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Morphotectonic Study in a part of Indo-Burmese Ranges in Eastern Mizoram, India

Farha Zaman[1,*], Devojit Bezbaruah[1], Lalhmingsangi[2] & Raghupratim Rakshit[1]
[1]Dept. of Applied Geology, Dibrugarh University, Dibrugarh, Assam
[2]Pachhunga University College, Aizawl, Mizoram
[*]Corresponding Author: pharha1530@gmail.com

Abstract

Mizoram fold belt, situated in geologically complex Indo-Burmese Ranges, comprises of arcuate sedimentary belt. This NS trending mountain series is cut by a number of parallel to subparallel NNE-SSW, NE-SW, and NW-SE tectonic features like faults, deformed hill ranges etc. This research work was carried out in Champhai district of eastern Mizoram, near Indo-Myanmar border. In this study, a morphotectonic analysis has been performed to know the presence of active tectonics for the region. Morphotectonic parameters were calculated for 32 basins of 3rd, 4th, 5th and 6th order basins. Tuipui River had been originated near Champhai town which is supposed to be a paleo-lake. The two major rivers Tuipui and Tayo have similar entrench meander patterns which might have been controlled by some structural features. Most of the other drainage shows rectangular, trellis, oval and circular pattern along with the unique river meanders. The eastern basins of the Tuipui river mostly shows WNW highly asymmetrical (|AF|=IV) tilted basins whereas the western basins shows SE moderately asymmetrical (|AF|=III) tilted basins. The basins on the eastern part of the Tuipui water-divide shows moderate to high asymmetry and SSE tilting. Although the basins near to the origin of Tuipui River and some of the surrounding areas viz. near Champhai, Khuai Lui and five others show symmetrical to moderately symmetrical basins (range I-II). The results are also reflected by the T values. Elongated to moderately elongated basins shows many anomalous SL points which coincides with the lineaments and tectonic features in the area indicating activeness of the region. Macro and micro lineament plots indicate different trends in local stage although most of them follow the regional NW trends which are quite opposite to the NNE stress component. The results indicate that this part of IBA is associated with active tectonics as confirmed by the morphotectonic studies.

Keywords: *Indo-Burmese Ranges, Morphotectonics, Asymmetric Factor, Lineaments*

Introduction

Indo Burmese Ranges (IBR) is an arcuate sedimentary belt with NS trending folded mountain chain. IBA is considered as an active accretionary wedge linked to eastward subduction of the Bengal basin oceanic crust. (Acharya *et al.* 1990; Curray *et al.* 1979; Bender *et al.* 1983 and Nandy *et al.* 1986). This fold-belt region, uplifted from Neogene Surma Basin, located in this north-east Indian part, was formed due to the collision between Indian and Burmese Plates (Nandy *et al.* 1983; Dasgupta, 1984). Such a complex tectonic setting is responsible for the lineament patterns in the area which infers the tectonic history as well as indicates the prevalence of the active tectonics in the area (Bull and McFadden, 1977). This study, therefore, obligates to the analysis of the presence of active tectonics in the eastern part of Mizoram, near to the core of the IBA. In this study, Champhai area has been considered to understand the active tectonic features in the vicinity of IBA. Morphotectonic study is very essential to understand active tectonics of any area. In mountain ranges, active tectonics is the controlling factor for rock upliftment and it is also reflected by the present-day topography which has resulted from the competition between tectonic and erosional processes (Pérez-Peña *et al*., 2010). The topographic variationon the earth surface is modified due to these activities, which also controls the landscape. Therefore, morphotectonic studies can reveal how such landscapes develop with time and space. In this study remote sensing and geographic information system based morphotectonic studies has been carried out. Different data products were used in the present study including satellite imageries and digital elevation model (DEM)for GIS works and topographic maps to evaluate the properties and to create drainage systems. Here, morphotectonic parameters, like Stream Length gradient index (SL), absolute Asymmetric Factor (|AF|), Transverse Topographic Symmetry Factor (T) etc. were calculated for 32 basins in the study area. Moreover, to understand the lineament patterns, the study of tectonic evolution through evidence from relative plate motion becomes essential (Ramli *et al.*, 2010). Therefore, the morphotectonic analysis is important for delineating the activeness of such tectonic features.

The study area is situated in the accretionary prism of the subducting Indian Plate along the ‘Mega Thrust’ beneath the Burmese Plate. The eastward subduction of Indian plate in the study area along the subduction surface causes the compressional stress in the upper crustal region, which gave rise to the hill ranges around the IBA. Moreover, the fault system around the study area controls the evolutionary processes. The study area is constrained by many fault zones viz. Dauki Fault (DF), Naga Thrust (NT) which are present in the north; Gumti Fault (GF) in the north-west; Kaladan Fault (KF), Chittagong Coastal Fault (CCF) in the west and Kabaw (KF) along with Sagaing Fault (SF) system in the east (Fig. 1). Churachandpur-Mao Fault (CMF) is another important strike-slip fault in the IBA.

Methodologies

Morphotectonic parameters were determined from different order basins dra-

Table 1: Morphotectonic parameters for all 32 basins in the study area

	Basin Name	Absolute AF	T	SL
1	Champhai Lake	1.56	0.58	395.73
2	Buang	12.45	0.32	244.44
3	Puaichhar	28.02	0.66	452.59
4	Paleo-Tuipui	9.87	0.36	127.09
5	Ramri	6.47	0.31	454.88
6	Khamkeh	23.41	0.4	1811.05
7	Tuikual	18.99	0.23	447.03
8	Mau	13.98	0.33	286.57
9	Tuitop	8.72	0.18	1450.12
10	Pumpet	4.81	0.44	989.16
11	Khuai	2.58	0.26	269.79
12	Tuikhhur & Kawngkhwn	23.23	0.35	896.78
13	Phalpha	20.44	0.25	960.92
14	Saikah	4.47	0.23	684.34
15	LongpuiZowl	9.31	0.16	1490.46
16	Bangla	20.40	0.31	1134.81
17	Saikhur	10.81	0.34	613.93
18	Khuai	16.36	0.28	479.62
19	Kurung	5.38	0.37	564.74
20	Smiti	18.05	0.35	547.82
21	Sawntlung	6.26	0.28	582.95
22	Saitawng	1.22	0.19	697.12
23	Lungverh	4.84	0.42	654.85
24	Far	16.26	0.45	1862.32
25	Nghasih	0.84	0.22	986.56
26	Narkawn	19.65	0.11	889.97
27	Tuishing	22.68	0.36	1125.12
28	Artlang	0.68	0.23	862.05
29	Tuitho	14.46	0.21	954.78
30	TuiMukh	9.56	0.11	1285.25
31	Tualte	5.88	0.33	995.68
32	Thlikva		0.57	887.65

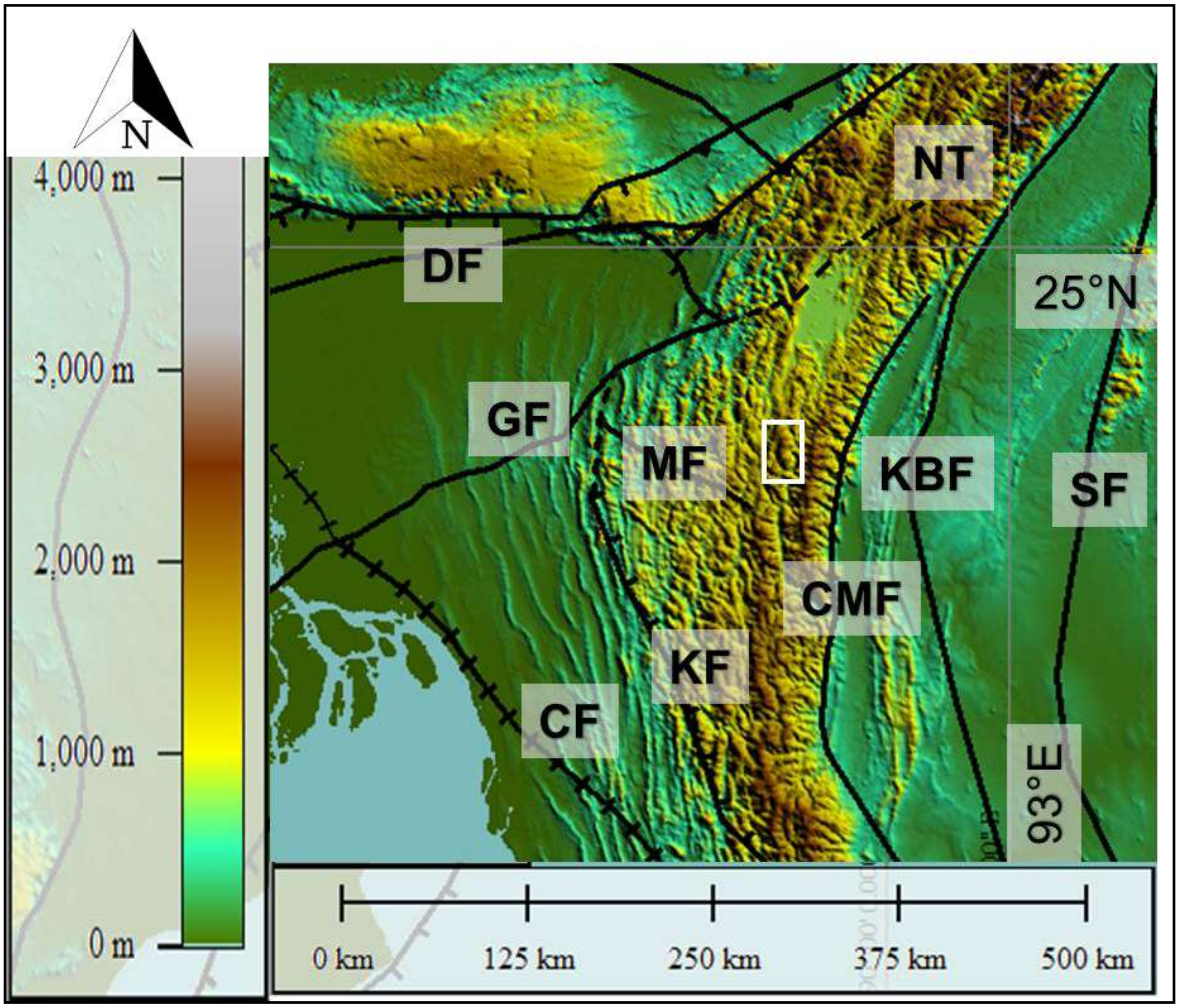

Figure 1: The regional tectonic features are shown on DEM. Some important fault systems in region are- NT-Naga Thrust, DF- Dauki Fault, GF- Gumti Fault, CF- Chittagong Fault, KF- Kaladan Fault, CMF-Churachandpur Mao Fault, KBF- Kabaw Fault, MF-Mat Fault, SF- Sagaing Fault.

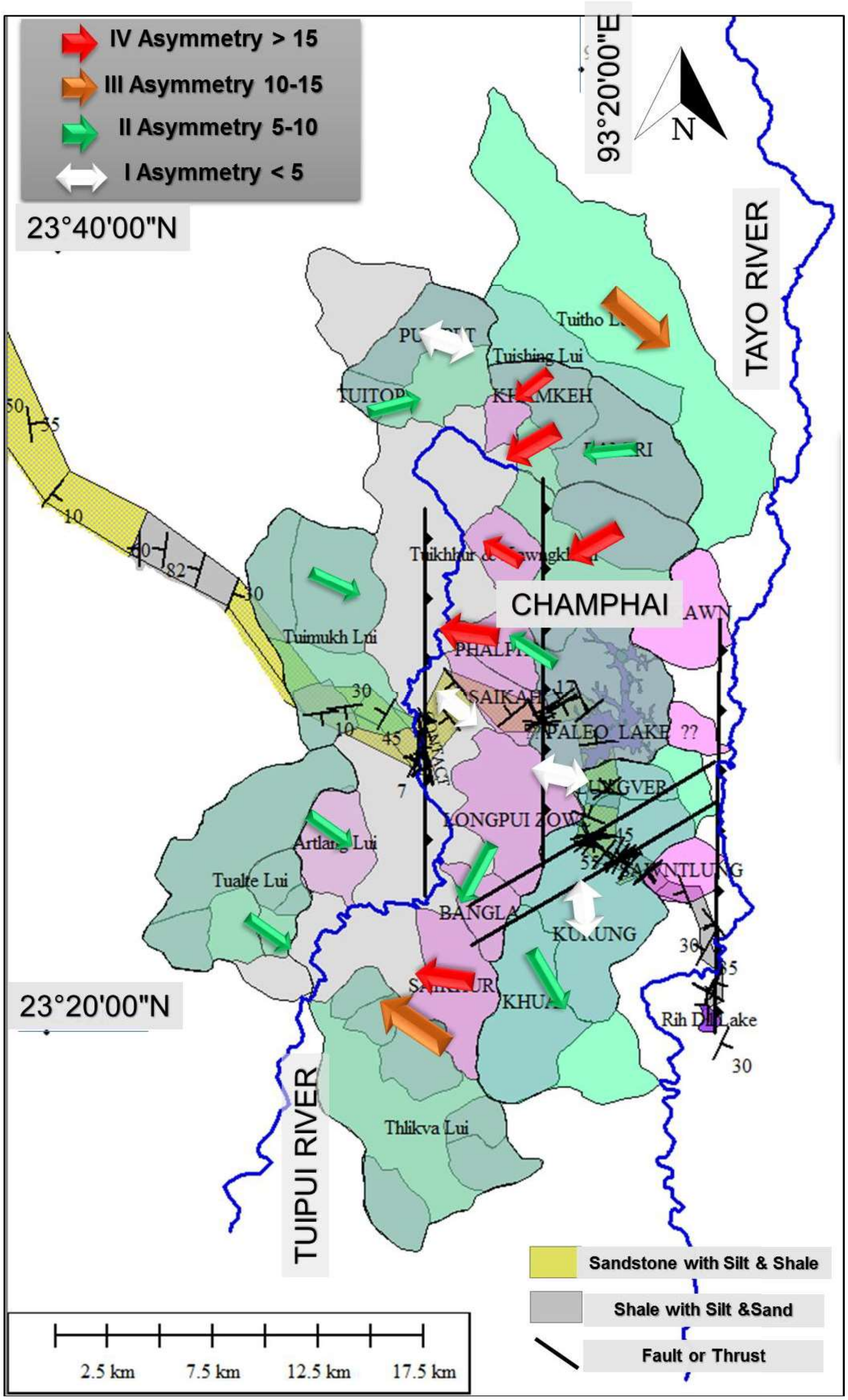

Figure 2: Tilting of the basins are indicated by |AF| ranges for some basins with geological map of the area

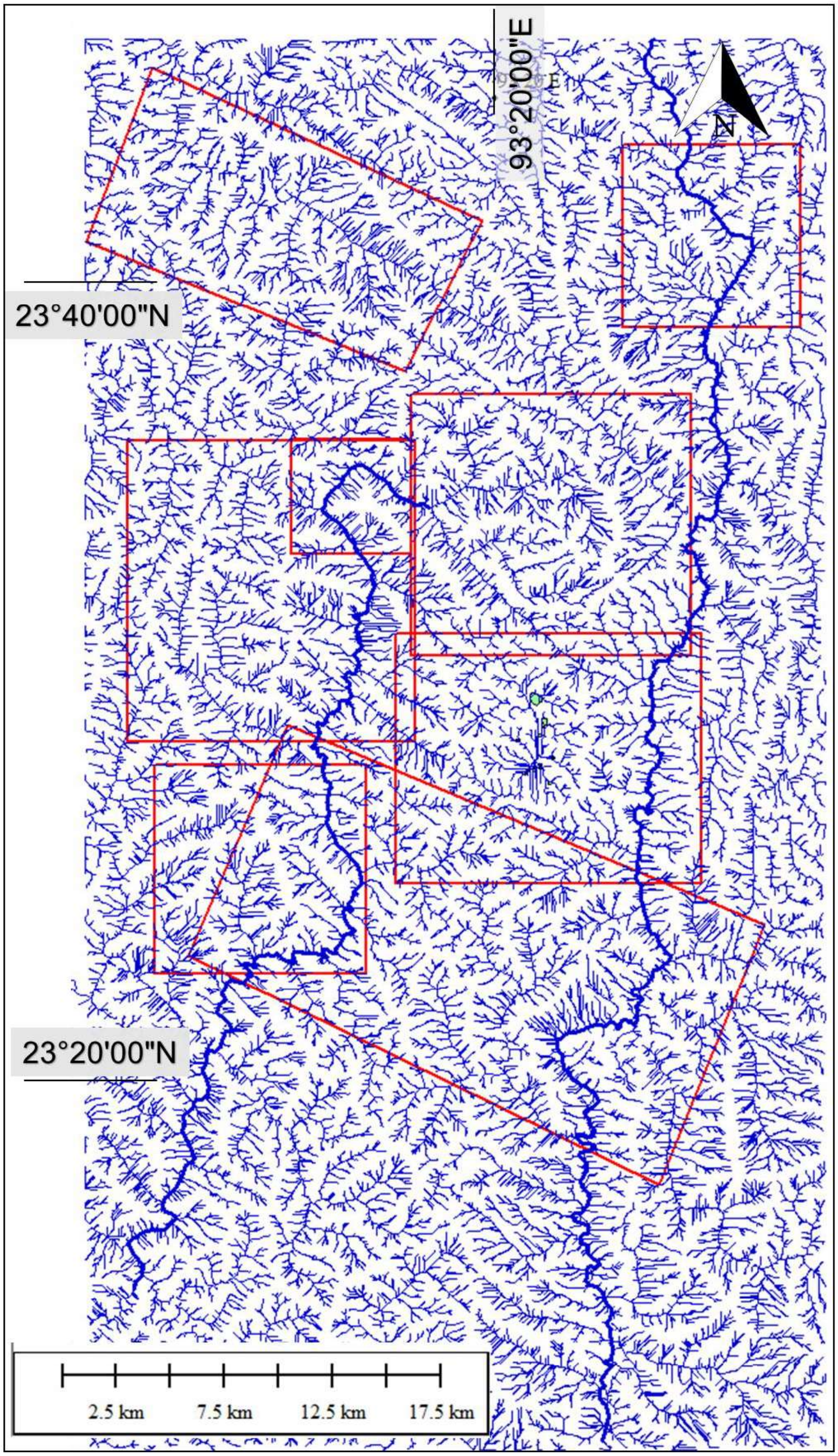

Figure 3: Drainage anomaly of the area shown by the boxes

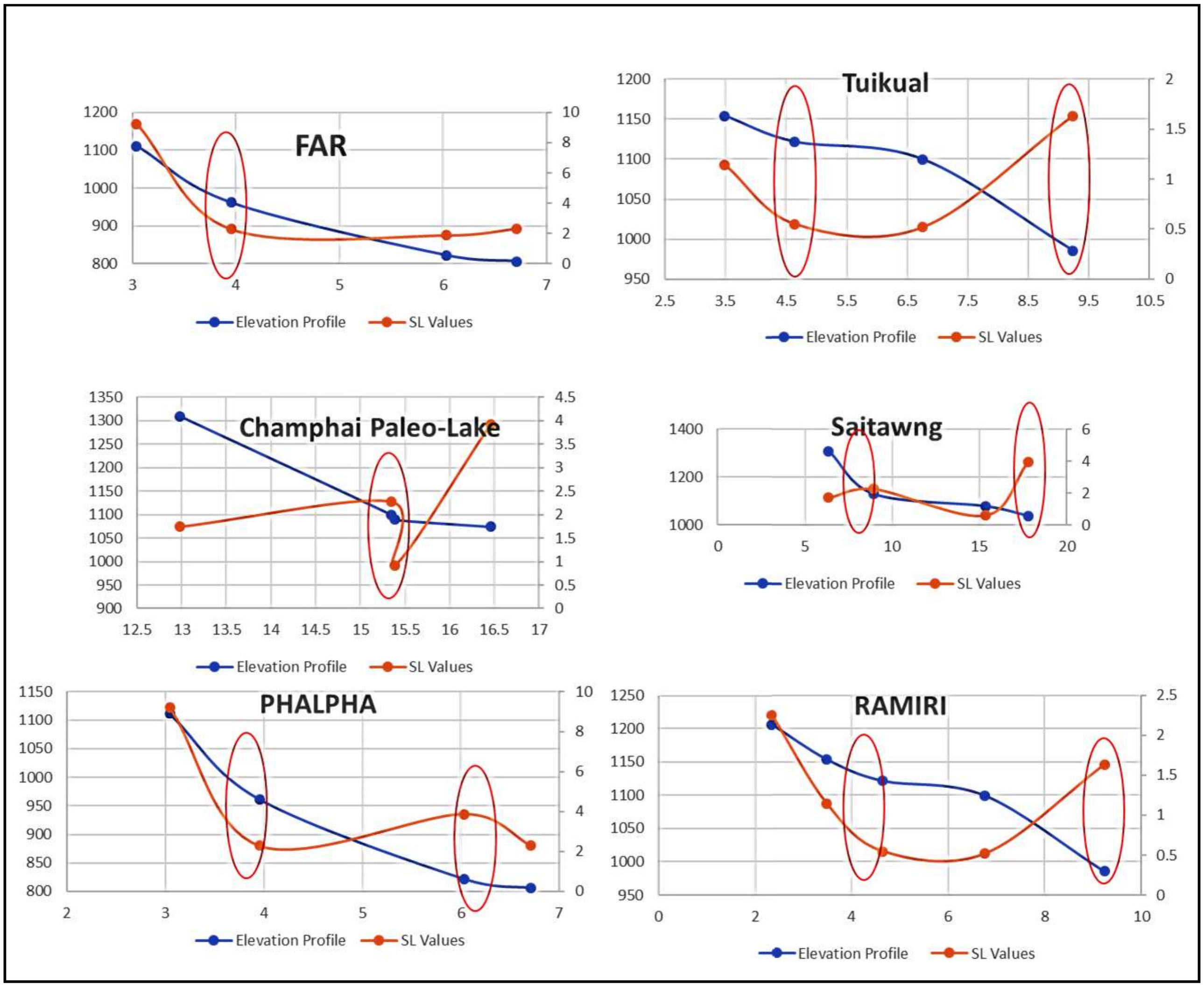

Figure 4: SL vs river long profile for some of the basins for the area

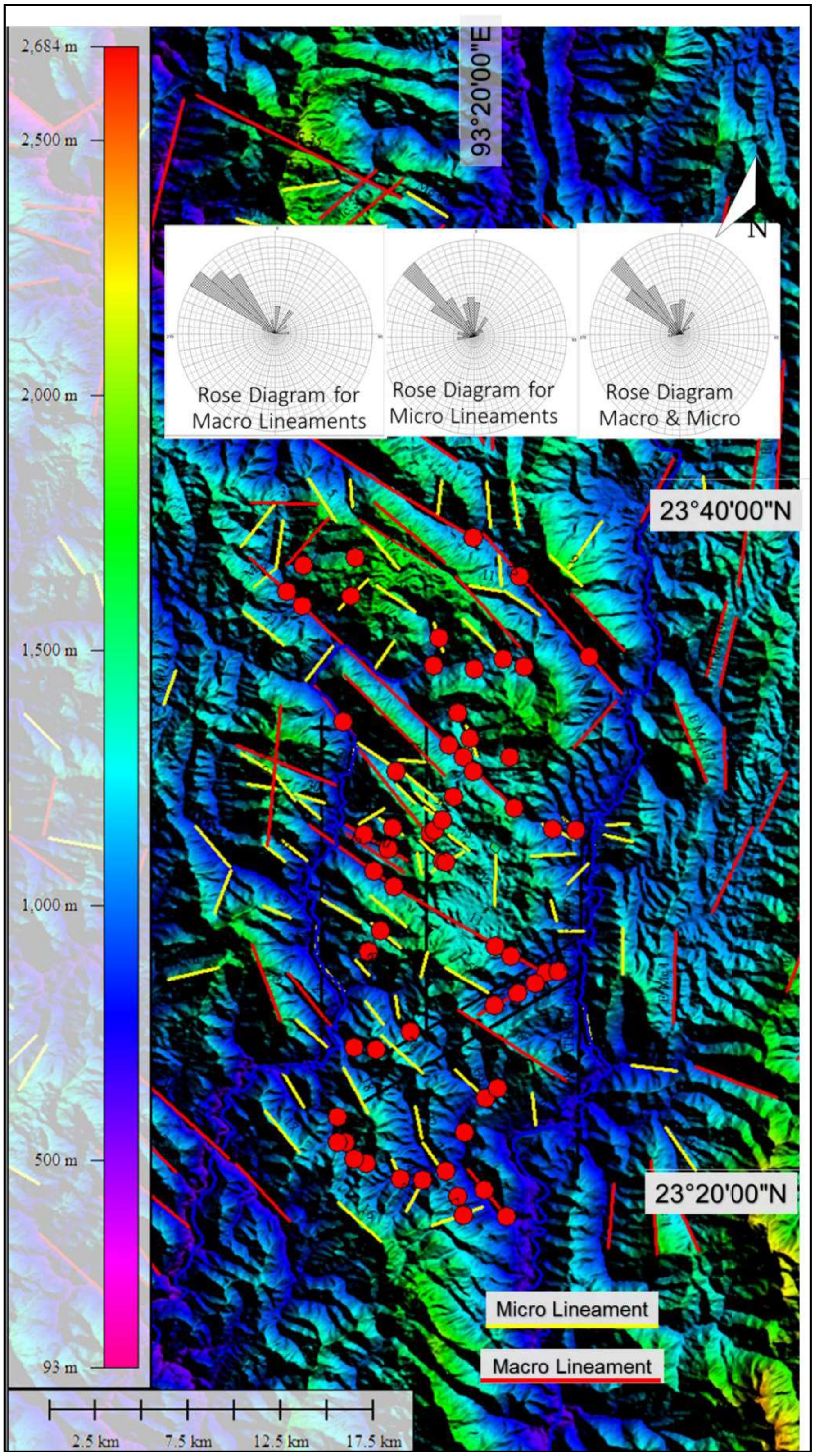

Figure 5: Lineament map of the area with anomalous SL points shown in a DEM map

-wn from Survey of India (SOI) toposheets and DEM (30 meter, derived from ASTER imageries). These imageries and toposheets were georeferenced by using Global Mapper v.15 software. Using of DEM helps us to demarcate different order streams, watersheds and lineaments. Morphotectonic parameters that were used in this study are Stream Length-Gradient Index (SL), Asymmetric Factor which is also known as Drainage Basin Asymmetry (AF), and Transverse Topographic Symmetry Factor (T). AF values indicate tilting of the area that caused by the presence of any tectonic deformation (Keller and Pinter, 2002). Generally, AF values are used but to delineate the grade of deformation or tilting, absolute AF values are used. The absolute asymmetry factor can be calculated using a simple formula. This formula is mathematically stated as $|AF| = |50- [100 (Ar/At)] |$; here Ar = total area in the right bank, when looking downstream of a river and At = Total area of the basin considered. Transverse Topographic Symmetry Factor (T) is evaluated by the following equation: $T=Da/Dd$, where Da is the total distance from the midline of the drainage basin to the meander, and Dd is the distance from the same midline upto the basin divide (Cox, 1994). Moreover, Stream Length-Gradient Index (SL) which is determined by using the formula: $SL=(\Delta H/\Delta L)\ L$. In this formula where $\Delta H/\Delta L$ is the channel slope and L is the total channel length between two points of the stretch considered at that instance (Hack 1973, Ramirez-Herrera, 1998; Azor *et al.*, 2002). SL values were calculated for each stream and channels and the values were plotted against river long-profile to identify the anomalous zones. Drainage patterns are drawn and evaluated for the presence of anomaly that would indicate structural or lithological control over the study area. The lineaments are marked using both toposheets and were correlated with lineaments that were extracted from DEM. Rozetta software was used to plot Rose diagram for lineament study.

Result and Discussion

Morphotectonic parameters were used to understand the active tectonic condition in the study area. AF index is used to identify and characterise the tilting pattern in the area (Table 1). Moreover, T values also indicate the tilting direction of the basins that can be used to identify the basin deformation pattern. The range of T values is found to be between 0.12-0.66. Most of the basins are found to be tilted towards NW or SE direction. This is because of the presence of multiple faulting zones being active in the area (Fig. 2). Tuipui river is showing WNW highly asymmetrical (|AF|=range IV) tilted basins whereas the western basins have SE moderately asymmetrical (|AF|=range III) basins. The basins on the eastern part of the Tuipui water-divide shows moderate to high asymmetry and SSE tiling. Although the basins near to the origin of Tuipui River and some of the surrounding areas viz. Near Champhai, Khuai Lui and five others show symmetrical to moderately symmetrical basins (range I-II). Some basins are associated with weak lithologies indicated by the grey colour polygons shown in Fig. 2 indicating the presence of argillaceous lithology. The area is also bounded by regional fault systems, with some other local factors. There are as many as three thrust zones as well as more than two strike-slip fault zone present in the area, which has regional scale association. Apart from that, there are some other small local scale disturbances that were also observed from the AF analysis. The fault zones have been found to directly control the tilting or deformation patterns of the basins and antiformal hill ranges. Therefore, these faults are also controlling the lineament pattern in the area which is discussed later.

The variations in the surface and sub-surface crustal dynamics are related to the morphological changes in topography. These changes can be observed in the drainage map for the entire study area (Fig. 3). There are considerable regions showing drainage pattern which seems to be out of order or sequence. These changes are noticed in the drainage map and have been demarcated as drainage anomalies. The anomalies that were found as circular, oval, rectangular, trellis, and some other unique continuous channel pattern both from north-south and east-west transects. These later patterns are associated with regional faults and furthermore they also show a relation with the lineaments in the region. Therefore, it can be stated that the fluvial morphological changes in the area are definitely constrained by the tectonic forces working beneath the study area.

SL values are delineated for each basin to understand the influence of the regional tectonics in the local deformational pattern along the stretch of the river or channel. SL values are self-explanatory for variable changes in a basin, although their best use can be seen when the SL values are plotted against the river long profile (Fig. 4). SL values are showing an anomalous trend in some of the river stretch for each basin which might also indicate profile change or knick points. This anomalous SL points when plotted in a lineament map as shown in Fig. 5. There are many elongated to moderately elongated basins which shows many anomalous SL points which coincides with the lineaments and tectonic features in the area indicating activeness of the region. Macro and micro lineament plots indicate different trends in local stage although most of them follow the regional NW trend. This regional trend is quite opposite to the NNE stress component of Indian Plate with respect to Burmese Plate, indicated by the plate motion studies. The anomalous SL points are found to be associated with lineaments in the region which can be explained by the differential rate of crustal movement (Tiwari *et al.* 2015) which enhances the diverse stress accumulation in the region.

Conclusion

This study helps us to identify the active tectonic features around the study area, bounded by some fault systems. The AF and T values indicate moderate to highly tilted basins which are also elongated to semi-elongated in shape. Most of the basins also comprise of the drainage systems that are having anomalous patterns which are indicative of deformational processes that are active in the region. The anomalous SL points associated with different lineament patterns in the area indicate a different deformational history of the area. The area shows mostly NW-NNW stress component which indicates tilting and deformational settings of the active tectonics shown by the different basins. Most part of present Champhai town is situated in the plain area with a number of small hillocks. This plain area is formed by sedimentation in the paleo-lake which is present earlier in the area. A similar feature is observed in the Rihdil Lake, 18 km away from the town. Tayo and Tuipui thrustsare the principal bounding components. These results are also found to be associated with dextral and oblique motion in parts of IBR. The greater dextral motion in the later phase also provides an account for the development of NW-SE trending strike-slip faults (viz. Mat fault, Gaumti Fault) and other lineaments in the area. Due to this many series of plunging antiform-synform systems are deformed to produce NW-SE lineaments. Therefore, from this study, it is seen that the area is under the active tectonic regime of the Indo-Burmese Ranges.

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