Morphotectonic Indices of the Mae Ping Fault Zone, Northwestern Thailand

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Abstract

The Mae Ping fault zone trends NW-SE across northwestern Thailand into Myanmar has sinistral strike-slip movement where estimated 500 km long. This fault zone first occurred in late Cretaceous and has been developed until now. Digital Elevation Data and satellite images were used to identify lineaments and fault. Morphotectonic analysis was used in order to better understand uplift, exhumation and erosion of the Mae Ping fault zone. Geomorphic indices were generally used to define tectonic active zone. Mountain front sinuosity index and Valley floor width to height ratio were selected. Most evidences show that the Mae Ping fault zone high tectonic activities until present. The active regions are identify by low values of mountain front sinuosity and valley floor width to height ratio are supported the concept that mountain topography is extremely impacted by active tectonics along the fault zone. This study result indicated that southern part of the Mae Ping fault zone is high tectonic activities.

Keywords: Morphotectonic analysis, Geomorphic indices, Mae Ping fault zone, Active faults

1. Introduction

The northwestern part of Thailand is the one of tectonic regions that shows expanded strike-slip faults. One of the major faults in this network is the Mae Ping fault zone (the other name is Wang Chao fault zone) (Lacassin et al. 1997; Morley 2007). The Mae Ping fault zone trends NW-SE from Myanmar to the northern part of central Thailand and its prolongation to SE is uncertain. The Mae Ping fault zone is estimated 500 km long which other interpretations expand Mae Ping fault zone over 1000 kilometers long to reach the Mekong delta in southern part of Vietnam (Lacassin et al. 1997; Leloup et al. 2001).The NW-SE Mae Ping fault zone has a major control of the landform change and stream profile of the area. Unfortunately, this fault zone has not been clear in detail, probably because its location along the border between Myanmar and Thailand, including highly mountain, dense forest, and logistic problem. The Mae Ping fault zone is located in tropical area and associated with high erosion rates which critically change or destroy morphotectonic appearance. Hence, these surfaces processes of tectonic activities can be used data obtain from remote sensing method (e.g., digital elevation models

(DEM), satellite images) and geological map to investigate them (Biswas & Graseman 2005; Bhatt 2007). These present research improve interpretation of tectonic activities in term of interaction between tectonic processes and erosional processes along the Mae Ping fault zone and supported previous data of this fault zone as its active until present and morphology were produced by tectonic activities. This study shows that fault zone in three sections which major NW-SE trending with component of morphotectonic indices.

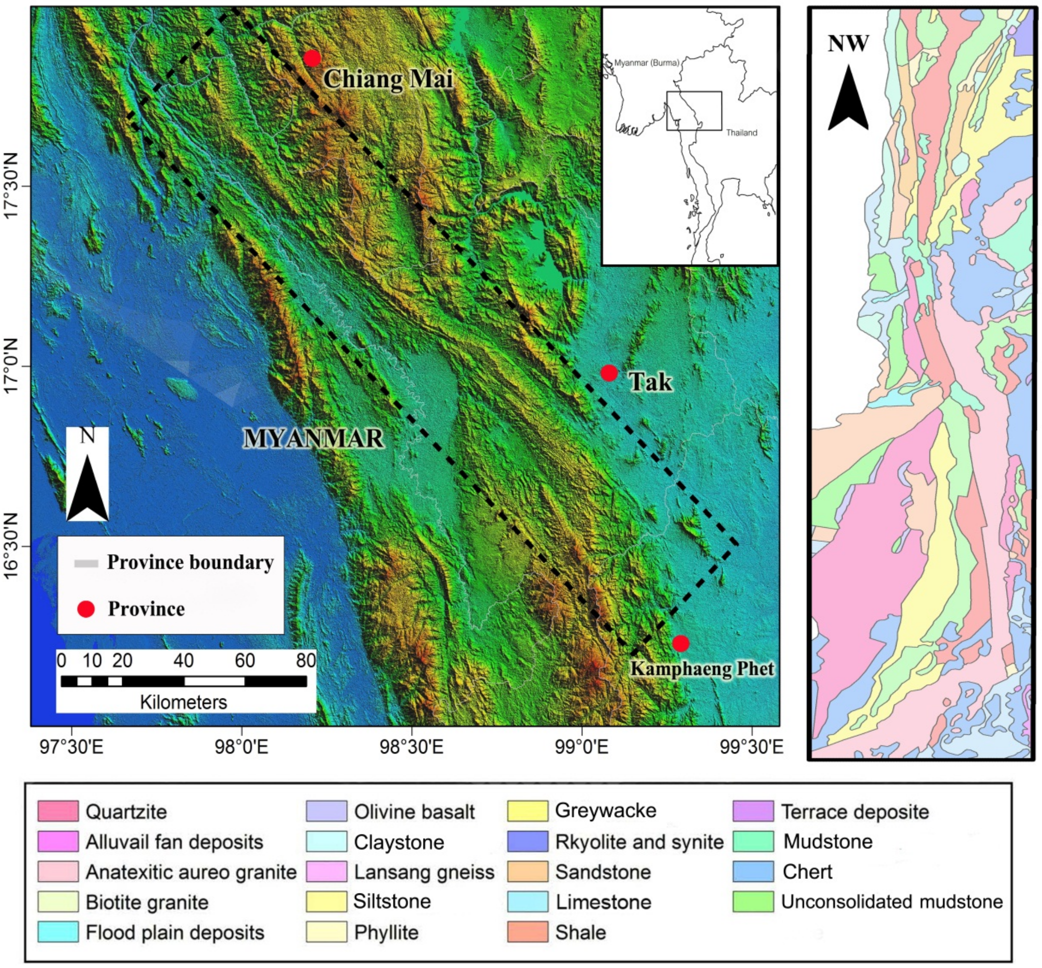

Figure 1. Simplified geological map of the Mae Ping fault zone, northwestern Thailand.

2. Geologic and tectonic setting

The Mae Ping fault zone is a dominate feature in northwestern Thailand, covering an area of about 10,000 km^2, is considered to be a sinistral strike-slip movement, bounded by the NW–SE trending faults with north-south trending sprays branching from it. The fault composes of gneisses, granites, Paleozoic-Mesozoic sedimentary and metasedimentary rocks (Morley, 2002). The Mae Ping fault is located in the Lan Sang national park in Tak province which is marked by mylonized greenschist facies gneisses as a main part of fault. There are leucocratic veins throughout and lie-sub parallel to the surrounding gneissic foliation (Lacussin et al., 1993). The sinistral displacement is revealed by boudinated restoration which is about 35-40 kilometers (Lacussin et al., 1993).Passing through the east side of Lan Sang area, The Mae Ping fault expands under the Pliocene-Recent cover of the Central Plains thermal sag basin(Morley,2002).The trace of Mae Ping fault is not well identified. The possible path of fault, which most widely agreed is the fault zone strikes NW-SE through Cambodia, in the locality of Ton Le Sap lake and through the Mae Khong delta (Lacussin et al., 1997).The Mae Ping fault zone first developed during a Late Cretaceous–Early Cenozoic transgressional event related to collision of the Burma Block with the western margin of Sundaland (Morley, 2004). This was a precursor to the main Indian-Eurasia collision when the fault zone underwent further sinistral motion during the Oligocene (Lacussin et al., 1997). In addition, isolated mountains were Palaeozoic and Mesozoic sedimentary, metasedimentary and igneous rocks. Mountains trend NW–SE azimuth direction (Morley et al., 2007). In the Lan Sang area can discovered the 33-30 Ma exhumation, which studied by Lacassin et al. (1997), and the exiting bend of the Khlong Lhan restraining bend, probably display the transgression with development from a thrust-dominated to strike-slip prominent type restraining bend (Morley et al., 2007).

3. Geomorphic indices

The quantitative measurement of landform is based on the calculation of geomorphic indices using topographic maps, digital elevation data and field work. The results of several indices can be combined in order to explain tectonic activities and to provide an assessment of a relative degree of tectonic activities in an area (Keller and Pinter, 1996).

3.1 Mountain front sinuosity

The straight or slightly curving nature of most faults or folds allows evaluation of the variation of erosional modification of a structural landform. Rapid uplift along a range-bounding fault generates the linear nature of the front. Erosion dominates landscape evolution after discontinuous of uplift and creates a sinuous mountain front, especially where rock resistance to erosion is weak (Bull, 1977). An index for this equation is simply defined as below (Bull and McFadden, 1977).

$$Smf = Lmf/Ls \qquad \text{(Equation 1)}$$

Where Smf is mountain front sinuosity index, Lmf is the straight line distance along contour line, and Ls is the true distance along the same contour line. In this study, Smf was calculated from the DEM data generated contours. Contours were derived with help of Global Mapper Software and were calculated in the GIS software after careful comparison with the topographic map.

3.2 Valley floor width-to-height ratio

This index helps in identifying the areas of tectonic inactive and areas that have been recently uplifted (Rhea, 1993). Relation of the floor width of a valley to the height provides an index suggesting whether stream is actively down cutting or primarily eroding laterally into the adjacent hill slopes. This index is defined by Bull and Mc Fadden (1977) as

$$Vf = 2Vwf/[(Eld-Esc) + (Erd-Esc)]$$ (Equation 2)

Where, Vf is the valley floor width to valley height ratios, Vwf is the width of valley floor, Eld and Erd are elevations of the left and right valley divides (looking downstream), and Esc is the elevation of the valley floor. High values of Vf are commonly related to low tectonic activities on the other hand low values are associate with active areas of abruptly uplift and valley incision. All values for input variable into equation 2 were measured along the different valley profile. The parameters were calculated from the DEM and contour line data using ArcGIS 9.3 and Google earth software. In this case, we selected valley profiles at a distance of 200 m – 1 km northward from active mountain front.

Table 1. Values of geomorphic indices for mountain fronts

No.	Location	Lithology	Front length (km)	Smf	Average Vf
I	Tha Song Yang	Triassic carbonate sedimentary rocks	4.7	1.38	1.18±0.52
II	Tha Song Yang	Triassic carbonate sedimentary rocks	8.0	1.36	0.60±0.17
III	Mae Ramat	Tertiary clastic sedimentary rocks	9.3	1.77	0.78±0.30
IV	Mae Ramat	Pre-Cambrian gniess	13.5	1.57	0.79±0.29
V	Muang	Pre-Cambrian gniess	11.5	1.66	0.82±0.29
VI	Muang	Pre-Cambrian gniess	4.5	1.62	0.55±0.17

4. Tectonic geomorphology

4.1 Front I

It is about 4.7 km long where located on Amphoe Tha Song Yang (fig. 2).The front trending is NW-SE direction. The exposed rocks along this front are Tertiary Pegmatite at the bottom of the escarpment covered by the Carboniferous quartzite and shale. The measured Smf value of this front is 1.38, while the average value for Vf is 1.18±0.52.

4.2 Front II

This front is about 8 km long where located on Amphoe Tha Song Yang. This front is NW-SE trending front (fig. 2). The exposed rocks along this front are Triassic shale and sandstone at the bottom of the escarpment covered by the Tertiary Pegmatite. The value of the Smf of this front is 1.36, while the average value for Vf is 0.60±0.17.

4.3 Front III

This front is about 9.3 km long where located on Amphoe Mae Ramat (fig. 3). This front represents a steep cliff composed of generally horizontal beds of Ordovician limestone, and Tertiary sandstone. A major fault in this front is the NW-SE right lateral fault. The value of Smf is 1.77, while the average value for Vf is 0.78±0.30.

4.4 Front IV

At the middle of the Mae Ping fault zone, the very steep escarpment changes its orientation to a more NS trend. The outcropping rocks along this front are formed of Tertiary sandstone and Carboniferous sandstone. The length of this front is 4.5 km (fig. 3). The Smf value for this front is 1.62, while the average value for Vf is 0.55±0.17.

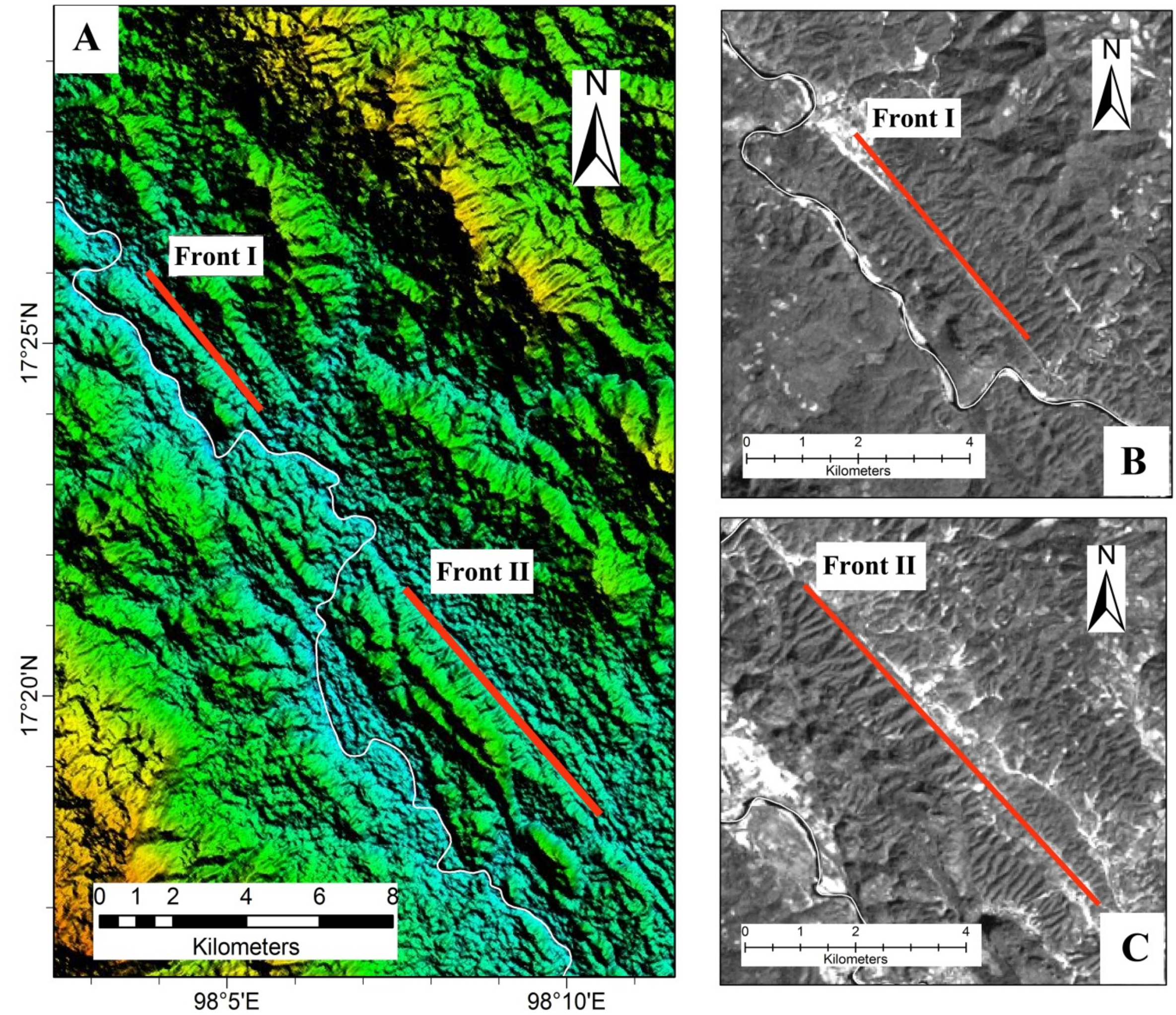

Figure 2. The valleys and mountain fronts north of the study area (a). Satellite image shows straight front and V shaped valleys (front I), (b). Satellite image shows the straight front (front II) (c).

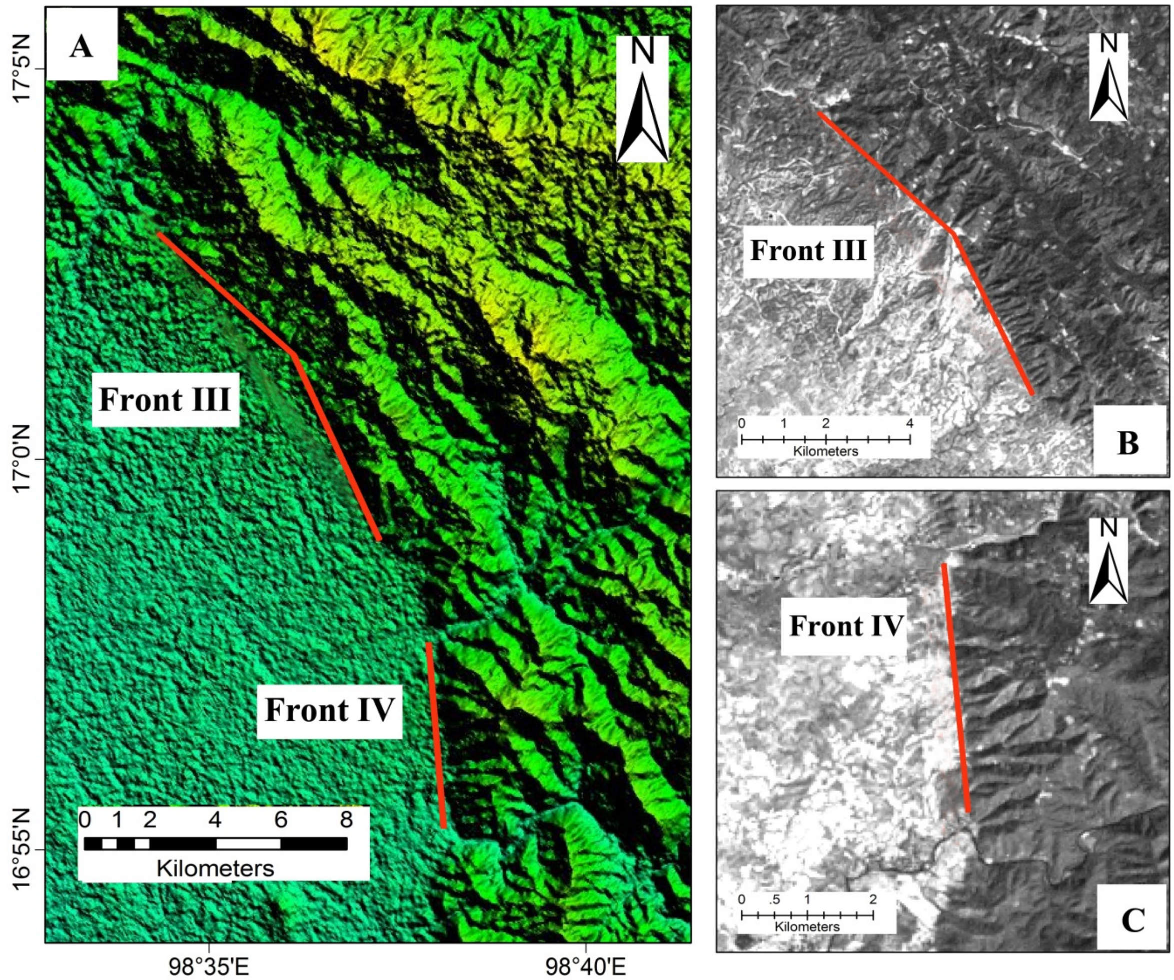

Figure 3. The valleys and mountain fronts middle of the study area (a). Satellite image shows straight front and V shaped valleys (front III), (b). Satellite image shows the straight front (front IV) (c).

4.5 Front V

The length of this trend is 13.5 km (fig. 4). The highlands east of the Mae Ping fault zone in this area consist of Lower Carboniferous metamorphic rocks. The value of Smf for this front is 1.57, while the average value for Vf is 0.79±0.29.

4.6 Front VI

This 11.5-km long front was considered one front because the trend does not change and the boundary structures are similar (fig. 4). It represents most of the highlands east of the Mae Ping fault zone. The outcropping rocks in this front are composed of Permian sandstone and Lower Carboniferous metamorphic rocks. The major structural features in this area are short extended faults. Smf index for front VI equals 1.66, while the average value for Vf is 0.82±0.29.

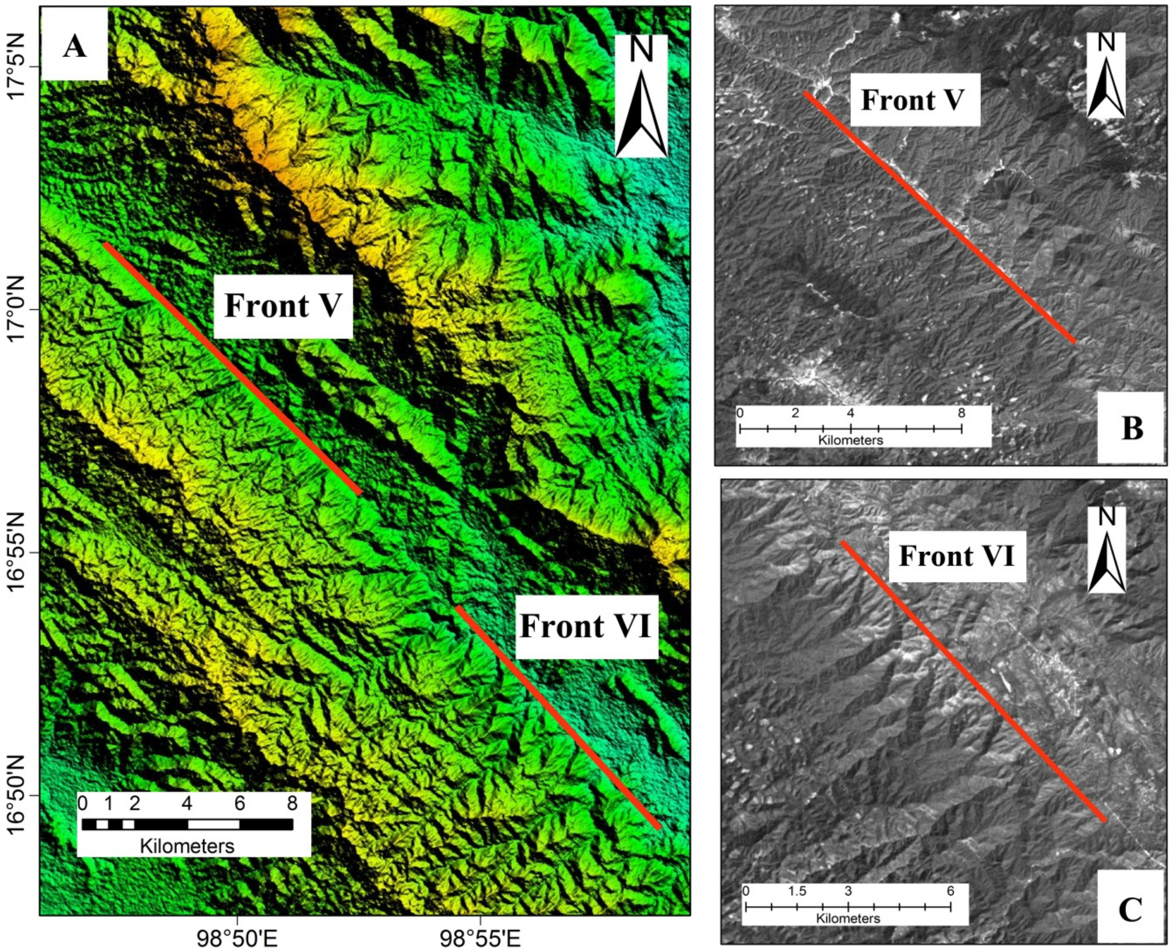

Figure 4. The major valleys and mountain fronts south of the Mae Ping fault zone (a). Satellite image shows the NW-SE trend of front V (b). Satellite image shows part of front VI (c).

5. Discussion and Conclusion

Remote sensing data (e.g., Digital elevation model (DEM), Satellite image) is a utility tool for quantitative study lineaments in regional scale. DEM and satellite image are source for calculated geomorphic indices which use to explain tectonic activities in the Mae Ping fault zone where dense of high mountains and logistic problem. From the satellite images interpretations associate with geomorphic indices show that tectonically active in an area. Low values of mountain front sinuosity and valley floor width to valley height are according with high tectonic activities. Consequently, the idea that the erosional processes are control the study area is not sustain by geomorphic indices. Moreover, variation of rock in the Mae Ping fault zone such as exhumation of metamorphic rocks, sedimentary rocks, and granite intrusion, it may take effect on values of geomorphic indices because of difference rock resistance on each type. From the trend of all geomorphic indices we propose that the geomorphological features in this study area are not only produces by erosional processes. It indicates that geomorphic features are generating by tectonic processes.

The present study improves that the remote sensing techniques is the useful tool for investigate lineament pattern and quantification of morphotectonic parameters of the Mae Ping fault zone. Geomorphological features like offset streams, triangular facets, shutter ridges, and fault scarps show that the tectonic controls in the area. Morphotectonic evidences such as straight mountain front and V-shape valley and narrow valley floor and result of geomorphic indices indicate that southern part of the Mae Ping fault zone is high tectonic activities.

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