Comment on planation surface

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Abstract Planation surfaces includes peneplain, pediment and etchplain, which differ from each other in formation and distribution. The double leveling surfaces theory offered by Budel can be used to explain the landforms in limestone areas. According to Budel, that the residue is the upper layer of a planation surface is very important in studying the formation environment and weathering crust deposit in planation. In recent years, some researchers have expresses doubt whether it is reliable to use fossils to interpret the rising amount and rate of rise of the Tibet Plateau. It is believed that the primary planation surface can be used as a reliable indicator of land rising.

Keywords: **planation surface, peneplain, pediment, etchplain.**

1 Review

IT has been a century since Davis[1] advanced the concept of peneplain, and Gilbert[2] presented the concept of the pediment, and yet both ideas remain among most the important basic theories in geomorphology. The concept of planation surface includes peneplain, pediment (or pediplains), and etchplain[3]. Although the concept of the peneplain has been criticized and doubted since it was proposed, its importance cannot be ignored in any discussion of the planation surface.

(ⅰ) Peneplain. "Peneplain" has been a debatable term. An ideal and uncompleted planation surface can be regarded as almost-plain or peneplain. The question is how to define an almost-plain or peneplain, though it is very clear that no one would believe a great relief landform to be a planation surface. Slope is important in discussing planation. For example, the relief of planation surface in Tibet Plateau can be 1 000 m, however, the slope is only 0.001, showing a 1 000-m relief in 1 000 km of horizontal distance[4]. Theoretically, the lower slope limit for soil creeping is the upper limit of planation slope. Budel measured planation slope 0.002 at Deccan Highland[5].

It is believed that the process of planation is controlled by sea level (ocean action)[6]. Theoretically, regardless of time and altitude, waves can destroy and land[7]. The word peneplain was created after Davis investigated the Jurassic bed in the middle USA. Later, influenced by Gilbert, Davis proposed the theory of "geographic cycle"[8]. Because a complete planation needs infinite time, Davis admitted that in a limited time the planation only reaches certain stage; therefore peneplain means an almost-lain and signals the end of the geographic cycle. Davis noticed mountain summits were at nearly the same altitude in New England and Appalachians. He believed that the summits were uplifted and dissected peneplain, and named the summits uplifted peneplain. This recognition offered strong support to his geographic cycle theory. Later, Penck proposed the mountain foot step theory[9]. According to Davis' original definition, denudation and planation are different phenomena[10]. The former refers to the process in youth and mature stages; the later refers to the old stage in the geographic cycle.

(ⅱ) Pediment and pediplain. Almost everyone agrees with the existence of pediment, because of its clear form and active process in many places[3].

(ⅲ) Etchplains. Etchplain refers to weathered and erosional surface, with bedrock exposures. Adams[3] questioned calling the area where bedrock has thick residue crust etchplain. Etchplain can be evolved from other planation surface, but not from mountains with great relief.

It is suggested that peneplain and pediment are used as they were offered originally. In fact, peneplain does lead to altitude decrease, though it emphasizes slope retreating. The piedmont surface theory emphasizes parallel retreating of slope, which must lead to altitude decrease finally. So wave erosion

plain, etchplain, or piedmont can be regarded as a stage of planation (or peneplain) under certain conditions, differing merely in process and rate (figure 1).

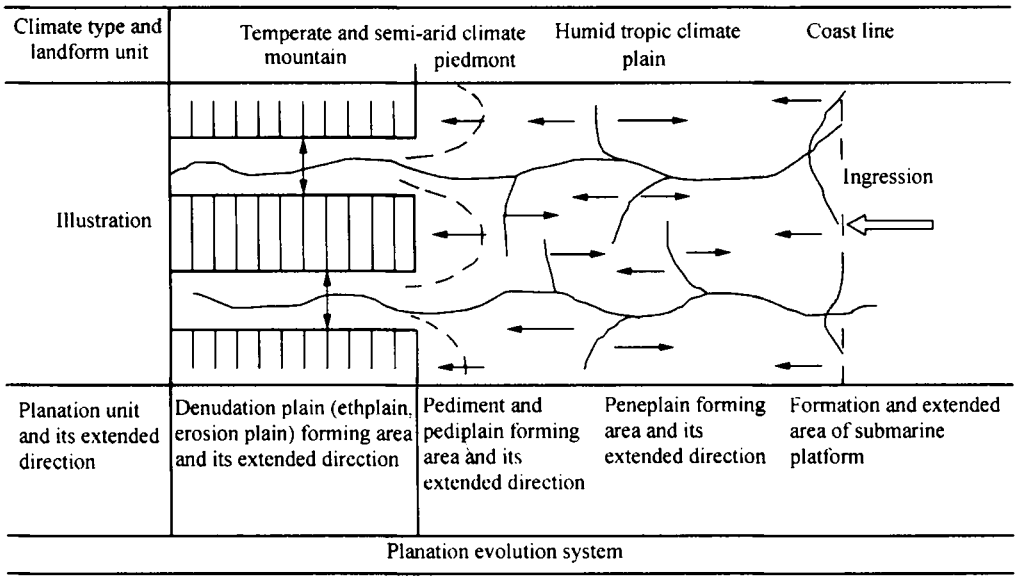

Fig. 1. Planation evolution system on the given tectonic stable-ingression cycle.

2 Planation research in today

In 1975, Adams edited the book *Planation Surface: Peneplains, Pediplains and Etchplains, Benchmark Papers in Geology*[11], which gave a thorough review of the works about planation in the past. As international researchers have considered the uplift of the Tibet Plateau in the 1990s, planation surface has become one of the most interesting issues. Shackleton admitted that planation surface can be regarded as an indicator of plateau uplift[12]. As far as the present knowledge is concerned, conclusive planation, together with forming time and original altitude, is the only acceptable evidence to judge plateau uplift. The planation surfaces that can be thought to have occurred in late Mesozoic Era and Tertiary Period (fig. 2)[13]. As tropical and subtropical areas were enlarged, the arid inner land and the no ingression areas, low and flat landform such as pediment and etchplain formed (figure 2).

There has been important research on planation[5,13—17]. In May of 1995, a conference was held discussing "morpho-genesis and morpho-origin of planation surface" in Tuelingen, Germany, by the Morpho-Genesis Commission of Germany Academy, with papers showing new development in planation re-

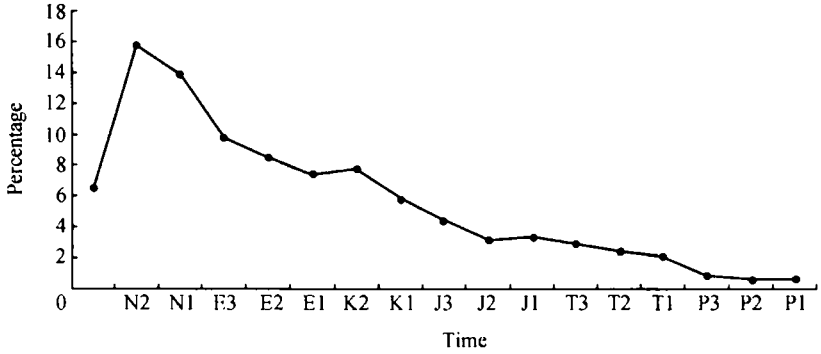

Fig. 2. Frequency of curve of planation age in the world (after D.A. Temofeev, 1979).

search, for example, "Weathering and Weathering Crust on Planation Surface", "Morpho-genesis", and "Planation Surface and its Spreading" among then. The central topic was on deep weathering. It shows that since Budel advanced the term "double leveling surfaces", weathering crust has become a key to understand planation surface (figure 3).

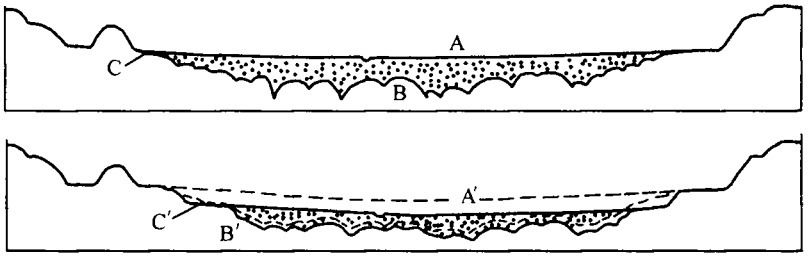

Fig. 3. Double-level surface and piedmont step (after J. Budel). Upper: double-develing surfaces (profile in tropic area). A: upper leveling surface-wash surface; B: lower leveling surface-basal weathering front; C: wash pediment. Lower: down extend double-leveling surface, development of rock steps-marginal wash pediment. A′ and B′ are lowered double surface, C′ pediment.

In the former Soviet Union and East European, scientists focus on the distribution comparison and sediment correlation about regional planation surface[19,20]. Soviet Union scientists also pay attention to structure and origin of planation.

In the 1960s—1970s, Chinese scientists paid attention to the existence, structure and comparison of planation surfaces[21,22]. In the 1980s—1990s, scientists paid more attention to the features of the planation surfaces itself, especially to the deformation of planation surface[23—25], and the relationship and signification between planation surfaces and plateau uplift[26,27]. Cui studied the existence and age of planation surfaces in the Miocene Epoch, structure, origin, and character of weathering crust in limestone area[4]. Based on the research of the Beitai Period Peneplain and the E'xi Period peneplain, Wu Chen found the Dianziliang Period Planation surface. This high-lights the "physiographic feature" again and perfects the physiographic feature series in the North China[1].

(ⅰ) Recognition of planation surface. 1) Landforms. What does a planatin surfaces look like? Budel pointed out that the Taimiland Plain, which is located at the eastern slope of the Deccan Highlands towards the Coromandel Coast in the region between Bangalore and Madras, is an example of planation surface[5]. The Taimiland Plain broadly follows the coastline and reaches inland 100 km, locally 200 km, with altitude 200 m, and on occasion 500 m. It is then succeeded by a steep step of some 100 m which leads to the higher Bangalore Plain (750—900 m) and overtopped with inselberg, the highest inselberg reaching almost 1 500 m. The higher and older landforms were formed in the Middle Miocene during a period of colder climate. The lower Taimiland Plain is a developing planation surface with double leveling surfaces.

2) Bedrock. In the Taimland Plain, the entire region consists of granite with only very small extents of sedimentary rocks penetrated by dolerite veins. The weathering resistance of bedrock is a time function. If the relief is great, it may be considered as a residual erosional surface by former erosional cycle.

3) Surface slope. In the Taimiland Plain, the entire slope is less than 2‰ (0.6°). The runoff troughs show a mean slope 10‰, with extremes of 20‰—30‰ (−1.2°—1.7°). Only in the area at the immediate front of the plain and top of high inselberg does the gradient exceed 3.5°—4°.

4) Red weathering crust and shield inselberg as necessary factors. A red loam layer, with average thickness of 4 to 10 m, covers the entire Taimiland Plain area. Along fissures in the granite the decomposition reaches great depth. The rounded bedrock protrudings under and above weathering surfaces become shield inselberg as they rise above the soil sueface.

1) Wu Chen, Ma Yonghong, Zhang Xiuqing, The physiographic feature and development history of mountain landform in the Northern China, 1996.

5) Modern geomorphologic process, erosive base-level (sea level) and tectonic movement. The entire profile of the red loam shows no denudation in the Taimiland Plain. The stream system from brook to main river transport the same load, which was provided by decomposition. It is composed of kaolin rich clay and fine sand. Larger rivers in the hyper-hsallow "run-off plain" are unable to acquire coarser material by erosive activity, therefore the runoff troughs are not morphological but only hydrological units. Active planation process is continuing at the margin of the plain and the piedmont of the inselberg. As long as the erosion base level remains constant, which requires a stable tectonic situation, the mechanism of duplicate planation surfaces with reduce the are to a planation surface.

6) Forming time and climatic condition. The Bangalore Plain formed before the Miocene in conjunction with a marine erosion-base, which persisted over a long period. The vaulting of the Deccan highland occurred in the Miocene, accompanied by the uplifting of the Bangalore.

Formation of peneplain needs tropical monsoon climate and tropical savanna climate.

(ⅱ) The original height. The original height of planation surface is important. Penck determined that the height is about 250 m above sea level. Markov suggested it as base level of denudation[28]. The average height of the Taimiland Plain in India is about 200 m, the height of pediment in North China is about 100—200 m. Based on the original height (200—500 m) of red loam and the development height of karst, the height 1 000 m (500—1 500 m), is taken as the original height of planation surfaces in Tibet Plateau and Southwest China[23].

(ⅲ) Active conditions and classification of planation surfaces. There is a basic question to be answered in all cases, is the surface still being shaped by the agents that contribute to planations or is the cycling still in progress, and is the surface now isolated from its original producing region? It is suggested that planation surfaces are classificated as follows.

Active surface: one still being shaped with respect to its base level, such as the eastern slope of Deccan Highlands, India. All are Holocene surfaces.

Dormant surface: one whose active shaping has ceased temporarily (perhaps because of climatic change) and is expected to function again in the near geologic future. It was in primarily Pleistocene and Holocene.

Exotic surfaces: one formed under climatic conditions that no longer exist and are not firmly expected to return, without age limit, such as the main planation surface in the Tibet Plateau in the Late Miocene Epoch.

Defunct surface: one that has been removed from the active zone of planation by uplift, depression, or climatic change, probably in the Tertiary and Quaternary.

Buried surface: one covered and preserved by sediments not related to its shaping or sealed by lava flows.

Exhumed or fossil surface: buried surface partly exposed by removal of nongenetic cover such as later sediments or lava flows.

Overlap surface: such as the main surface formed in hot-humid climatic condition during Miocene. After uplift, it was denuded by frost weatering (altiplanation in periglacial environment) in the Quaternary.

(ⅵ) Conclusions. The existence of different kinds of planation surfaces is certain. The planation surfaces are not random products of any geomorphological processes. The pediment and pediplain are easier to determine, the most difficult one is the strictly determined peneplain, although it is very difficult to distinguish between peneplain and etchplain. Because of uplifting or burying, the most important ages are the possible latest time when the surface begins to develop and the possible earliest time when the surface ceases to developing. When trying to infer continental uplift by elevation of planation surfaces, one must take into accout of its origin, development environment, base level (original elevation), and possible regional slope. In their research authors examing the relationship between the Qinghai-Xizang planation surfaces and the Plateau uplift[4]. It is not necessary for the development of planation surfaces to have the same climate at the outset. Planation surfaces can consist of different kinds of weathering crust, but the weathering process should be earlier than the erosion cycle. Planation surfaces can be classified

by sea level, endorheic basin above sea level and climatic control. Elevation cannot be used to determine the age of planation surfaces, because the oldest one may be higher or lower. Of course, on theoretical and empirical grounds, the older one should be higher than the new one in the uplifted mountains and plateau. The erosion cycle of planation has relationship with marine invasion in global scale. So the research of planation surfaces, plate tectonics, sea-floor spreading and continental change should be considered in different climatic area.

3 Prospect future

Tricart[29] did not agree with Budel's "double leveling surfaces", because it is too theoretical. Ollier supported Budel. Based on data of covered karst in Tibet Plateau and Southwestern China, the authors support Budel's theory.

The original elevation of the planation surfaces is very important. The Tamiland Plain is an active planation on the eastern slope of the Deccan Highland in India, which shows 200 m original elevation of planation surface. Therefore, established active planation surface should be near to sea level, about 200 m. An elevation range can be suggested by different observations of method such as fauna, flora, soil, karst, etc.

Accurate datings are needed in planation research. Relative comparison of planation surfaces is important. Although global correlation of planation surfaces is difficult, it should be possible. Because the development of planation surfaces is related to global marine invasion.

Budel[5] and the authors[4] stand for double leveling surfaces. The processes of surface denudation and subsurface weathering are related and in equilibrium. In 1990 at the conference in Tuelingen, Germany, some people asked whether the surface denudation and subsurface weathering take place in the same time, or alternate and whether modern planation is in progress?

In the area where deep weathering layer develops in crystalline rock with lots of core holes and observations in Nigeria and Uganda, Thomas[30] thought the deep weathering layer was developed in the Middle or Early Tertiary Period. He further emphasized that the deep weathering was earlier than the erosion cycle in most conditions. This is important because weathering should exist as the earth surface exists. So it is reasonable that weathering is earlier than erosion.

In exogenetic ore deposit, bauxite is regarded almost as the planation surface. According to the comparison research between planation surfaces and deposit period of bauxite, in Siberia and North Kazakhs during the Cretaceous and the Early Tertiary period, each sedimentary cycle of bauxite can be compared with a planation surface.

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