induce heavy damage as mentioned above. The study area had already experienced an earthquake of intensity V (Ms=5.0) in the year 1916 [17]. The NNE- SSW trending Arkawati River is the major river draining in this area. The present study area is limited to the catchment of NW-SE trending Chick Tore, one of the tributaries of Arkawati River covering ~ 116 km^2.

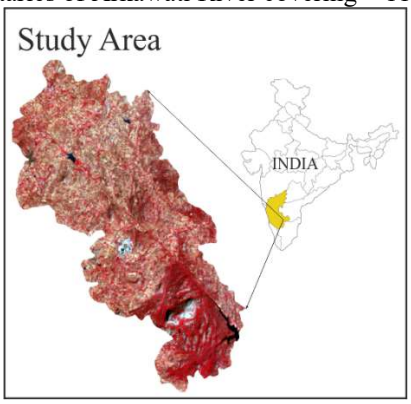

Fig.1 Study area shown as FCC of land sat image.

The general topography of the area shows the elongated hills trending NE-SW in the south eastern part. The area is mostly mid-range relief (1221m to 720 m), and most of the drainages flow along a gentle gradient.

The area regionally exposes rocks belonging to the peninsular Gneissic complex in which Clospet Granite belongs to Lower Proterozoic age. These rock units are intruded by basic dykes, acid dykes, and syenite and carbonatite bodies of Dharmapuri alkali complex of upper Proterozoic age.

The Clospet Granite, pink and grey, is prominently exposed as NNW-SSE trending body varying in width from about 15 km forms the basic rock unit in the study area.

III. METHODOLOGY

The present study extracted of drainages of Chick Tore from ASTER DEM using Hydrology tool of the spatial analysist and further calculated stream orders. The same has been validated with the georeferenced SOI toposheets. The watershed subdivided into 43 sub basins of 2nd and 3rd order streams using the snap pour point. The parameters like basin area, mid line and elevations are calculated using Arc GIS 10.6. The Transverse topographic symmetry factor and Valley floor width to valley height ratio are calculated from the Aster DEM.

IV. ANALYSIS

A] Lineament and drainage network

The NW-SE lineaments are found to be regionally the most persistent features within the study area. The NW-SE trending Chick Tore is also following along one such lineament (Fig.2). Though the main trunk of the river is of 5th order, there are several first order streams joining from south to the main trunk. Several closely spaced first order streams are joining the main trunk from north in the south-eastern side of the main trunk.

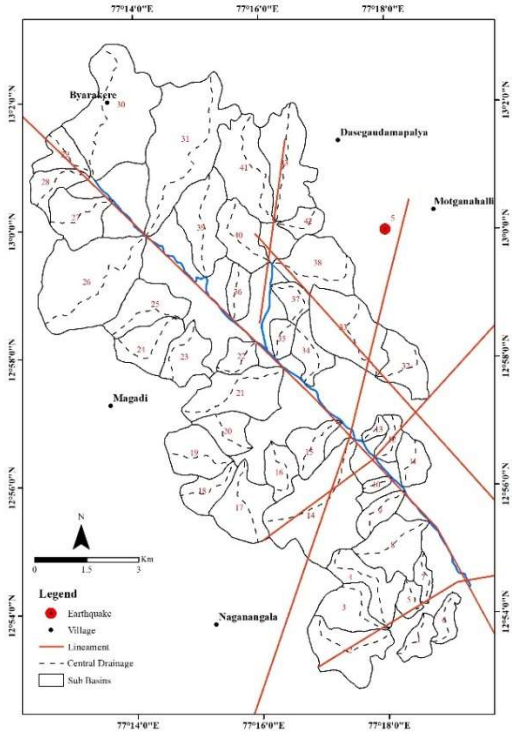

Fig. 2 Drainage basins and lineaments. Cnetral drainages and earthquakes are also shown.

Though most of the drainages joining from southern side of the drainage at right angle (NE-SW) to the main drainage, there are obvious curves towards northwest for many of them before its confluence with the main trunk. On the other hand, drainages joining from north meets the main trunk at an acute angle (N-S). It should be also noted that there are three 4th order and three 3rd order streams joining to the main trunk from south whereas only one fourth order and three 3rd order streams joining from the north to the main trunk. In the NE side of this river another parallel lineament is observed. In addition to that there are some NE-SW and N-S trending lineaments observed in the area appears to be influenced the drainage system.

B] Morphometric studies

Asymmetry Factor (AF), Transverse Topography Symmetry Factor (T) and Valley floor/Valley width ratio (V_f) are the geomorphic indices used in this study to detect the anomalies in the drainage system (Table 1).

Table 1: Formula used for calculating the various geomorphic indices

Indices	Formula	Remarks
Asymmetry Factor (AF)	AF = 100× (Ar/At)	Where, Ar = Right half of area of basin while facing downstream, At = Total area of the basin [14]
Transverse Topography Symmetry Factor (T)	$T=(D_a/D_d)$,	where D_a is the distance from the stream channel to the middle of its drainage basin and D_d is the distance from the midline to the basin divide [6]
Valley floor width to valley height ratio	$V_f = 2V_{fw}/[[E_{ld} - E_{sc}] + [E_{rd} - E_{sc}]$	Where V_{fw} is the width of valley floor, E_{ld} and E_{rd} are the respective elevations of the left and right valley divides, and E_{sc}, is the elevation of the valley floor [3]

B.1] Asymmetry factor

It is originally derived to detect the tectonic tilt of the basin areas [6, 18]. For a stream network flowing in a stable setting and uniform lithology, the AF would be falling close to 50. In all other cases there will be a change in value deviating on either side of 50 depending on the direction of drainage migration [6, 20].

The AF was calculated for all the 43 sub basins demarcated for the morphometric analysis and the value AF ranges from 22 to 78. If we consider a deviation of 10 for this structurally controlled terrain as normal values of AF, then it is observed that only 23 basins are falling in this range and 20 basins show anomalous AF (more than 10 from the perfect value of 50). Out of these 6 basins deviate more than 20 from the perfect value of 50. The highest anomaly basins (deviations more than 20) are observed mostly south of the main trunk of the river that is southern side of the study area. This may indicate that the tectonic disturbance may be more in the southern side of the NW-SE trending lineament.

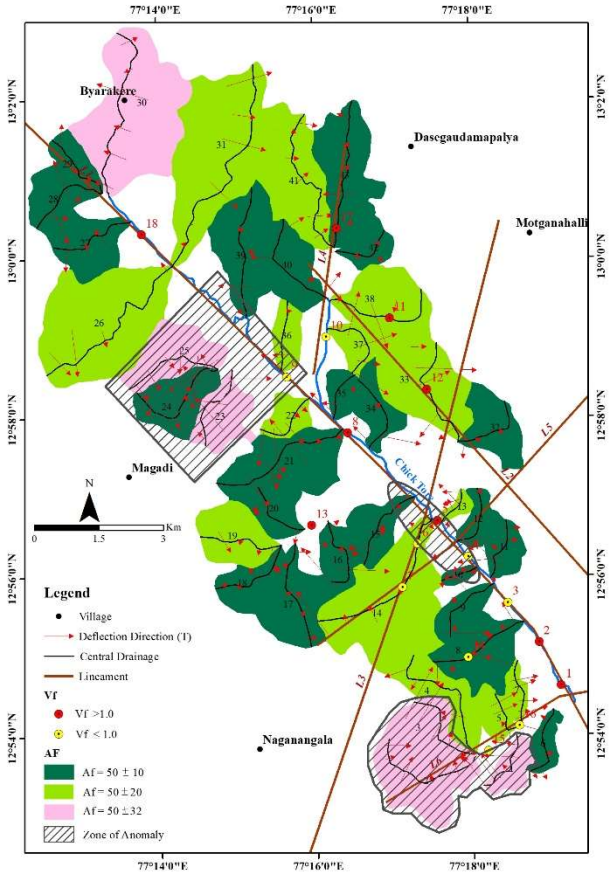

Fig. 3. Details of morphometric studies

B.2] Transverse topographic Symmetry factor (T)

Regional measurements of transverse topographic asymmetry are useful for recognition of several geological process of landscape evolution [19]. Similar studies carried out in the southern Peninsular India identified active faults [20, 21].

In the present study 'T' factor is calculated for the main trunks of all the 43 basins at different reaches. The direction of the arrows indicates the migration direction of the drainage from its original path. Higher the value of ratio, bigger will be the length of the arrow, which may indicate tilting of the terrain or conspicuous shifting of drainage from its original path.

The present analysis indicates that the drainage deflections are low in magnitude close to the main trunk of Chick Tore river though they show a consistent direction towards northwest in the southwestern side. It also indicates that on either side of the NW-SE trending lineament, through which the Chick Tore river is flowing, are deflected on opposite directions. The highly asymmetrical basins (Af) observed in the southern corner of the study area show a converging nature of T factor. The basins north of Magadi too show converging nature of T factor in the highly asymmetric basins. In contrary the T factors in the basin nos. 30 and 31 are diverging. Diverging pattern is also observed in the basins located between two NW-SE trending lineaments. East or north directed T factors are prominent in basins west of the NS trending lineament.

B.3] Valley floor width valley height ratio

Valley floor width - valley height ratio (V_f) is another geomorphic index developed by [3] for quantitative assessment for tectonically influenced geomorphic feature (e.g. SW USA [3, 22], Costa Rica [13], Oregon Coast Range, USA [23], southeast Spain [12], North western Himalaya, [24].

In the present study V_f is calculated at 18 locations across different reaches of the drainage system where the drainages follow straight course or/and following lineaments (table 2). The eight locations measured along the main trunk of Chick Tore river varied between 0.43-2.31. It is interesting to note that the highest value (2.31) of maturity of the river valley is observed at the beginning of the 4th order segment. In the downstream side of the main trunk, the valley appears to be more erosional. The ratio measured along the N-S trending 4th order stream also shows a relatively high value in the upstream side than that of one measured between two NW-SE trending lineaments. In contrary the ratios are very low along NE trending drainages flowing along the lineaments in the southern side of the main trunk.

Table 2: Values for Valley floor Valley Width ratio at different location

Loc.	E ld	E rd (m)	Esc (m)	Floor width (m)	Vf
1	800	810	700	123.31	1.17
2	870	830	720	162.03	1.25
3	1226	861	720	139.41	0.43
4	940	870	740	148.26	0.90
5	940	870	740	273.75	1.66
6	940	860	750	76.80	0.51
7	1126	920	780	109.90	0.45
8	880	900	760	132.68	1.02
9	850	942	780	65.51	0.56
10	977	850	780	97.39	0.73
11	940	920	820	117.88	1.07
12	880	860	800	76.79	1.10
13	1003	953	800	292.84	1.65
14	1126	960	820	122.52	0.55
15	970	925	740	95.73	0.46
16	970	925	740	55.94	0.27
17	965	884	820	147.86	1.41
18	912	979	820	290.08	2.31

V CONCLUSION

Chick Tore is a 5th order river having four 4th order tributaries flowing through uniform lithology (closepet granite). The main trunk of the river is flowing along a NW-SE trending lineament. Though this drainage broadly shows dendritic pattern several first order streams joining to the main trunk. The topographic asymmetries are inferred as selective preferred drainage migration. Morpometric studies identified anomalous values at three zones close to the NW-SE trending lineament as marked in figure 3. The spatial relationship of seismicity and the river valley raises the suspicion that the NW-SE trending valley is fault controlled and that the preferred drainage deflections are the result of local tectonic adjustments. The present study observed that the ongoing tectonic adjustments along the main NW-SE trending lineament are reflecting as drainage anomalies.

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