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Granite landform characteristics, distribution and evolution patterns in Huangshan Mt.

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The various types of granite landforms in the Huangshan Mt. are distributed in a concentric pattern. The remaining parts of the planation surface are in the center; domical peaks, castle peaks, pointed peaks, and ridges are arranged from the center to the periphery accordingly. This reveals that knick points are still near the center and the center area is the common divide of the radial water system. It is inferred that the granite bodies in the Huangshan Mt. were exposed to erosion in Miocene and Pliocene, and the planation surface was also formed then. After the slight uplift in late Pliocene, a light-incised surface was formed. Then, in early Quaternary, there were intense uplifts and incisions so that deep incised surface was formed. The above process is still in progress, and results in high peaks and deep gorges outside of the center area. However, due to the limited catchment area in the center, headward erosion is mild, and the current landforms in the Huangshan Mt. can be maintained for a long time.

granite landform, Huangshan Mt., landform characteristics, distribution and evolution patterns, concentric distribution pattern

There are two major reasons why abundant studies on landforms in the Huangshan Mt. emerged recently. On one hand, the beautiful scenery makes the Huangshan Mt. attractive to tourists as well as geomorphologists[1–4]; on the other hand, it is because of the long existing dispute on ancient glaciers here. This dispute started in 1936 when Li Siguang published his work on glaciers in the Huangshan Mt. and peaked in 1982 at the national glacier and periglacier convention[5–9]. The fundamental issues have been resolved by now[10]. The scenery landforms and their formation have been well addressed in the 1980s and 1990s by different researchers; therefore, the purpose of this article is to describe landform types, macroscopic distribution characteristics and landform evolution patterns in the Huangshan Mt.

In addition, the Huangshan Mt. has become a UNESCO world culture and natural heritage site. Whether for displaying the fame of the Huangshan Mt. in the museums or for the progress in geomorphology, it is extremely important to step beyond the general description of the landforms and their formation, and systematically analyze the distribution patterns as well as the evolution of the granite landforms in the Huangshan Mt.

The Huangshan Mt. is the highest mountain in southern Anhui Province; it is the divide of the Yangtze River and the Qiantang River. The main peak, Lianhuafeng (1864 m) is located inside the largest water sufficient area in China, with annual average temperature of 7.8℃, annual precipitation of 2396.5 mm and annual runoff depth of 1200 mm, and the stream incision is intense. Huangshan Scenery Park occupies 154 km^2 of land, 107 km^2 of which is granite. 77 peaks are above 1000 m; the rocks, rivers and gorges are famous for their astonishing beauty. Poets from ancient China had written numerous poems praising the Huangshan Mt.[11].

1 Overview of granite bodies in the Hungshan Mt.

The Huangshan Mt. is on the west of the Southern Anhui concave fold belt of the Lower Yangtze Platform. It belongs to the ancient Yangtze sea area in Proterozoic and

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Early Paleozoic era; there are sandstone, shale and limestone deposits. Crustal movement created a sea-land alternating environment between the Early Paleozoic and the beginning of Mesozoic era. The uplift in the Indosinia movement made this area a land area. There were frequent fault-block movements along with magma intrusions since then until the Yanshan movement, and this made granite bodies become the basis of the landform evolution in the Huangshan Mt.

The exposed area of granite bodies in the Huangshan Mt. is 107 km^2, and consists 70% of the total geopark area. Horizontally, it is oval-shape orienting 70°NW, intruding where the Sanfeng'an anticline and Shancha syncline intersects and the south side of Nanping rock body. According to the studies on Huangshan granite bodies, the granites are usually divided into four phases: The first phase is medium-coarse adamellite, the second is medium-coarse porphyritic granite, the third is medium-fine porphyritic granite, and the last is fine grained porphyritic granite. Now the landform in the center consists mainly of the third and fourth phases, approximately (128—131.6) ±5.2 Ma BP, and the latest is 124±5.2 Ma BP[1)]. Most of the famous peaks in the Huangshan Mt. are located in the center or the inner edge where the third and fourth phases are. However, both the first and second phases granites are on the periphery. Because of the long-time denudation, the terrain gradually transits to the surrounding rock area (Late Paleozoic sedimentary rocks and metamorphic rocks) (Figure 1).

2 The relationships between the peaks and the granite phases in Huangshan Mt.

According to Zhang[12], Yanshanian Shizilin granite bodies (7.7 km^2) are located in the center of the Huangshan Mt.; these correspond to the central gentle hill platform landform area according to the current authors' classification, represented by Shizilin, Guangmingding, and Gongyangshan. In the meantime, the Huangshan granite bodies cover the main peaks and ridges around the above center area. In addition, the Taiping granite body (204 km^2) intruded in Miocene is located in the northern area; it shows gentle hill basin scenery and no longer has towering peaks because of the long-term weathering and denudation.

General rules of geomorphic development could be derived through analyzing the locations and altitudes of the famous peaks in the Huangshan Mt. More specifically, four of the peaks are higher than 1800 m, and they all concentrate in the center area and its close inner edge. Five of the peaks are between 1700—1800 m, among them Aoyufeng is also located in the center area, and the other four are also located near the center area. Especially, as many as 17 of the peaks are between 1600—1700 m, among which 9 are above 1679 m, this is more than a half and the altitude is close to 1700 m. Therefore, there are totally 18 peaks above 1679 m, and they could be seen as remains of the same planation surface formed in Miocene and Pliocene. The other 8 among these are between 1600—1678 m, such as Jiulongfeng (1636 m), and Yunwaifeng (1656 m). Other than these, 10 peaks are between 1500—1600 m and they surround the above-mentioned peaks. All the peaks above 1500 m and the adjacent areas are the highest terrain in the Huangshan Mt., and all of them are located southeast to the center area. Some researchers referred to this area as middle mountains zone above 1500 m. It seems that ob-

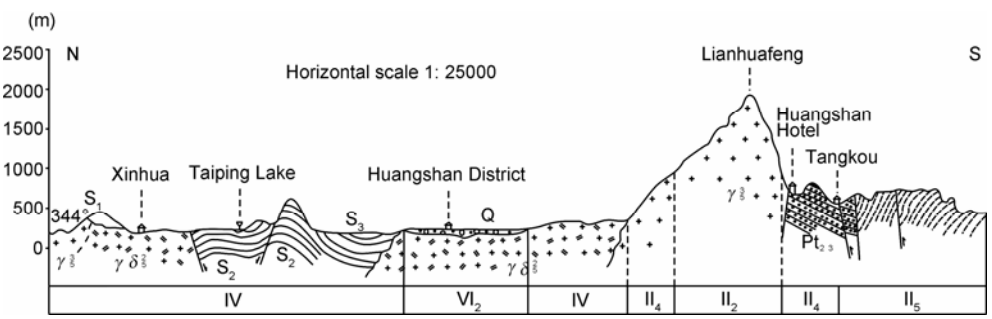

Figure 1 Geological Profile of Huangshan Mt.[1)].

1) Anhui 332 Geological Team's material, 2006

Table 1 The main peaks and three-level erosion surfaces in the Huangshan Mt.[4]

Level	Altitude (m)	Peaks and altitude (m)	Planation surface or not
First-level	1650－1800	Lianhuafeng (1864) Tiandufeng (1810) Guangmingding (1860)	Planation surface
Second-level	130－1500	Meimaofeng (1430) Zhushafeng (1370) Furongfeng (1335)	Erosion surface
Third-level	600－1000	Xianglufeng (945) Zhentoufeng (1005)	Erosion surface

vious rules could be drawn from the relationship between the distribution of the peaks, their shapes and granite phases, and their lithology. However, this does not mean that there are direct relationships between them, because the height of a peak is also related to the way of erosion and the time when it was formed. For example, most of the fourth phase fine-grained porphyaceous alkali-feldspar granite show domical peaks, but most of them are located at the center area; most of the third phase also show domical peaks and terraces, and they are located in the center area too; only the second phase coarse- grained porphyritic and porphyaceous granite body show various peak shapes, such as domical peaks, ridges, pointed peaks, pillars, and box-shaped peaks, and they are all at the periphery of center area (Figure 2, Table 1), it is related to the long-term intensive incision. According to the above analysis, the peak shape and granite lithology are probably unrelated, on the contrary, peak shape might be more closely related to tectonics and joints (Figure 2).

3 Concentric Pattern of Granite landform distribution in Huangshan Mt. ——a classical landform distribution pattern

Rules exist for the shapes and distributions of the various granite landforms in the Huangshan Mt; they are related to the evolution of the landform. The center area of the Huangshan Scenery Park (Beihai, Xihai, and Tianhai) is the remained parts of a planation platform (Figure 3). Because the water system of the granite bodies is radial, the center area becomes the common source and divide of all the rivers there, and its periphery is incised into deep-cutting gorges. The deepest sections are where the high peaks are, and the incision depth reaches 500－800 m (Figures 4 and 5).

The center area is now a gentle hill platform, and the relative height is about 200 m. There are weathering

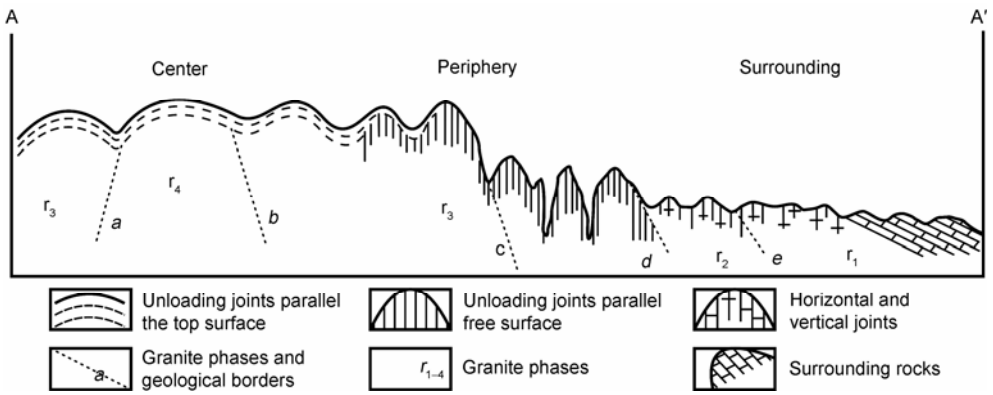

Figure 2 Profile of the granite phases and joint types in Huangshan Mt. (unloading joints can be divided into vertical joints and horizontal joints. See Figure 4 for profile's location).

Figure 3 Center platform in Huangshan Mt.--Guangmingding (right) and Pingtianqiang (left).

mantle and a 10-m-thick unconsolidated layer. The center area is surrounded by knick points, such as Paiyunting knick point (Figure 6); this type of knick point can be called headwater knick point or upper knickpoint. Aoyutuojingui is the clear south boundary of the remaining Huangshan planation platform and Pingtianqiang is the clear east boundary. At the intersection of knick points are various forms of remained corestones, such as Feilaishi, the group of corestones near the "mouth" of "Aoyu", and Houziwangdonghai (Figure 7(a)) on the north.

There is a group of domical peaks around the inner edge of the center, such as Shizilin (Figure 7(b)), Danxiafeng (Figure 7(d)), Guangmingding, and Gongyangshan. However, Aoyutuojingui and Pingtianqiang remain in their original platform shape. Further outward, there are castle peaks, such as Tiandufeng (Figure 7(c)), Lianhuafeng (domical-castle transitional type), Lianruifeng, Yupingfeng, Baiefeng, Shixinfeng, and Jiulongfeng.

In general, the distribution of granite landform in the Huangshan Mt. is concentric, and it could be divided into five parts from the center to the periphery (Figures 4 and 5; Table 2).

(1) Center area: mainly flat-topped peaks; gentle hillswith elevation difference around 200 m.

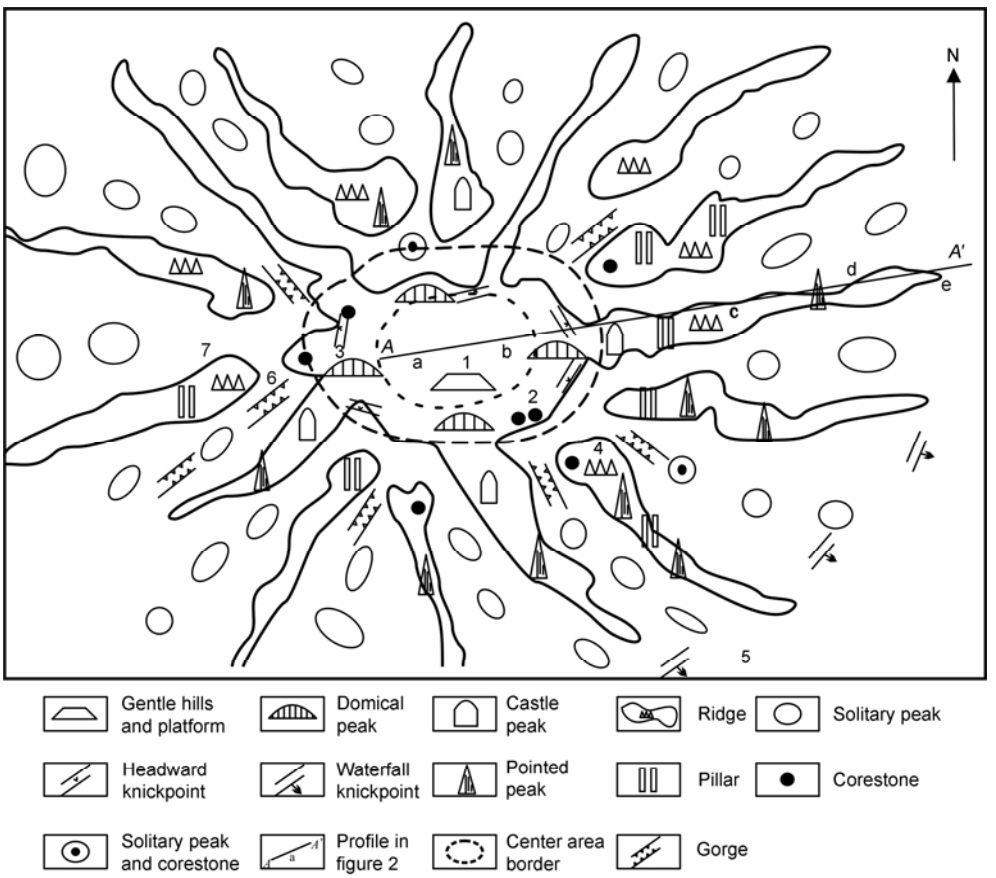

Figure 4 Landform distribution in Huangshan Mt. and its concentric pattern.1, Guangmingding, Pingtianqiang; 2, Feilaishi; 3, Danxiafeng; 4, Tiandufeng; 5, Jiulongpu; 6, Xihai gorge; 7, Jiulongfeng.

Table 2 The major landform types and representative examples

Landform types	Ridges	Pointed peaks	Castle peaks	Domical peaks	Pillars
Examples	Shisunqiang Shibaluohan (group) Jiulongfeng Shixinfeng-Baiefeng	Yupingfeng Lianruifeng	Lianhuafeng Shixinfeng Tiandufeng	Guangmingding Pingtianqiang Aoyufeng Gongyangshan Shizilin Danxiafeng Baiefeng	Mengbishenghua Xianrenfanan Xianrenshaixue Xianrenzhilu Tiangouwangyue Shuangmaobushu Shibaluohan

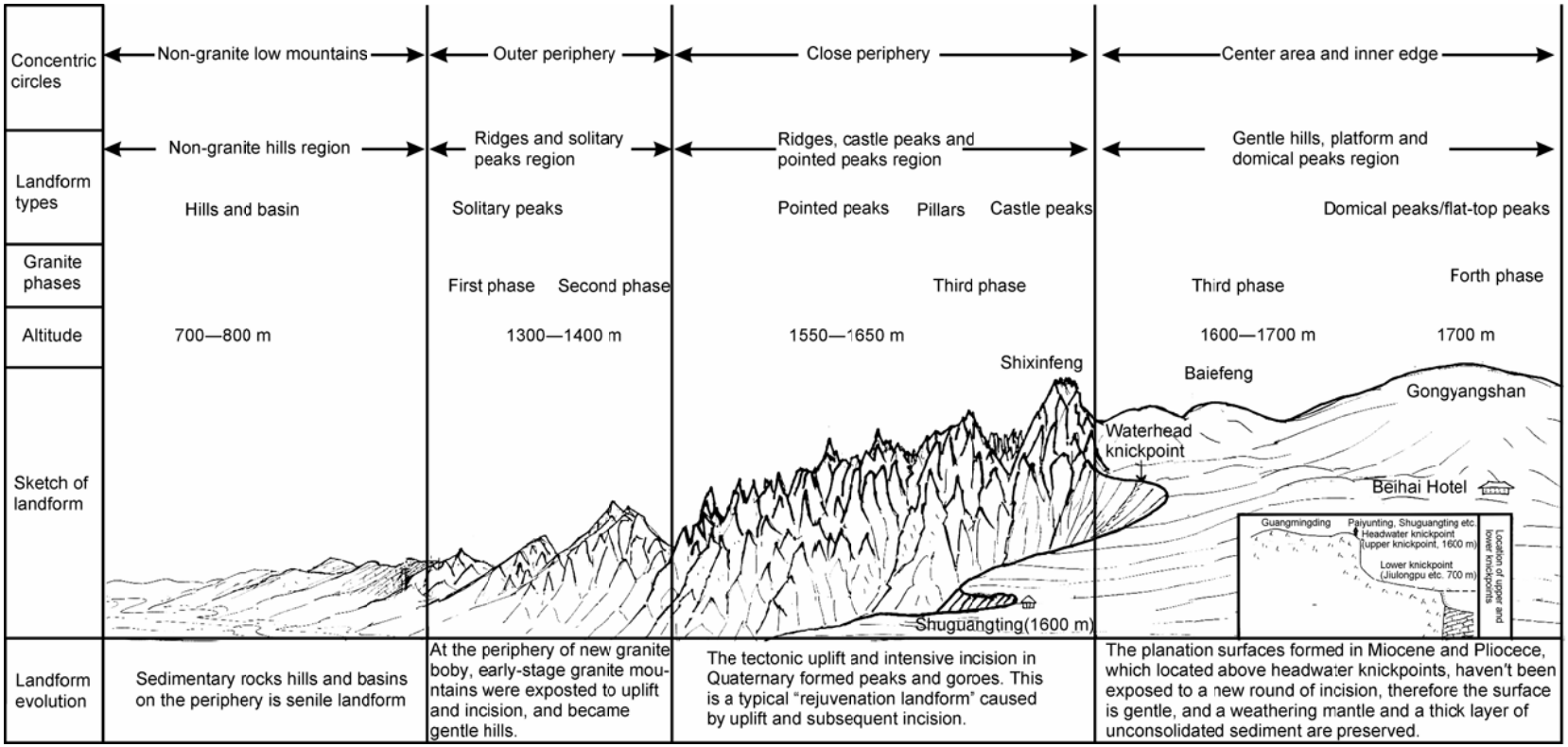

Figure 5 Sketch of the landform along Shixinfeng-Gongyangshan (view from Shuguangting) reveals the granite phases, the concentric pattern of landform distribution and the landform evolution in the Huangshan Mt.

Figure 6 Paiyunting knick point.

(2) Inner edge: mainly castle peaks; knickpoints have crossed the edge of the center area; corestones scatter around the center.

(3) Close periphery: extends as ridges; there are castle peaks and pointed peaks as well as pillars (e.g. Shixinfeng) on the ridges. Ridges could be divided into 2 categories: one is represented by ridges along Shixinfeng-Gongyanshan, and these ridges are still connected with the center area; the other category is represented by Jiulongfeng, and the ridges are disconnected with the center area (Figure 7(d)).

(4) Outer periphery: pointed peaks; the further from center, the lower the altitude are; most of them are first or second phase granite bodies, and exposed to long-term denudation. There are few main peaks left, and most of the peaks are between 1300—1400 m.

There are many waterfalls between the outer periphery and surrounding rocks area, such as Jiulongpu, Bailongpu, Renzipu, and Baizhangquan. Most of the waterfalls are in the southeast part, where the 45°NE Tangkou-Tanjiaqiao fault is. Because of this, the southeast slope is the steepest terrain in the whole Huangshan Mt. This area is the lower knick point of the two major knick points in the Huangshan Mt., and the altitude is around 700—800 m.

(5) Non-granite low mountains: located outside of the transition area between granite bodies and surrounding rocks, and most of them are low mountains made of metamorphic rocks and sedimentary rocks.

4 Granite landform zonality in the Huangshan Mt. and its relationship with tectonics

Granite landform in the Huangshan Mt. is influenced by

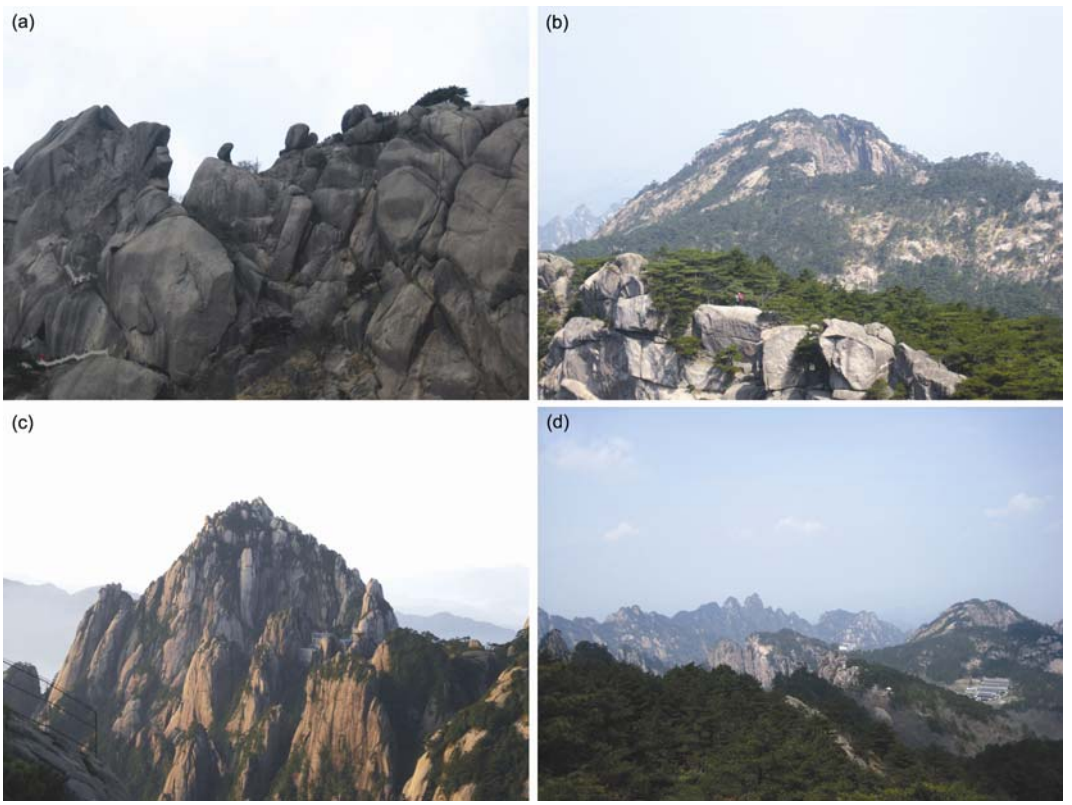

Figure 7 Famous peaks in Huangshan Mt. (a) Corestones before Aoyuzui; (b) Domical peak: Shizilin; (c) Castle peak: Tiandufeng; (d) Domical peak: Danxiafeng and ridges in southwest periphery: Jiulongfeng.

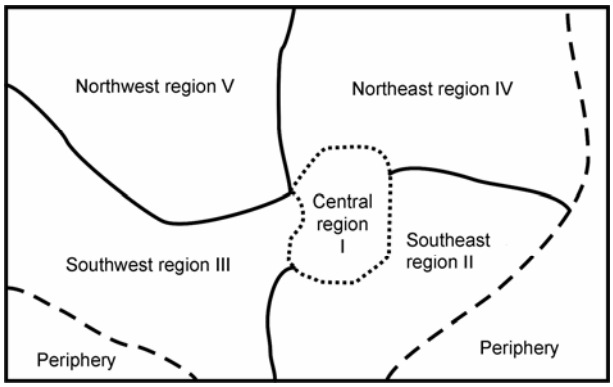

Figure 8 Granite landform zonality in the Huangshan Mt.

different tectonic lines, phases of granite intrusion, and levels of stream incision. There are five subareas including one center area and four areas surrounding the center, they are: I. center gentle hill and platform area, II. southeast peak and strath area, III. southwest gorge and ridge area, IV. northeast comb-shaped ridge-gorge area, V. northwest gentle ridge-gorge area (Figures 8 and 9).

The famous peaks, straths (Limaqiao strath) and large waterfalls all concentrate in the southeast area, and this is the lower knickpoint. From a macroscopic view, the concentric pattern of the landform distribution is best preserved in the southeast area; the southwest and northeast areas took the second place; and the pattern is least obvious in the northwest area. It is because there are relatively fewer third and fourth phase granite bodies in the northwest area but a large amount of sillite dikes exposed, which are mainly medium-fine grained biotite granodiorite. The geological bodies in this area are scattered, and the majority are early stage granite. They have been exposed to long-term weathering, and therefore, the landform units appear to be scattered and gentle.

The main tectonic line that controls the granite landform in the Huangshan Mt. contains a medium group of SN-trending faults, especially more than 10 SN-trending faults are evenly distributed on the east side, 1.5—2.0 km apart from each other. The north part of the second westmost among these faults is Songgu'an gorge where Taiping cableway goes through, and the south part of it cuts through the source of Xihai gorge, travels through the west side of Paiyunting and Feilaishi, and forms a large fault scarp. Meanwhile, the west most fault cuts through the end of Xihai gorge. It is special that there are 6 so-called "U-shaped valleys" on the southeast documented in previous literature, represented by Limaqiao U-shaped valley, in a row from south to west. There is a NE-trending broom-like fault on the northeast which makes this group of gorges turn slightly northeast,

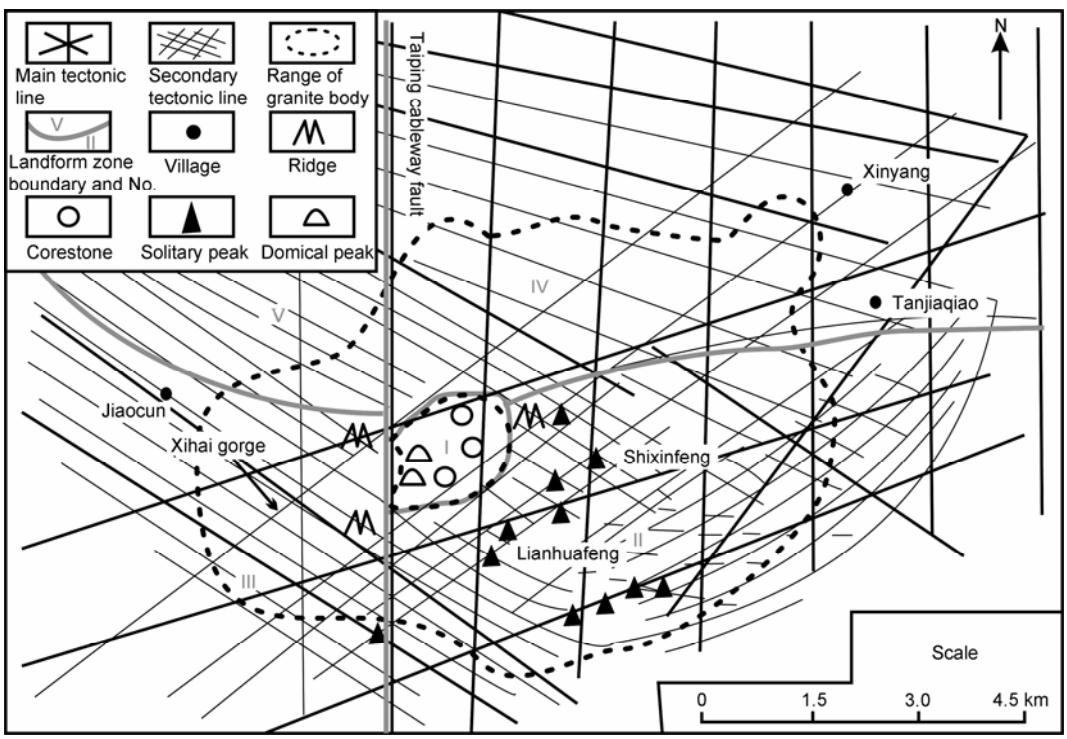

Figure 9 Tectonics, landform zonality and peaks in Huangshan Mt. I, Center gentle hill tableland area; II, Southeast peak and strath area; III, Southwest canyon and ridge area; IV, Northeast comb-shaped ridge-gorge area; V, Northwest gentle ridge-gorge area.

and the most typical manifestation is the unusual scene of inter weaving gorges with SN-trending and NE-trending at the south side of Yupingfeng and the upstream of Yuping stream. The sources of these so-called U-shaped valley all narrows down toward the upstream, and none of them have characteristics like "cirque" or "firn basin". Although there are so-called "firn basin" in west of Beihai hotel and Xihai hotel which is far from here, but there is no U-shaped valley at the downstream. Firn basin and U-shaped valley are inseparable indicators of glacier landform, however, it is ridiculous to relate these two separate and distant features together and see them as the coexisting signs of glacier landform. There are two groups of NW-trending faults and NE-trending faults, among which the Tangkou- Tanjiaqiao fault and Tangkou-Jiaocun fault control the NE-trending and NW-trending faults and make the south slope of the Huangshan Mt. steeper than its north slope. Xihai gorge is a representative example of the southwest area, and the NE-trending fault where it is located and the NW-trending fault at the downstream strictly controls the direction of Xihai gorge from Paiyunting directly to Diaoqiao, and then from Diaoqiao directly to Jiaocun, as well as the direction of Taohua stream running southeast toward Tangkou. Similarly, the large SN-trending faults also control the landform development. As mentioned above, the large fault from Paiyunting to Feilaishi clearly divides the granite landform in Huangshan Mt. into the distinct east area, west area, center area, southeast area where the peaks are (Figure 9) and northeast area. Certainly, the dense interweaving NE-trending and NW-trending faults (Figure 10) are also related to the fact that the peaks concentrate in the southeast area. The NE-trending strath is relevant as well. Straths are formed where such faults are dense and ridges are formed where such faults are sparse, and thus result in a landform with interweaving straths and ridges. This is unique scenery in the Huangshan Mt.: it is formed because the intersection of tectonic crack and unloading joint is susceptible to ero sion and collapse (Figure 9).

Especially, the Huangshan granite bodies have dense joints, but most of the joints are unloading joints. In the center of the granite bodies, the most common joints in places like Danxiafeng, Liandanfeng, and Guangmingding are horizontal unloading joints (Figure 11(a)). Vertical unloading joints (Figure 11(b)) are common on the periphery. However, Lianhuafeng in the transition area has both horizontal and vertical joints.

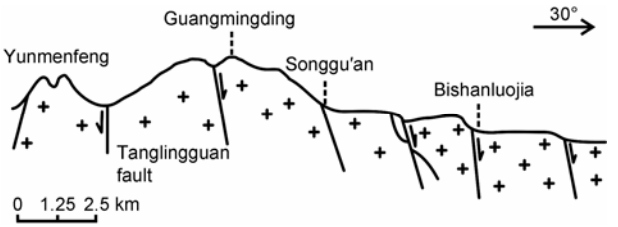

Figure 10 Profile of faults in northwest area[1)].

SN-trending faults control the landform in northeast area. The two major landform characteristics are completely controlled by this group of faults. From a macroscopic view, the SN-trending gorges and ridges are very obvious, but the EW-trending secondary faults divide the ridges into numerous parallel "stone walls", and the east side along Guangmingding and Liandanfeng and the north side mountains (such as Diezhangfeng) are the most obvious and magnificent ones (Figure 9).

Besides the NW-trending faults, a large amount of sillite dikes and adamellite dikes exist in the northeast area. Because of the intense weathering, these kinds of dikes have a reticulate surface and the hills are relatively gentle, unlike the other areas.

In detail, through their field work, Anhui 332 geological team confirms that the fault stress field of the center area is also mainly NE-trending and NW-trending, and the tectonic stress field of the joints also has the same trending except for the north slope of Lianhuafeng. The SN-trending faults and joints are salient on Liandanfeng, but the direction of quartz phenocryst long axis in the granites clearly indicates a EW-trending. This might be caused by the change in stress direction after the granite bodies formed, and the former also reveals the direction of force exerted by Pacific Plate.

By the way, in the Yupingfeng-Limaqiao section, there are lots of captive masses in the second phase medium-coarse porphyaceous granite. The captive masses drop along the edge due to differential weathering and leave groups of holes with various sizes (Figure 11(c); (d)). This supports the statement proposed by Cui in 1982 that the so-called "glacial groove" on the cliff on east side of Limaqiao is actually a discrete distribution of

1) See footnote 1 on page 4488

Figure 11 Unloading joints and captive masses. (a) Horizontal unloading joints on Danxiafeng; (b) vertical unloading joints on Shisunqiang; (c) captive masses in the third phase granite on Lianruifeng; (d) captive masses in the third phase granite had been weathered and denudated, and holes were left.

holes, which should be results of the above-mentioned weathering and denudation of captive masses[10].

5 Evolution of the granite landform in Huangshan Mt.——classical evolution pattern——landform rejuvenation

Davis (1932)[13], Penck (1953)[14], and King (1962)[15] all used the Morphological Analysis of Landforms approach when discussing the landform evolution of an area (like Andes, Alps and South Africa). The ruling idea of this approach is the phenomenon called "landform rejuvenation". It assumes that the tectonic is steady, and a block has been exposed to erosion or denudation and becomes a flat surface (planation surfaces), then a new round of uplift causes the surface to be incised (mainly by rivers). Although this approach seems to be out of fashion and simple, its basic ideas are still working well and employed by many researchers as they work well. Similarly, this approach could be applied to the landform evolution in Huangshan Mt. (mainly granite landform), too. For example, when Davis introduced Penck's piedmont surface development pattern, he used a figure to illustrate the evolution pattern of uplift (Figure 12)[13]:

(1) Headward erosion of the radial water system from the periphery toward the central tableland (Figures 4 and13);

(2) The edge was exposed to erosion first, which resulted in a shattered surface, groups of peaks and deep gorges;

(3) The high platform remains in the center.

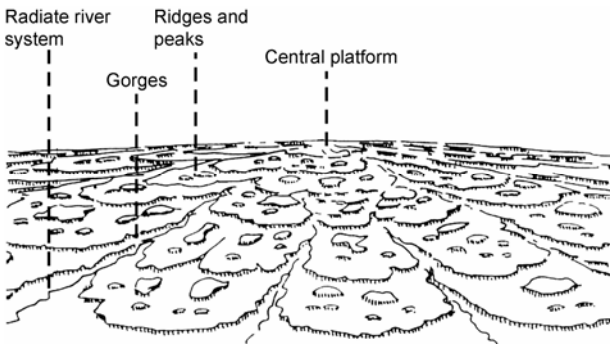

Figure 12 Penck's domical platform- piedmont surface evolution model[13].

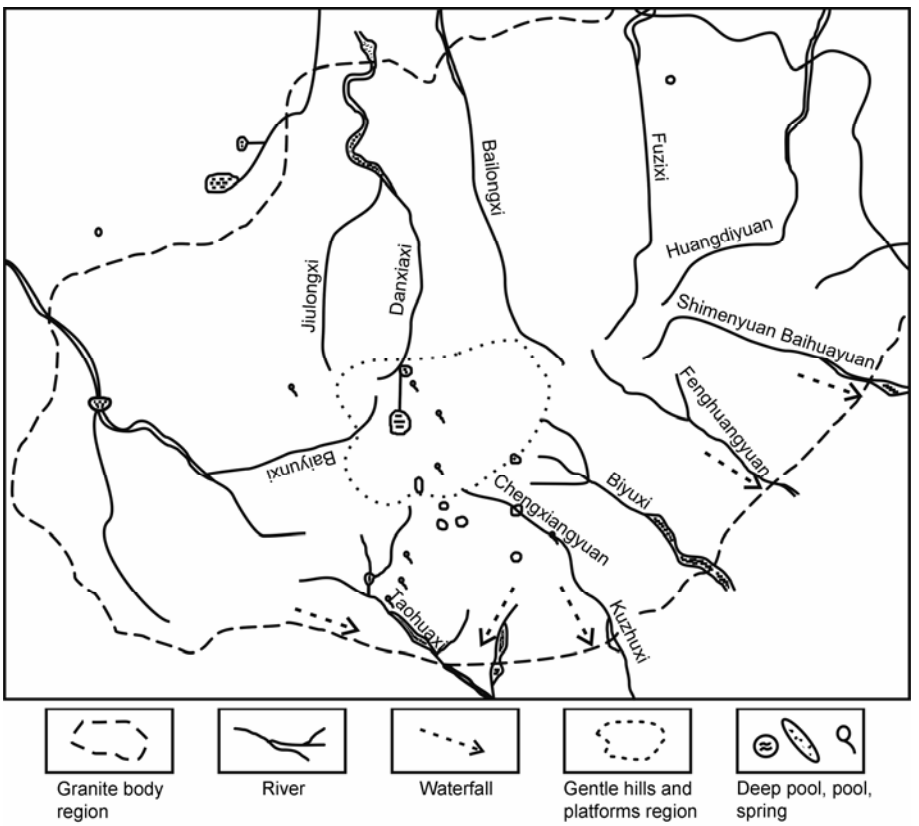

Figure 13 Sources of the radial water system in the Huangshan Mt.[1)].

For the Huangshan Mt., the only difference is that the uplift and incision are both more intense, and therefore the elevation difference is larger (Figures 4 and 5). The landform in the Huangshan Mt. is formed through the following process:

(1) Uplift and erosion stage: the high block was formed by granite bodies from different phases, and the latest intrusion time was (123.4—124)±5 Ma BP (Middle and Late Cretaceous). Then, after a long period of erosion until Miocene and Pliocene, planation surfaces were formed around the world.

(2) Planation surface stage: comparing the studies on planation surfaces in western China and those on similar planation surfaces in eastern China, it could be referred that the planation surface in Huangshan Mt. was also formed at that time. The gentle hills and platform in the center area are the remained parts of this planation surface. The major evidences are as follows: (1) There is an intensive weathering zone in the center area. It is part of planation surface and indicates a tropical-subtropical environment. It is said that during the construction of Xihai Hotel, the foundation had to execute a special procedure because of the unconsolidated layers was thicker than 10 meters. This was probably a result of putting the foundation on a weathering crust. (2) A bedrock stands out near the south foothill of Guangmingding. It is different from stone forests which are groups of rocks. Granite weathered mantle should have groups of tors and this bedrock might be one remained tor, which is also a trace of planation surface. For more information on granite planation surface weathered mantle and landform development features, see ref.[16]. (3) This remaining part of planation surface is surrounded by knickpoints of the surrounding rivers. The most representative one is Paiyunting knickpoint on the west side. It is located at the intersection of the center gentle platform and the source of Xihai gorge, and also located at the cliff east to SN-trending Taiping cableway-Shijianshi fault. Similar knick points include the top of "Yixiantian" (east of Aoyufeng) on the south, the one at Shuguangting (Figure 5) on the north, the one at the exit of Xihai reservoir under Shigufeng on the northwest, and the one

1) See footnote 1 on page 4488

below Guangmingding on the southeast (Figure 9). Usually, the block surrounded by knick points is the center of the divide of the radial water system (Figure 13). According to the definition, "knick point can only remain its shape when the elevation difference between knick points is larger than the depth of water"[17]. Therefore, these knick points have been there and will remain there for a long time. It is a shame that there is little running water on these knick points and thus there will not be large waterfalls[18–20].

The late period of the planation surface formation should be in late Pliocene. The crust was uplifted slightly and this caused light incision, and the gentle hills and depression currently in the center area were also formed in that period. However, the downstream corresponds to the remained replat at the top of gorge, and the clearest part is the upstream of Yuping stream and along Xihai gorge. The top replat is located at the entrance of Paiyunting gorge, and it is almost equal in height with Paiyunting, which is the surface at the light incised stage.

(3) Deep incised stage: as shown in Figure 14, the three replats H, M, and L are three intermediate stages during this stage. According to the general rules of landform development in China, this stage corresponds to Himalayan movement from late Pliocene to early Quaternary. During the Qiangzang movement, the uplift was very intense in 350 Ma BP, and there were also uplifts in 250 Ma BP and 150 Ma BP[21]. Then the Kunlun-Huanghe movement in 1.1—0.8 Ma BP made the Tibetan Plateau uplift to 3500 m and created the earliest and largest glaciation ever known—Kunlun Glaciation[22]. The Gonghe movement from 0.15 Ma BP caused intensive uplift of more than 10 mountains on the east edge of Tibetan plateau and made them reach the altitude of equilibrium line (3800—4000 m), thus only Last Glaciation was developed in these mountains[23]. This uplift also affected the mountains on lower terrace in eastern China; mountains such as Nanling, Dabieshan, Shandongqiuling, Jiangnanqiuling, Sanqingshan and Huangshan were all uplifted. Another example, the high mountains in Taiwan (Yushan, Xubashan, and Nahudashan) were uplifted due to being pushed by the Pacific Plate, and thus only Last Glaciation was developed as mentioned above. In addition, this uplift also influenced the mountains in Zhejiang, Anhui, and Jiangxi[24,26]. The corestones layer at the foot of light weathered zone on the planation surface is now distributed around the edge of the center area, such as Feilaishi, Houziwangdonghai, and Aoyuzui. According to the theory of granite weathered mantle zonality, this means the original light weathered zone of granite weathered mantle has reached the top of Huangshan Mt.; this is a result of uplift[16]. Further investigation is needed to find out which uplift movement the three levels replats in gorge corresponds to. This deep incision stage is still in progress now (Figure 14)[18,19].

The three stages mentioned above are illustrated in Figure 15.

According to previous studies, there are multiple levels of ancient erosion surface in the Huangshan Mt. From top to bottom, they were formed in Late Cretaceous-Eocene (85—50 Ma BP), Eocene-middle-Oligocene (45—30 Ma BP), Miocene-early-Pliocene (24—5 Ma BP), respectively[25–28]. However, according to the latest findings of Pu Qingyu[1)], Guangmingding adult surface (1600—1800 m) was formed in Oligocene-Mi-

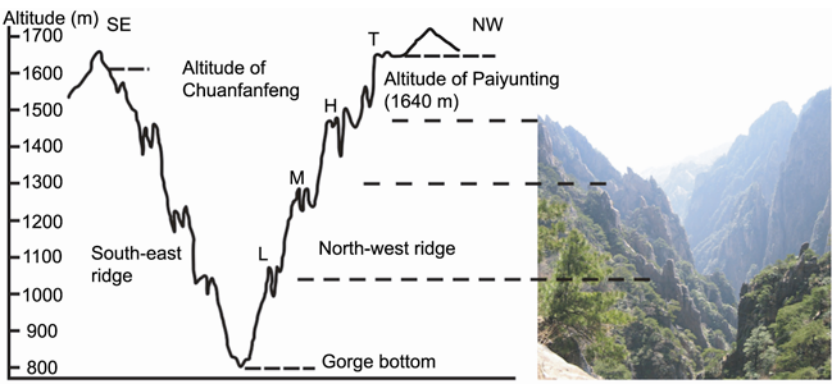

Figure 14 Sketch map of replats in Xihai gorge. T, Top replat; H, high replat; M, middle replat; L, low replat.

1) Pu Q Y. Research on Huangshan Mt. landform. 2008

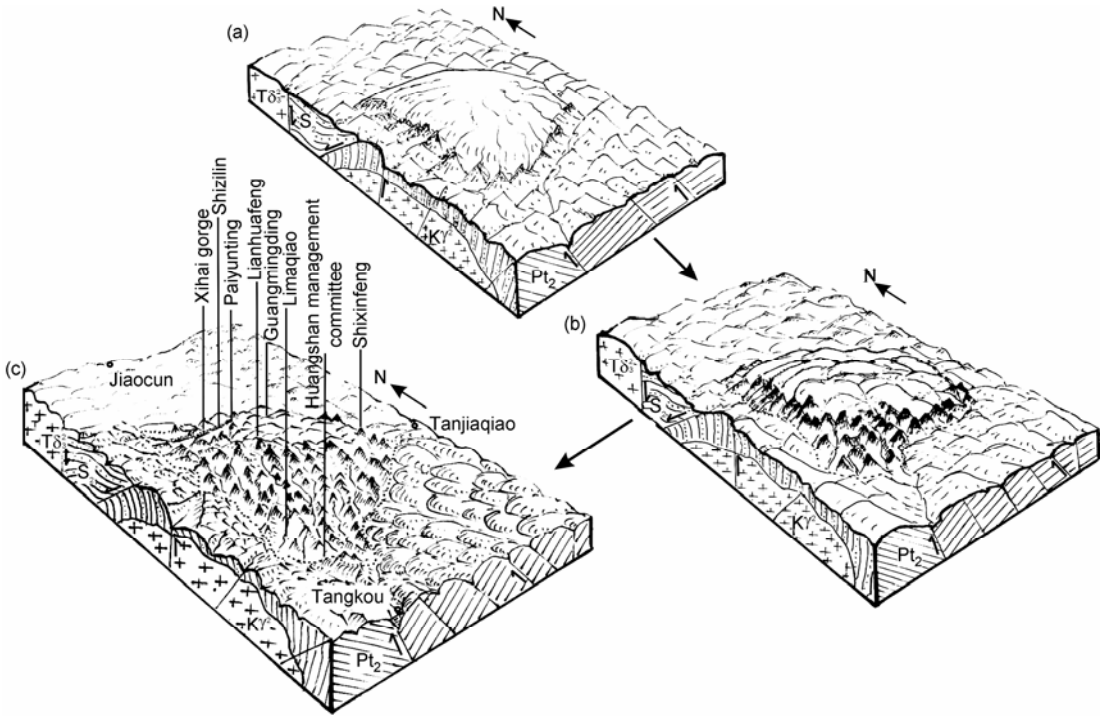

Figure 15 The three stages of landform evolution in Huangshan Mt. (a) Landform in Huangshan Mt. hundreds of millions of years ago (first stage). Granite bodies in Huangshan Mt. were exposed and showed domical mountain. The planation surface and weathering mantle were formed and surrounded by mountains of surrounding rocks. (b) Landform in Huangshan Mt. millions of years ago (second stage). Pliocene (5－2.5 Ma BP), slight uplift resulted in mild incision, the top of domical mountain is gentle, obvious incision and granite peaks appeared on the periphery. (c) Landform in Huangshan Mt. now (third stage). Intense uplift started from Quaternary (since 2.5 Ma BP). Paleo-planation surfaces were divided. The headward erosion of the rivers created gorges and high peaks.

ocene, the slightly lower Laorenfeng-Zhushafeng-Taohuafeng (1250－1400 m) adult surface was formed in Miocene-Pliocene, and the lowest Ciguangge strath surface (750－1100 m) was formed in middle Pleistocene (0.7 Ma BP). Meanwhile, according to Yuan Wanming's[1)] apatite fission track dating, there were also three stages: 56 Ma BP (Eocene), 45－32 Ma BP (Oligocene), and 15 Ma BP (Miocene), which almost coincide with the uplifts and denudation process in this area. He also claims that Huangshan Mt. was uplifted and exposed to denudation since Tertiary until early Quaternary. This resulted in the gentle hills scenery, and thus relative deposits in this time period are missing in the piedmont.

Pu[1)] found that there are three levels of terraces at the Bailongqiao profile in Xiaoyaoxi gorge. The elevation difference of T3 is 50 m (730 m a.s.l.); ^{14}C age of its gravel layer is 25.04±13 ka BP, and converting into incision rate is 2 mm/a. If so, it would take 55 million years to incise from the top of Huangshan's main peak (1864 m) to here (730 m), ignoring continuous uplift amplitude. Pu thought the duration of incision is 70 million years, but actually, uplift-incision had started at the beginning of Quaternary, corresponding to Kunlun-Huanghe movement in 110－80 Ma BP, which could probably increase the uplift-incision rate of the mountains in eastern China.

Meanwhile, Yuan[2)] found that the cooling crystallization rate of the samples from Middle-Miocene (13 Ma BP) until now increases. The speed is much faster than the previous two stages (170－75 Ma BP). The uplift rate is 0.12 mm/a and the uplift amount is 1.57 km. The total uplift amount of all the three stages is 6.71 km, and the speed of uplift also shows an increasing trend. Speaking of surface uplift, the uplift amplitude in the Huangshan Mt. varies between 450－2230 m.

Last but not least, granite landforms in the Sanqing Mt. in Jiangxi Province is somewhat different from

1) Yuan W M. Formation, uplift and denudation of Huangshan granite body. 2008
2) See footnote 1 on page 4497

those in the Huangshan Mt. in morphology[16], but they are almost the same except that the original surfaces are not well preserved in Sanqing Mt. Its stratified landform is not obvious either. It is hard to find any trace of the original planation surface. Therefore, the Sanqing Mt. has gone further in its landform evolution than the Huangshan Mt., and the Huangshan Mt. is very representative in granite landforms due to the well-preserved and classical landform type, distribution and evolution.

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