Part 1: Physical Geographic Features of the Qinghai-Tibetan Plateau

The Uplift of the Immense Landmass and the Complex Conditions of the Peripheral Boundary Surface

The Qinghai-Tibetan Plateau, on an average is 4,500m in elevation. Topographically it is the highest terrace in China and the highest and biggest highland in the world. In the southeast, the average elevation is 4,000m and in the northwest it gradually ascends to 5,000m. The surface of the main plateau is mainly covered by low mountains and undulating and broad basins. On the edges of the plateau, high mountain ranges constitute the geomorphologic skeleton of the Plateau. These mountain ranges are composed of two groups of mountains which run in almost east-westerly and south-northerly directions. From south to north lie the east-west oriented Himalayan Mountains, the Gangdise-Nyainqentanglha Range, the Karakorum-Tangula Mountains, and the Kunlun Mountains. On the eastern edge of the plateau lie the south-north oriented Hengduan Mountains, a mountain system folded by the tips of the eastern extensions of the Tangula and Nyainqentanglha mountains, and, from west to east, the Baishula Range, the Taniantaweng Mountains, the Ningjing Mountains, the Shaluli Mountains, and the Daxue Mountains. The Qinghai-Tibetan Plateau landform covers approximately 2,500,000sq.km. in extent and towers above the centre of the Eurasian continent.

Topographically, the contrast between the Qinghai-Tibetan Plateau and its periphery is remarkable, and such a contrast is further enforced by the surrounding criss-crossed mountains. On the western edge of the Plateau, the Northwestern Himalayan Mountains are linked with the Karakorum Mountains and extend northwards to the Pamir Mountain knot. These almost south-north ranging mountains average 6,000m in height and, among them, there are many high snow-capped peaks, e.g., the Qiaogeli Peak (8,611m), the second highest peak in the world, Nanjiapaerbati Peak (8,125m) and four more peaks over 8,000m high. The western sides of these mountains suddenly descend to the Indus River Plain, which is only several hundred metres in elevation, making an absolute difference of over 5,000m in altitude. The eastern edge of the Plateau is occupied by hilly land and mainly consists of the Minshan Mountains, the Qionglai Mountains, and the Daxue Mountains. This area averages 4,000m in elevation and descends to the Sichuan Basin where the elevation is 500m; the absolute difference is still over 3,000m. The Qinghai-Tibetan Plateau is shut off on the south from the rest of the world by the Himalayan Mountains with their main ridges averaging above 7,000m. Mount Everest in the Middle Himalayan Mountains is 8,848m high, the highest peak in the world, and eight of the 14 peaks that are above 8,000m are also to be found there. South of the Himalayan Mountains lies the Ganges-Brahmaputra Delta below 500m in elevation, an absolute difference of 6,000m in altitude between the Delta and the Plateau. The northern edge of the Plateau is covered by the Kunlun, Altun, and Qilian mountains, which average 5,500-6,000m in elevation. In the north, beyond these high and magnificent mountains, the Tarim Basin and Hexi Corridor have elevations of 1,400-2,500m, making an absolute difference of 3,000-4,000m in altitude between the mountains and the rest of the area.

The southern and eastern parts of the Qinghai-Tibetan Plateau are located on the windward sides of the southwest and southeast monsoons, and they have plentiful precipitation owing to the influence of the special boundary surface effect produced by the warm-humid currents and the terraces. Moreover, the great difference in topographic conditions enhances the erosive power of the running waters. Therefore, the boundary surfaces of these two terrace series are serrated, caused by numerous deep cutting rivers. Thus, the environmental complexity between the Plateau and its peripheral zones is further increased. On the other hand, the Plateau is not completely shut off from the outside world by high terraces. Some of its mountain ranges extend to the mountain systems outside. For example, in the west of the Plateau, the Karakorum and Kunlun mountains are connected westwards, via the Pamir Mountain Knot, with the Xingdukushi Mountain Range which extends further west linking with the Caucasus and Alpas mountains in Europe via the Pamisush Mountains and the mountains on the Plateau of Iran. Northeasterly, the Pamir Mountain Knot is connected with the mountains in Siberia via the Tianshan, Altay, Tannu Ola, and Sayanling Mountains. In the northeastern parts of the Plateau, the Qilian and Minshan Mountains are linked eastwards with the mountains in east and northeast China via the Qinling Mountains and the Daba Mountains. In the southeast, the Hengduan Mountains extend directly southwards to the mountains in the Indo-Chinese Peninsula.

The landforms described above bring distinctiveness to the Qinghai-Tibetan Plateau and lead to the formation of its unique fauna and flora and to the close relationship between the Plateau and its adjacent regions. Consequently, the Qinghai-Tibetan Plateau has a drastic effect on biodiversity in other regions.

Unique Heat-island Effect and Complex and Diversified Climates

The Qinghai-Tibetan Plateau, a land mass of about 2,500,000sq.km. and towering to the middle of the atmosphere between the earth's surface and the tropopause, has a strong impact on the atmospheric circulation that originates from the exchange of heat between the continents and oceans. This effect includes the mechanical pull of the land mass in the atmosphere, the frictional force of the land boundary surface on atmospheric movement, and the heating power produced by the land mass through solar radiation

Based on repeated research on the climate of the Qinghai-Tibetan Plateau, Chinese meteorologists have confirmed that "in winter, the Qinghai-Tibetan Plateau mainly effects atmospheric movement, however, this is caused by heat rather than mechanical power." In spring and summer, the Qinghai-Tibetan Plateau is a huge heat source. In June especially, an area of one square centimetre may produce 210 Kcal. per day. A Plateau with an area of about 2,500,000sq.km. can produce 1.1×10^{18} Kcal. in the atmosphere per day, on the average, over the year. In June, the whole Plateau produces 5.0×10^{18} Kcal. Under such circumstances, in spring and summer, the Plateau boundary surface directly heats the atmosphere over the surface, thus affecting the temperature and humidity of the low-level atmosphere. Below 500mb, a strong, hot low atmospheric pressure is formed. The upward movement of hot air leads to the appearance of an upper strong and stable, warm high atmospheric pressure of above 430mb (the strongest at 150-200mb) in the Plateau's troposphere, which is quite unique. The high atmospheric pressure occupies the upper level of the troposphere over the vast subtropics of Asia and Africa, not only affecting the current field of the northern hemisphere but also that of the southern hemisphere.

Thus, along with the seasonal change of the features and intensity of the Plateau's cold and heat sources, the air pressure field undergoes remarkable seasonal change, and so does the wind field. The most distinct feature is that, in summer, the wind around the Plateau converges on to the Plateau and in winter it diverges away. Thus, a unique plateau seasonal phenomenon occurs (Ye Duzheng et al. 1979). The special heat-island effect of the Qinghai-Tibetan Plateau exerts a tremendous influence on the climate of the Plateau.

1. The Qinghai-Tibetan Plateau monsoon destroys the planetary air pressure belt and planetary circulation in the middle of the troposphere; hence, the influence of the descending continental air mass (which is controlled by subtropical high atmospheric pressure and the westerly planet wind belt, both of which are of decisive importance to the climate of the latitudinal zone of the region) is weakened. As a result, a warm and rainy region of considerable size appears in the arid and semi-arid desert near the Tropic of Cancer.

2. The Qinghai-Tibetan Plateau monsoon enforces the monsoon phenomenon between the southern and northern hemispheres and the exchanges of air, water, momentum, and energy between the two hemispheres. The most important point is that it induces and thickens the southwest monsoon at the lower layer of the troposphere. Confirmed by the simulated tests of Habn and Manabe (1925), without the plateau the centre of the continental low pressure is located at 45°N latitude and 125°E longitude. Thus, in July, the mean southwest monsoon cannot go beyond 15°N latitude on the South Asian Continent. However, enforced

by the plateau monsoon, it can travel through all the longitudinal passages composed of numerous valleys on the southern edge of the Plateau that are deeply cut by running water and move further northwards into the hinterland of the Plateau. Influenced by various landforms, the southwest monsoon regularly releases the water and heat that it brings while it moves northwards into the Plateau's hinterland. Eventually, it has a direct effect on the distribution patterns of the ecosystems of the Qinghai-Tibetan Plateau region.

3. The plateau monsoon also enforces the exchange of air currents between Eurasia and the southeastern and southern areas of the South China Sea and the southwestern Arabian Sea. In summer, the southeast monsoon is enforced by the plateau monsoon and moves northwards along the eastern and northeastern edges of the Plateau to the Qilian Mountains, affecting the climate of those regions. Influenced by the plateau-heat-island effect, the winter rainfall cloud masses of the western Arabian Sea may affect the climate of the mountainous regions in the west of the Plateau and cause rainfall there in winter.

4. The plateau hinterland, facing the centre of the plateau's low-level heat, low pressure area, is a convergence centre for the air current around and horizontally becomes the drought and cold limit of the Qinghai-Tibetan Plateau. Revolving around this limit, the gradient change of water-heat assemblage conditions in the Qinghai-Tibetan Plateau brings polar zonality to the ecosystems of the Plateau (Li Bosheng 1985a).

Controlled by the special Qinghai-Tibetan Plateau circulation system, the Plateau has complex and diversified climates, and its water-heat assemblage is of great variation.

The plateau is the focus of international attention because of its numerous climatic types. Although it falls into subtropical latitudes, its action in enforcing the southwest monsoon and in impeding the cold air masses from the north causes the tropical monsoon climatic zone in the South Asian Subcontinent to extend to the southern edge of the Plateau and form a zonal climatic type at its base. This type of climate may even extend to 29°30'N latitude along the Yarlung-Zangbo River Valley. Because of the height of the Plateau itself, a climatic type, similar to that in a cold zone, appears on its northwestern edge. The movement of the southwest monsoon northwards, the core of drought and coldness in the northwest of the Plateau, and the gradual ascendance of its topography induce gradient changes of water-heat assemblages. Thus, the Qinghai-Tibetan Plateau has developed 'a plateau climatic zone,' similar to a climatic latitude zone, and different climatic regions that are features of the Plateau itself. From southeast to northwest the following regions can be found, (a) a tropical, lower montane, monsoon humid, climatic region, (b) a subtropical montane, monsoon humid, climatic region, (c) a plateau temperate humid, climatic region, (d) a plateau temperate monsoon, semi-humid climatic region, (e) a plateau temperate monsoon, semi-arid climatic region, (f) a plateau temperate monsoon, arid climatic region, (g) a plateau sub-cold monsoon, semi-humid climatic region, (h) a plateau sub-cold monsoon, semi-arid climatic region, (i) a plateau sub-cold monsoon arid climatic region, and (j) a plateau cold monsoon, arid climatic region (Shen Zhibao 1984).

The variation in the Plateau's climate not only reflects its diversified zonal climatic types but also its numerous vertical climatic types. Owing to a vast mountainous area on the edges of the Plateau, and snow-capped mountains on the broad flat plateau surface reaching into the clouds, the mountains in the different plateau climatic zones have their own distinctly vertical climatic zonal spectra. For example, the southern slopes of the eastern Himalayan Mountains on the southeastern edge of the Plateau have the most complete vertical climatic zonal spectra (Table 1) (Li Bosheng 1984) among all the humid mountains in the world. Their basal tropics with optimum water-heat assemblage conditions, along with the gradient change in water-heat assemblage caused by a gradual rise in altitude, transits to an extremely cold, polar montane ice-snow zone, via montane subtropics, a mid-mountain warm-temperate zone, a subalpine cold-temperate zone, an alpine cold zone, and an alpine cold-freezing zone. On Mount Everest, the highest peak in the world, standing at the southern edge of the Qinghai-Tibetan Plateau, and on the Qiaogeli Peak on the western edge, the second highest peak in the world, there is a most severe, montane cold-pole climate. According to measurements carried out by Chinese mountaineers at the summit of Mount Everest at 14:30 on 27 May 1975, the temperature there then was -35°C So one can speculate that the annual temperature at the top of Mount Everest is below -20°C. Thus, it can be seen that a great change takes place in the vertical climatic zone on the southern edge of the Qinghai-Tibetan Plateau from low mountain tropics to alpine cold pole; meanwhile, the climatic water and heat conditions may have different combinations.

Tables 2-4 show the structures of the windward mountain climatic vertical zonal spectra of the mountains on the east, south, west, and northern edges of the Qinghai-Tibetan Plateau. They are different to varying degrees from the world's most simplified climatic vertical zones of plateau cold-drought cores (Table 5). This shows that successional series of mountain climatic vertical zonal spectra exist from all edges up to the plateau cold-drought core. They are regularly distributed on the slopes of all the mountains of the Plateau. The Qinghai-Tibetan Plateau has extremely diversified mountain vertical, climatic association types and no other place in the world is compatable.

Table 1. Climatic Vertical Zones of the Southern Wing of the Himalayas (South Slope of Mount Nankabawa)

No.	Climatic Vertical zones	Ecosystemic Vertical Zones	Altitudes (m)	Annual Mean Temp. (°C)	Annual Mean Rainfall (mm)
1	Humid low mountain tropical climatic zone	Low mountain evergreen, semi-evergreen monsoon rainforest zone	<1100	>18	2500-5000
2	Humid montane subtropical climatic zone	Montane evergreen, semi-evergreen broad-leaved forest zone	1100-2400	11- 18	1500-2500
3	Humid mid-mountain warm temperate climatic zone	Mid-mountain evergreen needle-leaved forest zone	2400-2800	8 -11	2000-2500
4	Humid sub-alpine cold temperate climatic zone	Subalpine evergreen needle-leaved forest zone	2800-4000	2 - 8	1500-2000
5	Humid alpine cold climatic zone	Alpine shrub and meadow zone	4000-4400	-3 - 2	1000-1500
6	Humid alpine cold-freezing climatic zone	Alpine ice-edge zone	4400-4900	-5 - -3	< 1500
7	Humid alpine ice-snow climatic zone	Polar alpine ice-snow zone	>4900	<-5	< 1500

Table 2. Climatic Vertical Zones of the Eastern Edge of the Qinghai-Tibetan Plateau (East Slope of Gonggar Mountain)

No.	Climatic Vertical Zones	Ecosystem Vertical Zones	Altitudes (m)	Annual Mean Temp. (°C)	Annual Mean Rainfall (mm)
1	Humid montane subtropical climatic zone	Montane evergreen broad-leaved forest zone	1000-2200	8 to 18	1000-1500
2	Humid mid-mountain warm temperate climatic zone	Mid-mountain needle-leaved and broad-leaved mixed forest zone	2200-2500	5 to 8	1300-1500
3	Humid subalpine cold temperate climatic zone	Subalpine evergreen needle-leaved forest zone	2500-3600	0.8 to 5	1600-1700
4	Humid alpine cold climatic zone	Alpine shrub and meadow zone	3600-4600	-3 to 0.8	1000-1600
5	Humid alpine cold-freezing climatic zone	Alpine ice-edge zone	4600-5000	-5 to -3	< 1500
6	Humid polar alpine ice-snow climatic zone	Polar alpine ice-snow zone	>5000	<-5	< 1500

Table 3. Climatic Vertical Zones of the Western Edge of the Qinghai-Tibetan Plateau

No.	Climatic Vertical Zones	Ecosystemic Vertical Zones	Altitudesim
1	Arid montane subtropical climatic zone	Low mountain desert zone	800-2000
2	Arid mid-mountain warm temperate climatic zone	Mid-mountain steppe zone	2000-3000
3	Arid subalpine cold temperate climatic zone	Subalpine evergreen needle- leaved forest zone	3000-4300
4	Arid alpine cold climatic zone	Alpine shrub and meadow zone	4300-4600
5	Arid alpine cold-freezing climatic zone	Alpine ice-edge zone	4600-4800
6	Arid polar alpine ice-snow climatic zone	Polar alpine ice-snow zone	>4800

Table 4. Climatic Vertical Zones of the Northern Edge of the Qinghai-Tibetan Plateau

No.	Climatic Vertical Zones	Ecosystemic Vertical Zones	Altitudes (m)
1	Arid montane warm temperate climatic Zone	Montane desert zone	< 1400
2	Arid mid-mountain temperate climatic zone	Mid-mountain desert zone	1400-2800
3	Arid subalpine cold temperate climatic zone	Subalpine steppe zone	2800-3400
4	Arid alpine cold climate zone	Alpine meadow zone	3400-3800
5	Arid alpine cold-freezing climatic zone	Alpine ice-edge zone	3800-4800
6	Arid polar alpine ice-snow climatic zone	Polar alpine ice-snow zone	>4800

Table 5. Cold-arid Polar Climatic Vertical Zones of the Interior Continent of the Qinghai-Tibetan Piateau

No.	Climatic Vertical Zones	Ecosystemic Vertical Zones	Altitudes (m)
1	Arid plateau cold climatic zone	High and cold desert zone	4500-5000
2	Arid alpine cold-freezing climatic zone	Alpine ice-edge zone	5000-5400
3	Arid polar alpine ice-snow climatic zone	Polar alpine ice-snow zone	> 5400

In addition, the extremely complex landforms of the Plateau result in the formation of some unique climatic types, of which the most well-known is the dry river valley climate that occurs in the Hengduan Mountain region in the east of the Plateau. Meteorologists have different explanations for its formation. For example, because this region falls in the subsidence compensation area of the outer sphere of the plateau monsoon circulation sphere, the foehn effect caused by mountains in blocking monsoons and the influence of the local circulation of the valley wind are the reasons for the formation. Climatically dry river valleys are distinctly characterised by less rainfall, intense evaporation, plentiful heat, and a dry climate. According to the aridity formula of H.L. Punman, the aridity of such a climate is 1.5-5.0, belonging to semi-arid and arid steppe or desert-steppe climate. As to the heat, owing to the differences in physical position and in altitude, the criteria for heat are different for different dry river valleys in the Hengduan Mountain region. They are divided into three types: arid heat, arid warm, and arid temperate. This special, dry river valley climatic type has developed an unusual ecosystem and vertical zonal spectra, and it has given rise to special species.

In short, the Qinghai-Tibetan Plateau climatic variation is evident. The substantiality of this variation is that all of the climatic elements are discrepant in climatic niche at different horizontal and vertical locations on the Plateau. Although it is impossible to discuss the extremely high mountains owing to the inadequacy of first-hand data or on-the-spot investigation, speaking about changes at distances of from 500-5,000m from the Plateau edges up to its hinterland, the two extreme values of each climatic element are very impressive. For example, the annual mean temperature ranges from 20°C to -8°C, the annual rainfall ranges from 4,000mm to 25mm, and the solar total radiation ranges from 110Kcal./cm^2yr and 210Kcal/cm^2yr. The possible arrangement of the combination of all the elements will definitely form a fantastic astronomical figure. All these elements vary in different places and in different months of the year. The diversified climatic niches formed by these climatic elements have a decisive influence on biodiversity in the Qinghai-Tibetan Plateau.

Finally, it is necessary to point out that, owing to the complexity of the Plateau geomorphology, the climate is controlled by a plateau unique circulation. Hence, the plateau climate is obviously changeable according to time coordinates. If the southwest monsoon is considerably strong, the water-heat assemblage conditions along its water-vapour passages vary remarkably, and vice versa. Supposedly influenced by the monsoons, the annual mean temperature of this region ranges between 0.4°C and 7°C; thus each climatic zone boundary in the vertical zone will vary by about 100m up or down. Definitely this greatly affects the mountain ecosystems and directly influences the species' differentiation rate.

Long History of Development, Formation of Unique Modern Fauna and Flora

The Qinghai-Tibetan Plateau is not as many scientists outside China conjectured: glaciers thoroughly destroyed the previous vegetation without any trace and the plant kingdom after the Ice Age bore no relation to that of the Tertiary period; the re-establishment of this plant kingdom relied upon the flora of the areas surrounding those topographic barriers that did not suffer from glacial attacks (Li Shiying 1976 and Rau 1975). The Qinghai-Tibetan region was ancient land during the Proterozoic era. Since the Palaeozoic era, it gradually subsided into a huge sea basin and became the eastern sea waters of the Tethys Sea. Even during that period, terrestrial life occurred on numerous islands in the sea basin. The most ancient terrestrial, *Psilophyton,* was found in the stratum of the Devonian Poququn on the northern slopes of the Himalayan Mountains. At the beginning of the Carboniferous period, an ancient forest ecosystem composed of arboroid ferns, including huge arboroid *Lepidodendron* and *Archaeocalamites,* developed from the ancient continental island in Qamdo in eastern Tibet. In the Permian period, this forest ecosystem was succeeded by a palaeotropical fern forest ecosystem dominated by southern *Cathysia* flora, including *Lepidodendron, Sublepidodendron, Calamites, Cyathea spinulosa,* and *Gigantopteris* of Chinese origin (Xu Ren 1982). Some paleontologists believe that the *Cathysia* flora, composed of pteridosperms, including *Gigantopteris*, are ancestors of the modern Chinese angiosperms. If so, plentiful fossils of pteridosperms found in the Permian stratum in the Qinghai-Tibetan region can fully support the idea that the Qinghai-Tibetan region should occupy a place in the history of the development of Chinese fauna and flora.

Up to the continuous action of the Triassic period, with movement of the land west of the Tethys and Yanshan Mountain, the sea basin of the Tethys began to lift slowly from north to south and from east to west. During the Upper Triassic period, the Kunlun Mountains, Hoh Xil Range, and Qamdo-Deqen area in the Qinghai-Tibetan region emerged as land from the sea and formed the ancient lands of northern Tibet and Qamdo. In the early Cretaceous period, northern Tibet and Qamdo became one piece of land, linked to other parts of China on the east and northeast. To the south and west of this ancient land, there were strip island lands along the Gangdise-Lhasa. The terrestrial ecosystem of the Qinghai-Tibetan region started a constant successional process. In the late Cretaceous period the movement of the Yanshan Mountains came to and end, and the powerful movement of the Himalayas commenced. This was followed by the rapid uplifting of the earth's crust in the Karakorum Mountain region and along the Gangdise-Lhasa-Bowo-Zay (Isotope K-Ar Group of the Institute of Geology of the Chinese Academy of Sciences 1979). Till the Palaeocene epoch of the Cenozoic era, several east-west oriented island lands emerged successively from the sea along today's Fenshuiling in southern Tibet to the Himalayan Mountains, separating the western sea realm of the Tethys into several latitudinally extending sea basins. Later, through the continuous movement of the Himalayas, these island lands began to rise and expand and water through the long narrow sea passages between them receded in northwesterly or southeasterly directions. In the late Eocene epoch, the movement of the Himalayas entered into the second stage. The Indian continental mass moved below the Eurasian continental mass, causing the Himalayan Mountains to rise rapidly. Consequently, the left over ancient sea in the Qinghai-Tibetan region completely disappeared, and the plateau was connected with Eurasia.

The great vicissitudes of the Qinghai-Tibetan region caused a great change in the terrestrial ecosystems of the region. In the late Triassic period, a tropical elfin forest ecosystem composed of *Cycas,* gymnosperms (pines and cypresses), and pteridosperms was developing on the ancient continent of northern Tibet and Qamdo in northeastern Tibet, which belong to the Tethys littoral subregion of the southern China palaeontological geographic region (Wu Xiangwu 1982). In the Jurassic period, large-scale sea erosion shrank the area of the ancient Qinghai-Tibetan continent. By then, a tropical forest ecosystem, composed of gymnosperms and pteridosperms, similar to that of the late Triassic period was developing in this ancient continent, and *surischia* were multiplying in tropical swamps in the humid warm climate. In the early Cretaceous period, the sea erosion in the Qinghai-Tibetan region ended and the dense lush tropical forest ecosystem expanded further. It was an important period for coal formation on the Plateau. In the late Cretaceous period, the terrestrial part of the QinghaiTibetan region expanded further, and the Tethys diminished. Great changes took place in the geographic conditions of the Qinghai-Tibetan Plateau and its adjacent regions. The humid marine climate was replaced by a Mediterranean climate, which is dry in summer and humid in winter. In such a climate, up to the Eocene epoch. the tropical forest ecosystem, composed of ancient gymnosperms and pteridosperms, in the Qinghai-Tibetan region was gradually substituted by a newly developing angiosperm community, a Mediterranean sclerophyllous forest composed of Eucalyptus (Tao Junrong 1981). Meanwhile, *Tsuga* forests appeared in the mountains. Since its appearance, this forest ecosystem, dominated by newly developing angiosperms, has displayed the unique features of the region and its differences from other regions of China.

In the Oligocene epoch, after the land formation process finally ended, the Qinghai-Tibetan region began to enter into a period of rapid upliftment in the formation of the plateau. The third movement of the Himalayas occurred during the Oligocene epoch and promoted the continuous uplifting of the ancient continent of northern Tibetan and Qamdo, with an average altitude of 2,000m and a gradually ascending terrain. Southern Tibetan, shortly after developing into a continent from a sea, drastically squeezed by the Indian continental mass, formed a series of east-west oriented mountain ranges, i.e., the Gangdise Range, the Nyainqentangha Range, and the Himalayan Mountains. In the Miocene and Pliocene epochs, the fourth movement of the Himalayas caused the Qinghai-Tibetan continental stratum to reach a high tide of folding, faulting, rock mud movements and entire upliftment (Isotope K-Ar Group of the Institute of Geology of the Chinese Academy of Sciences 1979). This unprecedentedly strenuous movement laid the basic outline for the modern geomorphy of the Qinghai-Tibetan Plateau. By the late Tertiary period, the Qinghai-Tibetan region attained an average altitude of 2,000-2,500m, and the mountains standing on the Plateau averaged above 3,500m, i.e., the Kunlun Mountains, the Karakorum Mountains, the Gangdise Range, the Nsainqen-Tangulha Range, and the Himalayan Mountains. So far, the Qinghai-Tibetan region had completed the initial stage in the formation of the Plateau, and it began to enter into the final stage of its formation (Li Jijun 1979).

Owing to the above described changes in the Qinghai-Tibetan region, the Plateau gradually enforced its influence on atmospheric circulation and gradually strengthened the monsoon climate of the Asian region. With the influence of this climate, obvious discrepancies occurred in horizonal distribution of the Qinghai-Tibetan Plateau ecosystems.

Owing to the strong impact of the marine monsoon, a *Dipterocarpus* tropical monsoon rain forest ecosystem was developing on the southern slopes of the Himalayas on the southeastern edge of the Plateau and a *Quercus semecarpifolia* sclerophyllous evergreen, broadleaved forest ecosystem was widely distributed in the Yarlung-Zangbo River Valley in the south of the Plateau. Along with the weakening marine monsoon, a semi-humid and semi-arid subtropical forest-steppe ecosystem was gradually being established in the north and northwest of the Plateau. The discovery of *Hipparion* fossils from the Pliocene epoch in the Biru Basin of northern Tibet, Gyirong of western Tibet, and Nyalam and the Zanda Basin clearly confirmed the occurrence of this ecosystem (Huang Wanbo 1980). Meanwhile, because of the formation of a series of large, high mountains on the Plateau, this region became a cradle for the development of vertical zones of world tropical and subtropical montane ecosystems in the early Cenozoic era. For example, the discovery of *Spiraea alpina, S.mollifolia, Cotoneaster microphyllus, Rhododendron baileyi,* and *R.laudandum* in Mongxiang of Namling County in southern Tibet, from the Oligocene to the early Miocene, and *Rhododendron sanzugawaense* and R. *namlingense* from the Wulong flora in the Zondang Basin of Namling County from the late Miocene indicated that the world's earliest tropical and subtropical subalpine and alpine ecosystems had already been established on the Qinghai-Tibetan Plateau.

In the Quaternary period, the movement of the Himalayas was in the ascendant. Within three million years, the Qinghai-Tibetan Plateau, with an average altitude of 2,500m, became the 'roof of the world' with an average elevation of 4,500m. The mountains at its edges rose even higher. In three million years, the Himalayas and the Karakorum Mountains rose about 4,000m. This lifting speed is not comparable anywhere. With the uplifting of the Plateau, the heat-island effect on the Qinghai-Tibetan Plateau became stronger and stronger. Under the influence of the heat-island effect, the Plateau gradually developed its own special plateau monsoon climate. The aridity of the climate in the northwest of the Plateau intensified. Influenced by the fauna and flora from the arid region of Middle Asia, high-cold steppe and high-cold desert ecosystems with unique plateau features gradually became established. From southeast to northwest, the Qinghai-Tibetan Plateau gradually formed a horizonal distribution pattern of tropical rainforest, subtropical evergreen broad-leaved forest, subalpine evergreen needle-leaved forest, alpine shrub-meadow, high-cold steppe, and high-cold desert. In the mountains of each horizonal zone, ecosystemic vertical zonal spectra developed especially for that zone.

During the Quaternary period, the alternation of glacial period and interglacial period had tremendous effect on the formation of the Plateau's modern ecosystems. When a glacial period came, the climate turned cold. There were frequent contacts between the warm cloud masses from the south and southeast and the cold air masses on the Plateau. Thus, rainfall increased the snowline of the Plateau appreciatively, and its mountains descended and valley glaciers extended downwards. The boundary of each horizontal zone of the Plateau indicated in time coordinates was pushed from northwest to southeast and vertically to low altitude. The distance of this shift could be several hundred kilometres horizontally and several hundred metres vertically. During an interglacial period, the climate on the Plateau turned warm and the Plateau ecosystems shifted horizontally and vertically in the opposite direction. This alternation of cold and warm, humid and dry climatic conditions accelerated the differentiation of the species in the ecosystems, as well as the disappearance of some species. However, due to the topographic and geomorphic complexity, man/species survived in relatively stable microenvironments in valleys on the southeast of the Plateau. This made the coexistence of ancient species and new species possible, as well as the plentitude of biodiversity (Li Bosheng 1988).

The fauna and flora on the Qinghai-Tibetan Plateau were established during a long and changeable historical environment. Such a complex process greatly affected modern biodiversity.