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The Geomorphologic and Geological Characteristics of China Qinling Mountain Based on DEM

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Abstract: The Qinling Mountain plays an important role in the formation and evolution of China continent, which is the North-Southdivide of China in physical geography. It constitutes three parts: East-Qinling, Central-Qinling and Western-Qinling Mountains. The paper was aimed at analyzing the different geomorphic characteristics based on DEM and the relation between the landforms and geology. Some topographic parameters were calculated, such as mean elevation, summit and base level, local relief and mean slope. The DEM data was the SRTM DEM with spatial resolution of 90m. The swath profiles method was used, which the profiles were divided into 5-km -wide segments. For each segment, max, min and mean elevation data of 100-km-long swath were projected onto the profile. Three swath profiles were constructed across the eastern, central and western part through the Qinling Mountains. The results show that: elevation is higher in the west traverse comparing the central and east traverse. The area of granitite by high values of local relief which are related to the deeply incised valleys prevailing in the Taibai Mountain. Lithology and drainage network influence the geomorphology pattern in Qinling Mountain which is the reason that different geomorphology from the south to north.

Keywords: Geomorphologic, Qinling Mountain, DEM, Relief

1. Introduction

The study of landform is one of basis of geomorphology, which quantitative analysis is the main approach to extracting some topography parameters, such as altitude, slope, local relief and so on. Combing with the geological knowledge, we can find important significance that those parameters indicate. The quantitative analysis of geomorphology is supported more by DEM (digital elevation model), and many scholars obtained some results successfully in the study of tectonic zones, such as Alps (A Kühni et. al., 2001; Francesca Ferraris et. al., 2012; Jérémy Billant, et. al., 2015), San Jacinto Fault (Neta Wechsler et. al., 2009), Sinai Peninsula (Alaa A. Masoud, et. al., 2011), and Himalayas (Mingxing Gao, et. al., 2013) et. al. A. Kühni et. al. (2001) analyzed the dependence of Alpine topography on bedrock lithology by means of numerical analysis of the morphometry. Montgomery (2002) analyzed the relationship between erosion rate and topography in the Olympic orogen. The DEM data also reveal a relation between mean slope and local relief. Neta Wechsler et. al. (2009) use the morphometric parameters of drainage density on both sides of the San Jacinto Fault, detecting rock damage. The hypsometric integral (HI) and stream length gradient index (SL) was used to evaluate relative rates of deformation in the northeastern margin of the Tibetan Plateau. The results show that HI are not significantly affected by lithology, but SL, its most pronounced anomalies of the stream length gradient are associated with the thrust faults (Mingxing Gao, et. al., 2013). This paper is aimed at 1) analyzing the different geomorphic characteristics based on DEM; 2) finding the relationship between the drainage systems and geology; and 3) Comparing the geomorphologic parameters, drainage network and erobility in the different landscape from north and south of Qinling mountains.

Qinling Mountain is located in the central of China, which is an collision between theYangtze block and the north china block, and is also the North-South divide of China. It extends for about 1500 km from the Tongbai Mountain in the east to the Qilian and Kunlun Mountains in the west (Zheng-wei Qin, 2014), divided into West, middle and East (Shen Changyu, 1954). It is a composite continental orogen, which experienced prolonged and multiphase orogenesis and played an important role in the formation and evolution of china continent, so many geologists had been interested in the Orogenesis and dynamics of the Qinling orogen, and made great contributes to this field (Zhang, 2004). Several scholars used DEM to classified geomorphologic types of QinlingMountains. MO Shengguo (2008) divided Qinling Mountains into15 types of landform by STRM-DEM. Chang ZHiyang et. al. (2014) classified West-Qinling Mountains into 14 types of landform. However, DEM is not used widely in the study of geomorphologic features of Qinling Mountains. Application of DEM is very useful in deciphering geomorphic and structural features. It can provide new method and way for the study of Qinling landform, and also provide foundation for the development and utilization of nature resource.

2. Method and Data

2.1. Swath Profile

Topographic profiles depict long-term landscape equilibrium, where as river longitudinal profiles represent the short-term response of the landscape to the tectonic, lithological and climatic changes; swath profiles can be examined statistically to extract maximum, minimum and mean topographic elevation for each transect (J.V. Pérez-Peña, in Press). Recently, several topographic analysis of mountain belts have been done along cross-sections perpendicular to the main structures of different orogens (A Kühni et. al., 2001, Zhang Huiping et. al., 2006, Mingxing Gao, et. al., 2013). In this study, the swath profiles method was used, which the profiles were divided into 5-km -wide segments, for each segment, max, min and mean elevation data of 100-km-long swath were projected onto the profile. Three swath profiles (Fig. 1) were constructed across the eastern, central and western part through the Qinling Mountains.

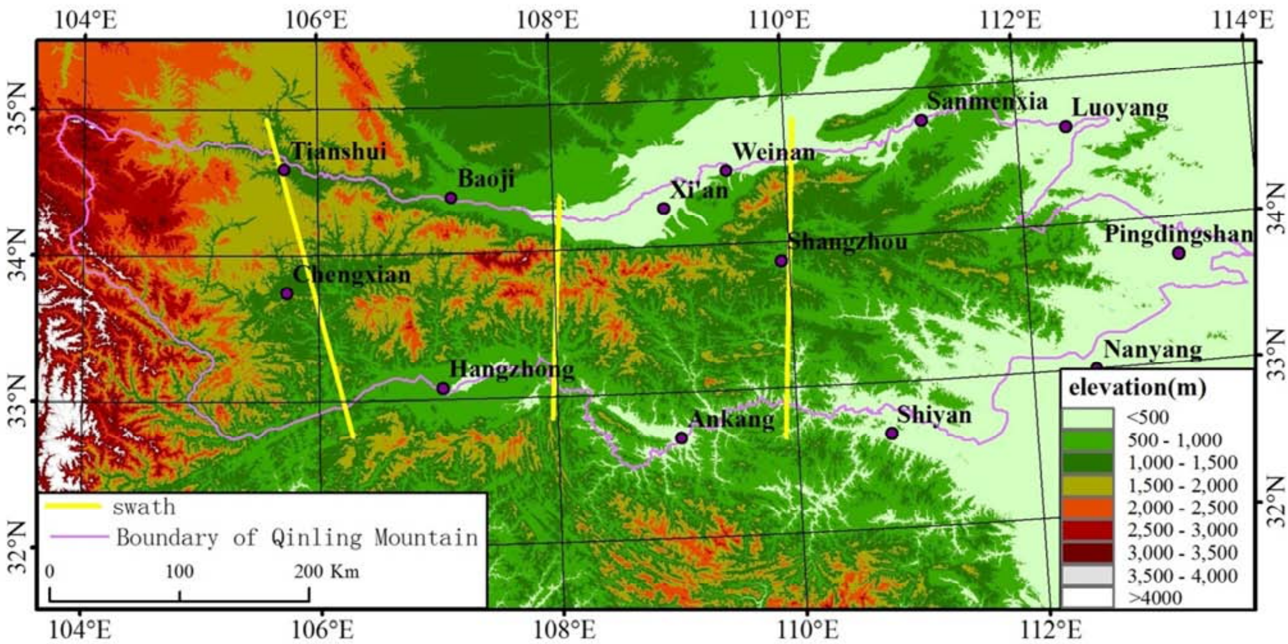


Fig. 1. *The DEM of Qinling Mountain.*

2.2. Data

The SRTM obtains elevation data on a near-global scale to generate the most complete high resolution digital topographic database of the earth. The SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour. To quantify the characteristics of the present topography of the Qinling mountain, the SRTM-3 with spatial resolution of 90m is used, the DEM data are transformed from WGS 84 coordinates into the Albers projection system co-ordinates and the Datum D_Krasovsky_1940, which the cell size is resampled into 200×200m.

3. The Geomorphologic Features

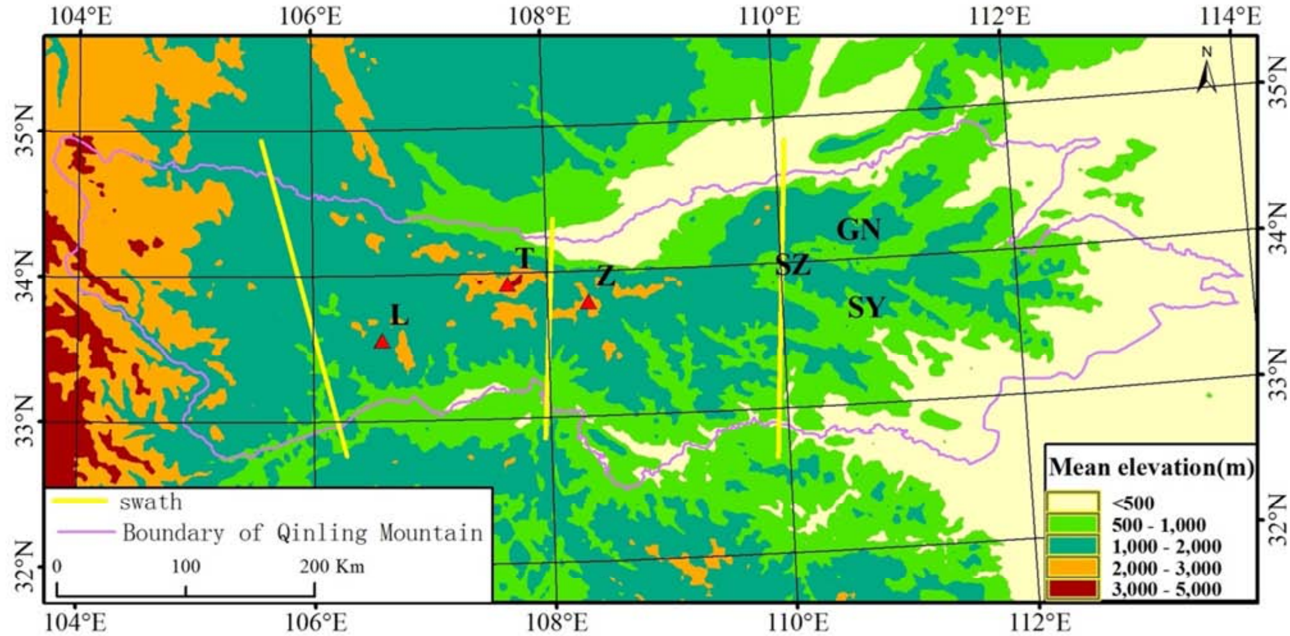
Taibai Mountain is the peak of Qinling Mountains, at an elevation of about 4000 meter. In the east of Taibai mountain, Zhongnanshan mountain rolling 2000-2500 meters, Huashan mountain rolling 2200-2300 meters, the other ridge in 1500 a 2000 meters; in the west of Taibai Mountain, Fengling fluctuation in 2500 a 3000 meters, the other ridge in 2000 a 2500 meters (Zhang Baosheng, 1981). Qinling Mountains mountain ridge is second higher Qinling mountains was divided into 15 types of landform. By the basic types of plain, platform, hill, mountains and elevation, the main types of landform were small-middle relief hills and mountains (Mo Shengguo, 2008). It is a composite continental orogen, which experienced prolonged and multiphase orogenesis and played an important role in the formation and evolution of china continent, so many geologists had been interested in the Orogenesis and dynamics of the Qinling orogen, and made great contributes to this field (Zhang Guo-wei et. al., 1996; Wang Pingan et. al., 1997; Zhang Guo-wei et. al., 2002; Jiangfeng Qin et. al., 2009; Yu Shi et. al., 2013, Yunpeng Dong et. al., 2016).

The morphometry of a landscape can be described as a function of the elevation of minimum, mean and maximum values within a spatial domain at a specified resolution. (A. Kühni et al., 2001). DEM data, available at different scales, allow a quick analysis of the area-altitude distribution of land. In this study, average elevation map, summit level map base-level map and local relief map are constructed from DEM with ArcGIS. Summit level maps are generally interpreted as a general dynamic level of erosion in a mountain belt. It contains all the major summits of a mountain belt, smoothes the adjacent topography and eliminates the local irregularities of topography caused by the incision of river. Base-level map smooth the topography, however does not contain whole river profiles (Deffontaines et al., 1994), Local relief is an expression of incision by rivers, and often used to describe the characteristics of mountain belt.

3.1. Average Elevation Map

Fig. 2 shows the distribution of mean elevation, when each data point is averaged over its neighboring points within a 5km×5km area. For data points near the edges of the DEM, the nearest edge points are used to compute an average.

Two belts between 2000 and 2500m can be identified in the west of Qinling. Both belts follow more or less the major water divides, and merge in the Taibai peak. The north belt is around Baoji city. The south belt is around Liuba country. Both belts of high elevations correlate to areas with granitic bedrock type. Zhongnan peak is located in the east of Qinling Mountain which summit is also above 2000m, correlating with metamorphic bedrock type. The Shangzhou basin, Shanyang basin, Genan basin can be easily recognized in the mean elevation map which are located in the east of Qinling.



L: Liuba Mountain, T: Taibai Mountain, Z: Zhongnan Mountain, SZ:shangzhou Basin, SY: shangyang Basin, GN: genan Basin

Fig. 2. *The mean elevation map of QinlingMountain.*

3.2. Summit Level Map

The summit level map can be developed from a DEM by numerical selection of spot heights (Deffontaines et al., 1994). It is computed by dividing the DEM into squares of equal size (5×5km). For each of these squaries, the coordinates of the point of highest elevation are determined and stored.

As the summit level map show, the branches of Hanjiang Valley are clearly preserved, and flow. The secondary water divides. Also the three major regions of the highest elevation discussed above can still be distinguished. The maxima belt located in West-Qinling follow the major water divides. Comparison with a geological map reveals that except Huashan peak of metamorphic rocks, other maxima all coincide with granitic rocks.

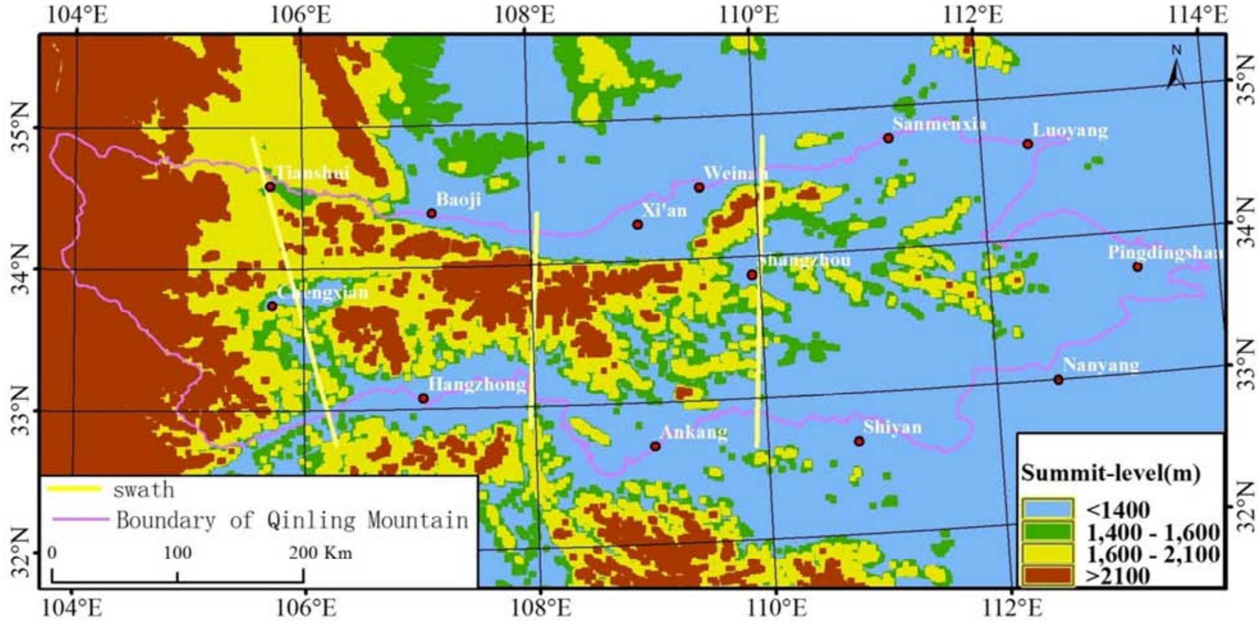


Fig. 3. The summit-level map of Qinling Mountain.

Base-level map

A base-level map links the lowest points of the DEM. Fig. 4 shows the base-level map developed using the points of lowest elevation for the same 5km×5km grid used to construct the summit level map. However, many more detailed features can not be seen in the base-level map. Major nick points information in the valley bottoms requires the entire drainage network to be incorporated into the construction of the base-level map (Deffontaines et al., 1994). There are three belt in this map, the elevation is gradually decreasing from west extend to east, and the WE directional divide of Qinling is clearly preserved.

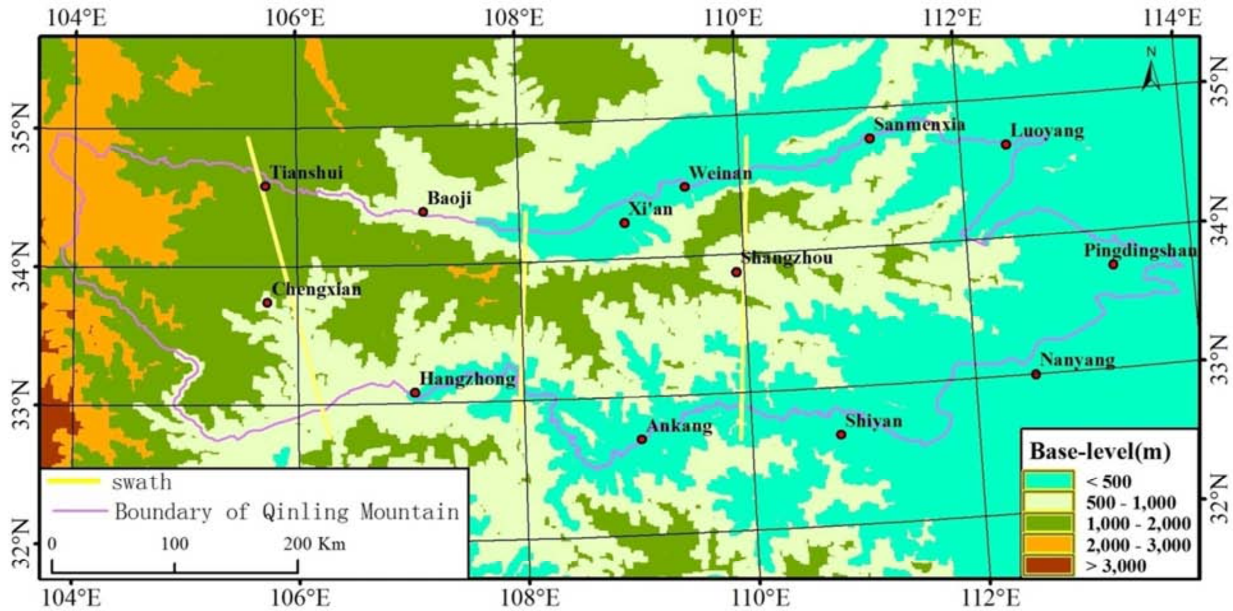


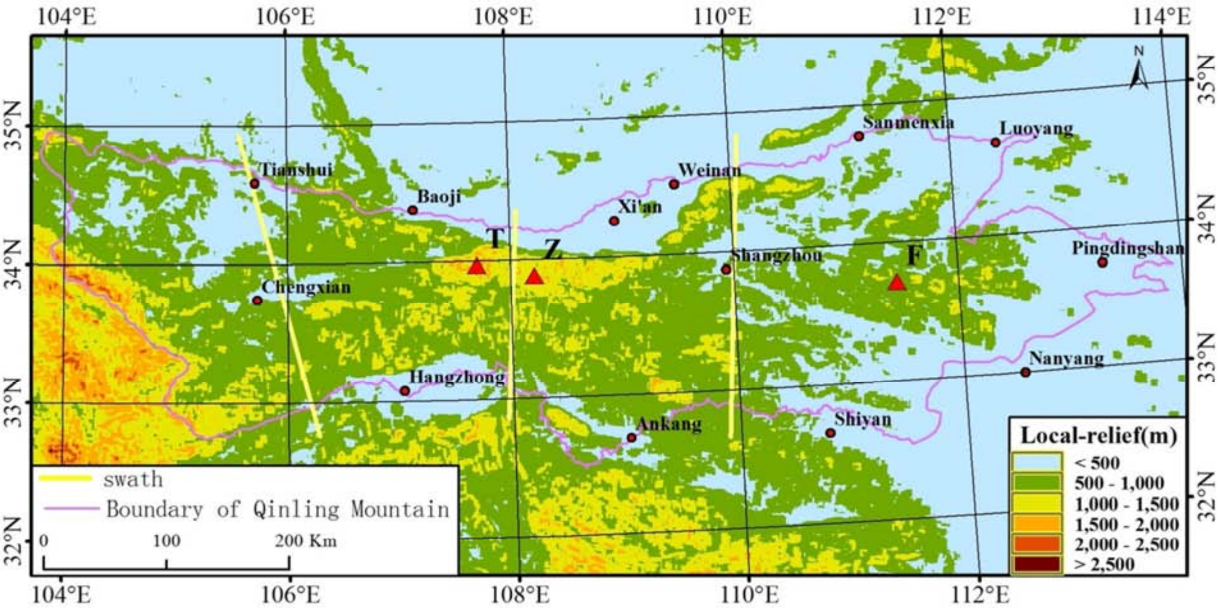
Fig. 4. The Base-level map of Qinling Mountain.

Local relief map

A moving 25×25 window was used for determining local topographic relief by determining the maximum change in elevation within the window. The difference between the lowest and highest elevation cells was calculated, and resulting values were reclassified into the six categories (Fig. 5). Interpreting the significance of local relief is difficult, because local relief depends on numerous interdependent processes, each with factors controlling its effectiveness (A Kühni et al., 2001).

Fig. 5 shows the local relief map with a sampling grid of 5km×5km. A high relief area which value is above

2000moccurs with Taibai peak, Zhongnan peak and Funiu peak. A minimum of local relief occurs around the branch of Wei Valley and Han Valley, which built up large scale fluvial plain and the mountain basin. These basins with loss sediments are more erodibility, According to geological map, the Taibai peak and Zhongnan peak are made of granite, the Funiu Mountain of the metamorphic rocks.



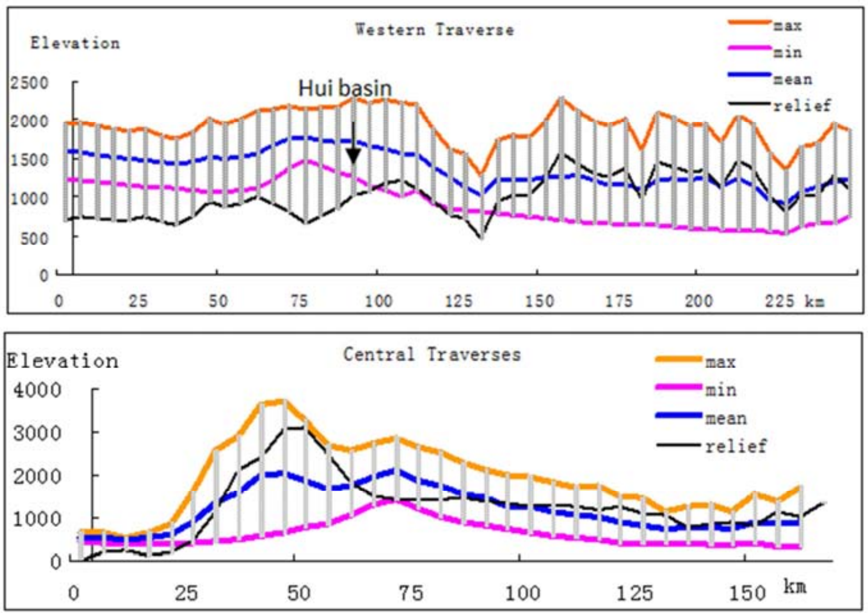
T: Taibai Mountain, Z: Zhongnan Mountain, F: Funiu Mountain

Fig. 5. The local relief map of Qinling Mountain.

4. Topographic Analyses with Swath Method

To evaluate the correctness of the summit level, base level and local relief maps, they are compared to the results from three traverses through the Qinling Mountains. The traverses are across the main divide water of Qinling Mountains, sited in the west, central and east of Qinling Mountains (Fig. 1~5).

As shown in the western traverse map (Fig. 6), the altitude is above 2000m along the western traverse. The lowest elevation occurs within Huixian basin, which is located in the Chengxian County, and it is the north-south divide which of the shale and mudstone. The south of this basin is deeply incised by the main longitudinal rivers formed by the Jialing river, furthermore, this area underwent denudation and erosion.



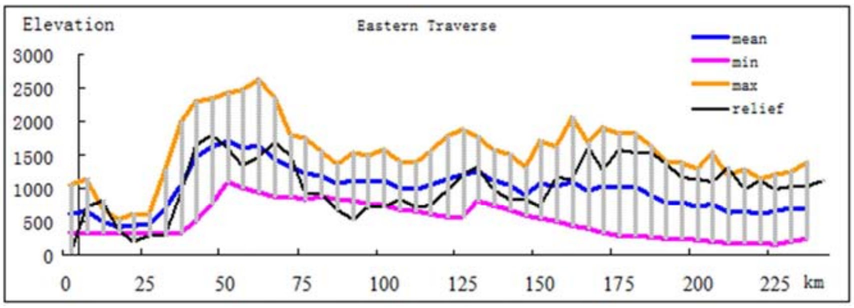


Fig. 6. *Three topographic profiles across the Qinling Mountian (location of projele traces are shown in Fig. 1) constructed using a swath profile method.*

The northern part of the central traverse is characterized by high values of elevation and local relief which are related to the deeply incised valleys prevailing in Taibai Mountain. The slope is steeper in the north of Qinling, where granitite rocks outcropped at the surface. Along the central traverse, the elevation decreases gradually from north to south, and the elevation is below 500m in the Hanyin basin. The Hanjiang river in the south of Qinling has a radial stream drainage system, and running from south to north..

The value of local relief changes significantly along the eastern traverse. The peak point occurs within the Hua peak located in the north. The valley geomorphologic pattern indicates that the basins located in the south accompanied by highly incision.

5. Conclusion

The geomorphologic features is fundamental in digital geomorphologic analysis. In this study, the max-elevation, the min-elevation, the mean elevation and local relief are extracted with spatial analysis technology based on SRTM DEM. We discussed the dependence of Qinling topography on bedrock lithology and drainage network by means of numerical quantitative analysis. The area of granitite by high values of local relief which are related to the deeply incised valleys prevailing in the Taibai Mountain. The geomorphologic changes significantly along three traverse, elevation are higher in the west traverse comparing the central and east traverse. The three traverses can reveal the different geomorphologic pattern from north of south in Qinling Mountain, give relationship between the lithology and geomorphology.

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