# TECTONIC GEOMORPHIC HISTORY OF TEIREI WATERSHED, MIZORAM

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**ABSTRACT** *Mizoram is one of the tectonically very active regions of India. The topography is immature as a result the area shows high topographic relief. The Teirei watershed which spreads in an area of about 688 km² in Mamit district of Mizoram in the northeast India exhibits a variety of structural and fluvial geomorphic features along with geomorphic signatures indicating ongoing tectonic activity. An attempt is made in this study to reconstruct the tectonic geomorphic history with the help geomorphic signatures and tectonic indicators.*

***Keywords:*** *Geomorphic signatures, tectonic activity, Teirei watershed, structural control, Indo-Burmese Wedge*

## 1.Introduction

Mizoram falls under high intensity seismic zone (Zone V) in the northeast India. The topography is highly complex with linear to curvilinear, narrow crested, north–south aligned structural hill ranges separated by deep structural valleys. As the area is tectonically active, quite a good number of fractures, faults and lineaments are formed across the terrain. Most of the structural valleys are controlled by the existing structural features like long faults. In fact, a majority of the fluvial systems are also largely controlled by faults and fractures developed by the strong ongoing tectonic activity at a number of sections along the river courses. As a result, several rivers exhibit straight courses for several kilometres. About 100 metres long and 5 -10 m deep fault scarps developed in this area at different places in Mizoram clearly indicate the intensity of tectonic activity. In addition, many streams exhibit straight courses in different directions in this area. For instance, a major river called 'Mat lui' in Mizoram exhibits a clear transverse fault in NW-SE direction shows a shallow shear motion along its river course for about 9-10 kilometres which is the extension of Indo-Burmese Wedge. It clearly shows the motion between India and Sunda plates along the Churachandpur Mao Fault (CMF) in the Indo-Burmese Wedge and Sagaing Fault in the Myanmar region (Tiwari et al ., 2015). Moreover, many fluvial systems exhibit drainage anomalies as geomorphic characteristics of an area are preserved drainage basins if the area is under the influence of tectonic activity (Shabir Ahmad, 2012). The present study is an attempt to understand the tectonic influence on Teirei watershed.

## 2.Materials and Methods

The boundary of the study area was extracted from the survey of India topographical maps 83D/8, 83D/12, 84A/5, 84A/6 and 84A/9 on 1:50,000 scale. IRS P6, LISS IV, MX, Geocoded satellite imagery and topographical maps have been used with field checks to interpret the geomorphic features. Digital elevation models of the study area acquired by SRTM (Shuttle Radar Topography Mission) of United States Geological Survey have been used to indentify significant morphotectonic features. ArcGIS 9.3 software has been used for onscreen digitization of the maps.

## 3.Study area

The study area 'Teirei' watershed is located between 92° 22' – 92° 33' E longitudes and 23° 35' – 24° 12' N latitudes in the Mamit district (Fig.1). It is an elongated watershed in north-south direction covering an area of about 688 km² . 'Teirei' also known as 'Pakva' is the main river draining in the study area. The river is originated in the southern part of the watershed at an elevation of 1080 m near Saithah village. It flows in north direction over a length of 105 km and joins the river Tlawng in the northeastern part of the district near Bairabi village. The river flows further in north direction in Cachar district of Assam and finally joins the river Barak. This elongated watershed is bounded by Tut on the east, Langkaih on the west, Khawthlangtuipui on the south and Mat watersheds on the southwest. The Teirei watershed is bounded topographically by two long hill ranges on the east and west. The eastern hill range is located an average elevation 900 m while the highest point on this ridge is 1253 m above MSL whereas the western ridge is comparatively lower than the eastern ridge with an average elevation of 600 m and the highest point on this ridge is located in the southwestern part at an elevation of 1265m above MSL.

The study area experiences humid tropical type of climate with an average rainfall of about 3000 mm while the district annual average is 2391.42 mm. Temperature ranges between 6$^{o}$C and during winter and 32$^{o}$ C summer, respectively. As the study area is purely a sedimentary terrain, it is composed of rocks such as sandstones, siltstone-shale complex and clayey sand formed in long folds during the Tertiary period (Ganju, 1975). Soils are mostly Entisols, Inceptisols and Ultisols. The area is characterized by tropical wet-evergreen and tropical semi-evergreen forest types owing to its tropical location.

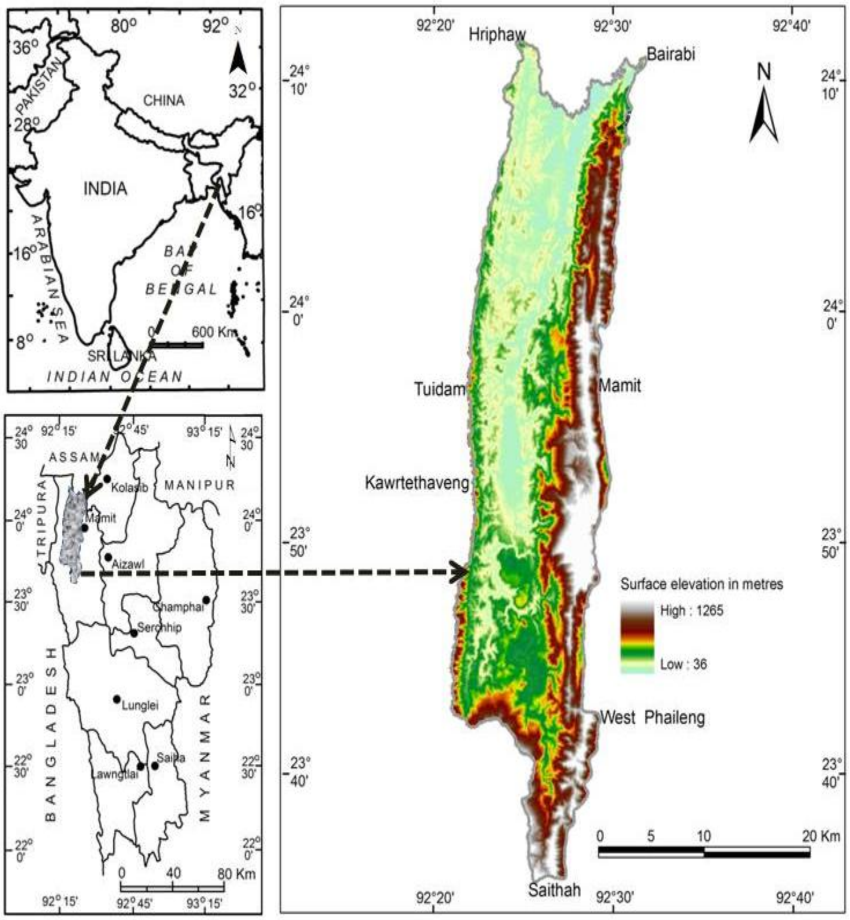


Fig.1 Location map of the study area (Digital Elevation Model)

## 4. Results and Discussion

## 4.1 Reconstruction of Geomorphic History

### 4.1.1 Geomorphic Signatures

The Teirei watershed provides several geomorphic and morphotectonic signatures in its geomorphic set-up. The area exhibits quite a good number of structural features such as faults and lineaments in prominent direction. The major landforms found in this area are broadly of structural and fluvial origin.

#### 4.1.1.1Structural landforms

The structural landforms such as (i) structural hills, (ii) structural valleys (iii) faults/fractures/lineaments, (iv) fault scarp and (v) escarpment are the prominent geomorphic features identified in the watershed.

Structural hills are mostly narrow crested and oriented in north - south and also in E-W direction, concentrated more on the eastern side of the study area. These are separated by deep valleys which are controlled by long faults at many sections in this watershed. A majority of the valleys exhibit straight courses indicate its structurally controlled directions (Fig.2 and 3). The central part of the watershed exhibits elevations around 36 m above MSL. The entire basin appears to be tilted towards its left and northeast (WNW- NNE) as seen on digital elevation model.

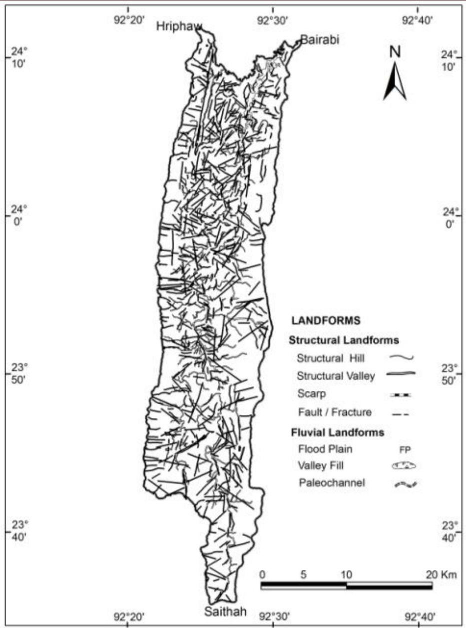


Fig.2 Landforms in the study area.

Faults are the major tectonic features in this area which control streams and the main river course at several segments along the 105 km long Teirei river. Faults are oriented in almost in 360 º directions of which those run in NE-SW, NW-SE and E-W directions are striking denote the intensity of ongoing tectonic activity.

About 200 - 300 m long and 5 – 10 m deep faults scarps and escarpments are seen on the eastern part of the study area along the northern and western edges of the long hill ranges which are believed to be formed by the rigorous ongoing tectonic activity.

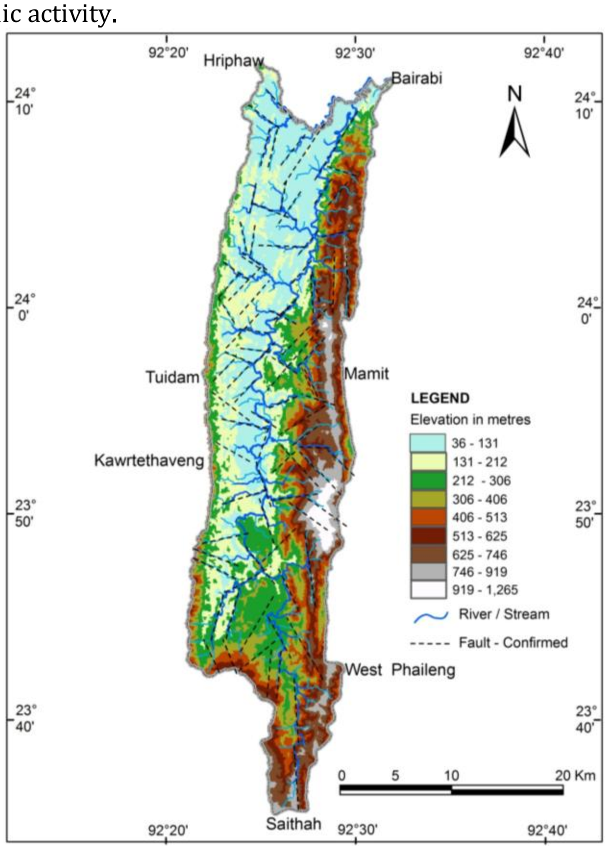


Fig.3 Digital elevation model showing orientation of major faults in the study area.

#### 4.1.1.2 Fluvial Landforms

Flood plain, paleochannels and valley fills are the significant fluvial landforms which indicate the ongoing tectonic history in this area.

A narrow strip of about 250 – 400 m long and 6 km wide flood plain is seen on the left bank of the river Teirei in downstream section before its confluence in the northeastern part of the study area. About 3-4 sets of paleochannels are seen in this flood plain (Plate 1A & 1B). Similarly, in the middle reaches of the watershed a series of paleochannels exist in the waterlogged areas with marshy /swampy land on the right side and also left side of the main course. Valleys fills are also seen in several places on the eastern side of the structural hills.

### 4.2 Drainage Anomalies

The area is characterized by dendritic drainage network as the terrain is composed of uniform lithology with sedimentary rocks. Trellis and parallel types are also seen in the northwestern and central parts due to strong structural control as the presence of horizontal bedded sandstone and siltstone-shale lithounits in this terrain. The drainage density in the Teirei watershed ranges from 3.54 - 6.66 km/km$^2$ which signifies the area has high drainage network. A majority of the streams in this area are controlled by faults which are oriented in preferred directions.

### 4.3 Tectonic Indices

The significant tectonic indices such as basin elongation ratio, transverse topographic asymmetry, basin asymmetry and lineament density reveal some significant inferences on the nature and intensity of tectonic activity.

#### 4.3.1 Basin elongation ratio (Re)

It is defined as the ratio of diameter of circle having the same area as the basin (A) and the maximum basin length (Lb) (Schumm ,1956). It is one of the most significant factors which indicates tectonic activity. This can be computed using the following formula.

$$Re = 2A/\pi/Lb$$

The elongation ratio value obtained for Teirei watershed 0.12 shows elongated shape of the basin which is less than 0.70 of the range of the values of elongation ratio (Schumm, 1956). According to Bull and McFadden (1977) scale of tectonic intensity the values less than 0.50 can be considered as tectonically active influenced by folding and faulting.

#### 4.3.2 Transverse topography asymmetry (T)

It is ratio of distance from stream channel to midline of the drainage basin and the distance from midline to the basin margin. This gives an idea of lateral tilting of a basin (Cox et al. 2001). The value close to 1, indicates the migration of stream laterally away from the middle of the basin towards the margin, representing the tilted basin (Prakash et al.2016). The average value of T factor obtained for the basin is 0.382 (Table 1). The high values ranging from 0.317 to 0.780 at certain sections along its course indicate migration of channel towards margin of the basin (Fig.4) due to change in lithology from sandstone to siltstone-shale, structural control by faults and other tectonic disturbances such as tilting of the basin (Prakash et al. 2016).

Table 1: Transverse topographic asymmetry values.

| Segment | Da | Dd | Da/Dd | Segment | Da | Dd | Da/Dd |
|---|---|---|---|---|---|---|---|
| 1 | 0.431 | 1.585 | **0.272** | 16 | 2.94 | 6.337 | **0.464** |
| 2 | 0.469 | 1.66 | **0.283** | 17 | 0.912 | 6.071 | **0.150** |
| 3 | 0.836 | 1.952 | **0.428** | 18 | 1.178 | 6.122 | **0.192** |
| 4 | 0.101 | 2.944 | **0.034** | 19 | 1.901 | 5.995 | **0.317** |
| 5 | 0.405 | 2.522 | **0.161** | 20 | 1.191 | 5.488 | **0.217** |
| 6 | 0.663 | 2.446 | **0.271** | 21 | 0.532 | 6.16 | **0.086** |
| 7 | 0.431 | 3.625 | **0.119** | 22 | 3.838 | 6.297 | **0.609** |
| 8 | 0.76 | 4.994 | **0.152** | 23 | 3.988 | 6.15 | **0.648** |
| 9 | 1.838 | 3.853 | **0.477** | 24 | 3.985 | 5.954 | **0.669** |
| 10 | 0.709 | 6.109 | **0.116** | 25 | 3.542 | 5.907 | **0.600** |
| 11 | 2.617 | 5.83 | **0.449** | 26 | 4.28 | 5.707 | **0.750** |
| 12 | 2.078 | 5.615 | **0.370** | 27 | 4.381 | 5.614 | **0.780** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | 2.218 | 6.578 | **0.337** | 28 | 3.652 | 5.658 | **0.645** |
| 14 | 3.384 | 5.729 | **0.591** | 29 | 2.263 | 3.247 | **0.697** |
| 15 | 1.115 | 5.767 | **0.193** | | | **Mean** | **0.382** |

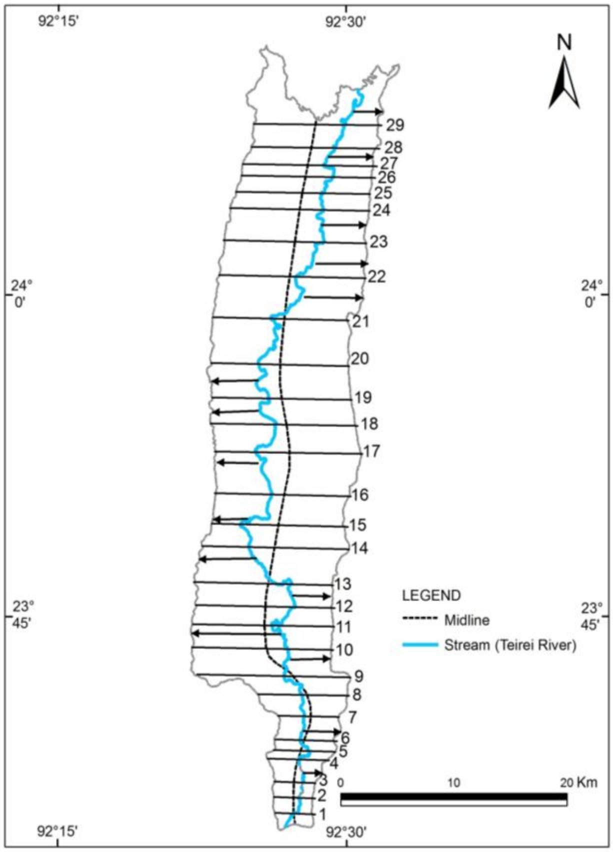


Fig. 4 Migration of channel towards basin margin (numbers indicate location of segments and arrows indicate direction of channel shifting)

### 4.3.3 Asymmetry Factor (AF)

Basin asymmetry or asymmetry factor is useful to estimate tilting of drainage basins with reference to main river course due to impact of tectonic activity (Hare and Gardner 1985; Cox 1994) ; Cuong and Zuchiewicz 2001; Raj 2012 ). It is defined as the ratio of area of the right side of the drainage basin (Ar) facing downstream to the total area of the basin (At) multiplied by 100 (Gardner et al., 1987). It is calculated using the following formula .

$$\text{Asymmetry Factor (AF)} = (Ar/At)\ 100$$

The value obtained in the study is 46.9. This value indicates the channel has shifted towards right side of the basin facing downstream as the value is less than 50 (Molin et al.,2004). It is also clear from transverse topography asymmetry observation that the channel has shifted to its right side boundary. The channels in these areas particularly in the middle reaches and downstream areas before the confluence are characterized by meander scars, meander cut-off and paleochannels as seen in high resolution google earth images (Plate 1A & B).

### 4.3.4 Lineament Density

Lineaments are oriented in NE-SW, NW-SE and a few in N-S directions. Most of the streams and the main river course are guided by faults at many parts. Its density ranges between 0.038 and 0.212 km/km$^2$ (Fig.5). The western and northern parts show comparatively low lineament density whereas the central, eastern and a small extent of the southern parts show medium to high lineament density. The presence of number of lineaments in preferred directions aligning with streams indicate the intensity of ongoing tectonic activity.

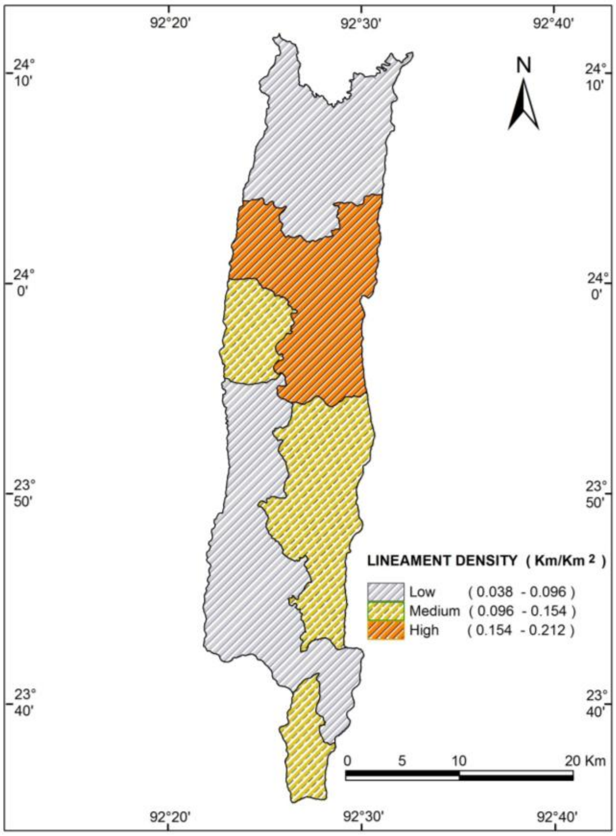


Fig.5 Lineament density.

The area is tectonically active as indicated by several geomorphic signatures and tectonic indices. The presence of number of structurally controlled streams, existence of fault scarps, paleochannels, shifting of river courses strongly support the ongoing activity in this area. The existence of paleochannels in middle reaches and also in the downstream section on the left side of the main river course suggest that the river is shifting its course progressively towards its right side i.e. eastward. It has been observed based on the overlay of drainage layer on lithology layer in GIS environment that the river has shifted its course towards left side when it flows through sandstones and shifted to its right side when it flows through siltstone-shale complex. It is clear from this observation that lithology has played a major role in guiding the river channel by structural control in addition to faulting. The high values of transverse topographic asymmetry and basin asymmetry indicate the migration of the main channel towards the right margin of the basin due to change in lithology from sandstone to siltstone-shale, structural control by faults and other tectonic disturbances such as tilting of the basin. Further, the basin elongation ratio also reveals that the area is tectonically active by folding and faulting.

### 4.4 Conclusion

It is surmised based on the existence of number of faults in preferred directions, alignment of streams and river courses with the active faults, existence of paleochannels, shifting of river courses and tilting of the basin strongly support the ongoing tectonic activity in this area.

### References

1. Bull, W.B. and McFadden, L.M. (1977) Tectonic geomorphology of North and South of the Garcloack Fault, California. Journal of Geomorpholology, 1,15-32.
2. Cox, R.T. (1994). Analysis of drainage basins symmetry as rapid technique to identify areas of possible quaternary tilt-block tectonics: an example of from Mississippi Embayment. Geological Society of America Bulletin, 106, 571-581.
3. Cuong, N.Q and Zuchiewiecz, W.A. (2001). Morphotectonic properties of the Lo River fault near Tam Dao in North Vietnam. Natural Hazards and Earth Systems Science, 1,15-22.
4. Ganju,J.L.(1975). Evolution of the Orogenic Belts of India. Geological Minerological Meteorological Society of India, Bulletin, 48, 17-26.

5. Gardner,T.W., Back,W., Bullard,T.F., Hare,P.W., Kesel,R.H., Lowe, D.R., Menges, C.M., Mora,S.C., Pazzaglia, F.J., Sasowsky,J.D., Torester, J.W. and Wells, S.G.(1987). Central America a and Caribbean. In: Graf, W.L.(ed.), Geomorphic systems of North America: Boulder Colorado. Geological Society of America, Central Special, 2, 343-401.
6. Hare, P.W. and Gardner, T.W.(1985). Geomorphic indicators of vertical neotectonism along converging plate margins, Nicoya Peninsula, Costa Rica. In: Morisawa M, Hack, J.T (eds) Tectonic Geomorphology : Proceedings of the 15th annual Binghamton geomorphology symposium Allen at Unwin, Boston. 90 -104.
7. Miller, V.V.(1953). A Quantitative Geomorphic study of Drainage Characteristics in linch Mountain area, Virginia and Tennessee. Technical Report 3, Office of the Naval Research, Department of Geology, Columbia University, New York, 150p.
8. Molin, P., Pazzaglia, F.J. and Dramis, F.(2004). Geomorphic expression of active tectonics in a rapidly deforming forearc, Sila massif, Calabria, Southern Italy. American Journal of Science, 304 (7),559-589.
9. Raj, R.(2012). Active tectonics of NE Gujarat (India) by morphometric and morphostructural studies of Vatrak River Basin. Journal of Asian Earth Science, 50, 66-78.
10. Schumm, S.A.(1956) .Evolution of drainage systems and slope in badlands at Perth Amboy, New Jersey. Geological Society of America Bulletin, 67, 597-647.
11. Shabir Ahmad, M.I.Bhat (2012). Tectonic Geomorphology of the Rambiara basin, SW Kashmir Valley reveals emergent out-of-sequence active fault system. Himalayan Geology, 33(2), 161-172.
12. Tiwari, R.P., Gahalaut, V.K. U.B.Rao, Ch., Lalsawta, C., Kundu,B. and Malsawmtluanga (2015). No evidence for shallow shear motion on the Mat Fault, a prominent strike fault in the Indo-Burmese wedge. Journal of Earth Systems Science, 24 (5), 1039-1046.


Plate 1 A: Paleochannels, meander scars and meander cut-off in the downstream of Teirei river.The river channel is progressively shifting towards its right side.Remarkably, flood plain is seen on leftside only.


Plate 1 B: Middle part of the river Teirei showing shifting of river channel towards its right side. Paleochannels, meander scars, meander cut-offs and oxbow lakes can be seen on the left side of the river.