

PERMAFROST DEGENERATION IN THE EAST OF QINGHAI-XIZANG PLATEAU

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ABSTRACT: The zoning boundaries of permafrost are theoretically determined from the relation between permafrost and modern climate in this paper. The boundary elevations are given in a profile. There are many phenomena demonstrating a common degeneration, such as buried frozen soil, pseudo-permafrost landforms, variations of patchy permafrost table, multigelation, and vegetation changing in different regions. The important conclusion is that a basic trend of the permafrost changing in the plateau is degeneration.

KEY WORDS: east of Qinghai-Xizang Plateau, permafrost, degeneration

I. DISTRIBUTION OF PERMAFROST ZONE

The east of Qinghai-Xizang Plateau is located in the plateau region to the east of Qinghai-Xizang highway, east longitude 92° — 103° , north latitude 32° — 39° , with a mean altitude from 5,000 m to 3,000 m. Particularly in order to research the influence caused by the permafrost degeneration because of the recently global warming-up of the climate, the permafrost is zoned into three types from the need of the engineering conditions and environmental evaluation, i. e., the continuous permafrost zone, the discontinuous permafrost zone and the modern seasonal frozen ground zone. The permafrost distribution across the middle of the studied area is shown in Fig. 1, from north to south along the national highway 227 (Ning—Zhang highway)—the national highway 214 (Qinghai—Sichuan highway). The elevations about the permafrost zoning in the zones with different latitudes is listed out in Table 1, the continuous permafrost zone is located in the areas where the ele-

vation is greater than the upper boundary elevation, the modern seasonal frozen ground zone is located in the areas where the elevation is less than the lower boundary elevation, and the discontinuous permafrost is located in the areas where elevation is between the upper boundary and the lower boundary elevation.

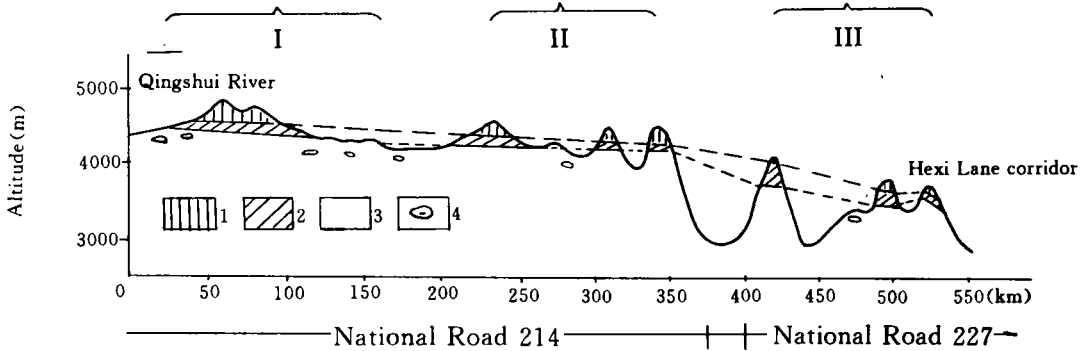


Fig. 1 A profile showing the permafrost distribution in the east of Qinghai-Xizang Plateau

1. continuous permafrost zone
 2. discontinuous permafrost zone
 3. modern seasonally frozen ground zone
 4. shown areas of the buried frozen soil
- I. Bayan Har Mountains II. Burhan Buda - A'nyemaqen mountains III. Qilian Mountains

Table 1 The upper and lower limits of the discontinuous permafrost zone (1991-1994)

| Position | Bayan Har Mountains | | Burhan Buda - A'nyemaqen mountains | | Qilian Mountains | |
|----------------|--------------------------|------------------------------|---------------------------------------|--------------|------------------|---------------------------|
| | South slope | North slope | South branch | North branch | South branch | North branch |
| | South slope of Ba Mt. | Chalaxung - Xiao Yema Mt. | Chang Shitou - Heihe Bridge | Ela Mt. | Daban Mt. | North slope of Obo Mt. |
| North latitude | 34° | 34°20' | 35° | 35°30' | 37°30' | 38° |
| Upper limit(m) | 4550 | 4450 | 4400 | 4300 | 4000 | 3600 |
| Lower limit(m) | 4450 | 4300 | 4200 | 4150 | 3800 | 3400 |

II. ZONING BASES OF DISCONTINUOUS PERMAFROST

In the same direction of slope in Qinghai-Xizang Plateau, the continuous permafrost zone is located in the area with a high altitude, and the modern seasonal frozen soil zone is located in the area with a lower elevation. It shows the difference of atmospheric temperatures in different heights, i. e., the higher the elevation, the lower the atmospheric temperature, and the lower the elevation, the higher the atmospheric temperature. On the other hand, in the area between the above-mentioned zones, frozen soil islands and nonfrozen soil islands coexist independent on the altitudes, therefore, it must be explained according to the developing mechanism of the permafrost.

is greater than 2.5°C , the ground temperature of the upper boundary situated at the bottom of the lower adherent layer is greater than or equal to 0°C . Thus, the annual temperature accumulation is plus, only the seasonal frozen soil can be generated. When the mean annual air temperature is between -2.5°C and -4.0°C , for the surface of the moist fine soil, the absorbing heat is less, but the evaporating heat is greater, the mean annual ground temperature situated at the bottom of the lower adherent layer is still minus, and for the surface of the dry coarse soil, the absorbing heat is greater, but the evaporating heat is less, the mean annual ground temperature situated at the bottom of the lower adherent layer is plus. Therefore, the frozen soil islands are generated under the ground surface of the moist fine soil and turf, and the seasonally frozen soil is generated under the ground surface of the dry coarse soil.

What we want to explain is that, in the first place, the zoning air temperature shows the relation between the modern climate and the permafrost developing, according to the relation, the distribution sites of the permafrost can be effectively traced in other historic times. In the second place, the zoning value is directly related to the local climate. The above-mentioned zoning value has been confirmed in Qinghai- Xizang Plateau. In the area with high altitude, the solar radiation, the daily and annual changing amplitudes of the air temperature are greater, the increment of the ground temperature of the lower adherent layer relative to the air temperature is greater. The principle of adherent layer can be used, but the zoning air temperature value of discontinuous permafrost zone should be corrected.

III. PHENOMENA AND TRACES OF PERMAFROST DEGENERATION

The traces of the permafrost degeneration are repeatedly discovered, but the phenomena are not identical in different regions, it is obvious and common in the boundary area of the discontinuous permafrost and the modern seasonal frozen soil.

1. Modern Seasonal Frozen Soil Zone

1.1 *The developing of the pseudo-permafrost land forms*

There are many pieces of hilly and porphyritic turf on the ground surface, the squamous and concave multigelation is shown up in slope regions, even the heights of the hummocks are up to $0.5-2.0$ m. The combination of the periglacial phenomena is the particularly original mark of permafrost developing on the ground surface. But the permafrost development is not able to be demonstrated nowadays according to the above-mentioned phenomena. When it is demonstrated by field survey only the seasonal frozen soil exists there, it is indicated that the permafrost

had once existed. the modern pseudo-permafrost landforms belong to the remaining traces of permafrost degeneration. Along the lines of national highway 214 (Qinghai—Sichuan highway) and 227 (Ning—Zhang highway), the elevations of their traces are 10 m , even up to 200 m, lower than the lower limits of the modern discontinuous permafrost, and the range can be extended to the discontinuous permafrost zone. Fig. 3 shows a field profile, the section is situated between the south of Madoi County and the north of Xingxinghai area, up to Heihai town, the testing pits are No. 33, No. 55, No. 37 respectively, the distances between each other are 3 km. There are typical pseudo-permafrost landforms in the slope areas and common geological conditions. But the seasonal frozen soil exists in end pits of both No. 33 and No. 37, the depth of seasonal freezing is about 2.0 m. Only in the middle pit, there is some suprapermfrost water in the depth from 0.6 m to 1.8 m, the bottom belongs to the permafrost. Obviously, in the both ends of the section the permafrost has been degenerated and thawed, the frozen soil islands in the hole of No. 55 will also be thawed completely. There are a lot of common sections on the north slope of Daban Mountain near to Ning—Zhang highway and the south slope of Bayan Har Mountains near to Qinghai—Sichuan highway, etc.

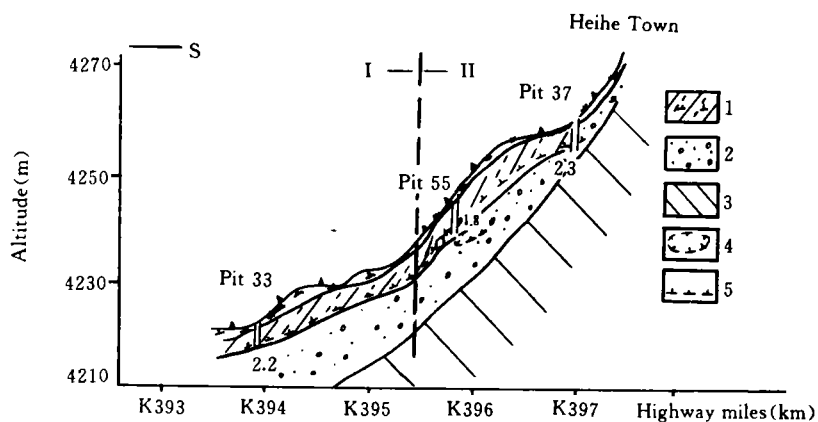


Fig. 3 Geological profile showing the appearance sites of pseudo-permafrost landforms

1. Turf clayey soil
 2. Gravel soil
 3. Rock
 4. Remaining frozen soil islands
 5. Depth of seasonal freezing
- I. Modern seasonal frozen soil zone II. Discontinuous permafrost zone

1.2 Remaining buried frozen soil layer

The buried frozen soil is obviously relative to the shallow seasonal frozen soil under the influence of modern climate environment in the order of times, which has more powerful persuading than the temperature record of permafrost layer, it is demonstrated that the modern seasonal frozen soil is the result of permafrost degeneration.

1.3 *Vegetation*

In permafrost zones, the hummocks belong to the cold-resistant Cyperaceae, in seasonal frozen soil zones, there are mainly warmer grass belonging to Gramineae and shrubbery belonging to *Tamarix chinensis*. In modern seasonal frozen soil zones of the Changjiang (Yangtze) River valley, there are mainly Cyperaceae vegetation near the area of the upper limit, a few of them belong to Gramineae. In some newborn ground surface, there are no Cyperaceae vegetation, and there are only some Gramineae vegetation, odd pieces of shrubbery is lower. From the landscape the warm vegetation is gradually extended to the area of non-frozen soil islands in discontinuous permafrost zones, it is shown that the lower boundary of the discontinuous permafrost moved upward obviously.

2. Discontinuous Permafrost

2.1 *Frozen and nonfrozen soil islands*

The frozen soil islands are separately enclosed by nonfrozen soil islands (belonging to seasonal frozen soil), they all appear in a single island and don't take a principal part on the whole. Individually, the ground surface area of the hummock which is often seen is greater, but the range frozen soil islands is narrow, that is to say, the surrounding edge of frozen soil island has been degenerated into the seasonal frozen soil. Sometimes irregular arc crackles are seen near the periphery, which are caused by the frost difference of the active layers above frozen soil islands and nonfrozen soil islands. The phenomenon is clearly seen on the north slope of Qilian Mountains, Jingyang Mountain and the south slope of Bayan Har Mountains.

2.2 *Variations of patchy permafrost table*

In the inside of frozen soil islands, the variations of permafrost table are greater. On the south of Huashixia and the north slope of Changshitou Mountain, in the discontinuous permafrost zone, three drillings were drilled, the distances among them are 3.5 km each other, and their geologic conditions are identical, but the natural permafrost tables are 3.0 m, 4.8 m, 3.0 m respectively. There is a more persuading example, on the north of Huashixia, three drillings were also drilled, the distances among them are 3 km each other, the permafrost tables of both end drillings are 3.2 m, 3.0 m respectively, but the middle drilling has been thawed and separated into two small frozen soil islands, the thickness of the islands is only about 2—5 m.

2.3 *Discontinuous state of patchy permafrost*

Along the vertical depth of the frozen soil islands, the frozen soil layers appear in a discontinuous state. As far as the section where the drilling 29 is situated in

Dayema Mountain, the soil layer of 0—2.5 m belongs to seasonally thawed layer, 2.5—5.0 m belongs to permafrost layer, 5—6.5 m belongs to thawed layer, more than 6.5 m belongs to permafrost layer. It is the same as near the highway maintenance squad 7 on the south slope of Bayan Har Mountains, the top buried depth of frozen soil layer in the drilling 87 is about 3.8 m, in the drilling 74 that is about 3.9 m, which exceed the seasonal refreezing depth of 2.8 m.

2.4 *Upgrading of the upper and lower limits of discontinuous permafrost*

According to relative references, the range of modern discontinuous permafrost zone is upgraded, among which the upgrading of the lower limit is clear and more common. For example, in 1992, the altitude of the lower limit of Ela Mountains near Qinghai—Sichuan highway is 4,150 m, along the lines of Xinghai, Tongqie, and Kuze, which have an identical latitude with Ela mountains, on the sunslope according to the report^[4], the lower limit is 3,800m, but on the leaveslope it is 4,000 m. It is able to be confirmed that the lower limit of discontinuous permafrost is upgraded. In 1993, on the south slope of Tanggula Mountain (Qinghai—Xizang highway), the lower boundary of discontinuous permafrost zone was shifted by 9 km to the north in comparison with Wang Jiacheng's report^[1].

3. Continuous Permafrost Zone

3.1 *Multigelation*

Near the lower boundary of continuous permafrost zone, there are large pieces of stepped gelifluction and solifluction landforms, bogged hummocks and uncovered soil spots medallions, on the contrary, the geomorphologic phenomena which were caused by frost heaving, for example, ice cone and pingo are hardly seen. There mainly are some annual seasonal frost mounds in the local saturated water regions, the body is small. The reason is that the upper boundary of permafrost is upgraded, the active layer is shifted into the top of the original permafrost layer with underground saturated ice, thus, the original stable structure is changed and the multigelation is expanded, but the perennial frost heaving landforms isn't expanded because of the lower boundary changing of permafrost.

3.2 *Rising of the ground temperature of permafrost*

To the south of Tanggula Mountain near Qinghai—Xizang highway, some of drillings were repeatedly probed for the ground temperature, the mean annual ground temperature (about 10—15 m deep) rose 0.2—0.3°C in 1989 over that in 1975. Although the accuracy of the rising amplitude is not high, it is confirmed that the mean annual ground temperature can't decrease.

When the many above-mentioned phenomena in different zones are simultaneously combined and extensively exposed, they can be explained only using that a

basic trend of the permafrost changing is degeneration.

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