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ZONALITY OF DISTRIBUTION OF PHYSICO-GEOGRAPHICAL ZONES IN CHINA

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ABSTRACT: With the methods of regression analysis and trend surface analysis, taking the bottom and top lines of dark conifer forest, bottom line of permafrost and the snowline of the latest glaciation in China as examples, this paper discusses the zonality regulaties of the distribution of physico-geographical zones in China. (1) Latitude zonality obeys the mathematical model of normal frequency distribution, being approximate to descending straightly within the latitude of China. (2) Longitude zonality shows that the elevation of physico-geographical zone rises straightly with the distance to east coast. (3) The combination of latitude and longitude zonalities appears a plane inclining from SSW to NNE. The decline of physico-geographical zone resembles a semiellipse-sphere inclining from the Qinghai-Xizang (Tibet) Plateau to northeast China, reflecting the effect of relief. (5) Physico-geographical zonation depends on the combination of hydrothermal conditions. Thus the factors influencing the distribution regularities of physico-geographical zones of China are latitude zone, the distribution of oceans and land and relief features.

KEY WORDS: physico-geographical zone, latitude zonality, longitude zonality, trend surface analysis

I. INTRODUCTION

The zonality regularities of physico-geographical zones result from the combination of hydrothermal conditions , one of which is the elevation of distribution of physico-geographical zone changes regularly with the hydrothermal conditions. With the methods of regression analysis and trend surface analysis, taking the bottom and top lines of dark conifer forest, bottom line of permafrost and the snowline of the latest glaciation in China as examples, this paper quantitatively discusses the models and characteristics of latitude zonality in the Qinghai-Xizang Plateau, then analyses the main factors affecting the distribution of zonality.

Considering that data of four lines mentioned above are not evenly divided, we had properly deleted some data. Thereafter, 98 data (32 from bottom line of dark conifer forest, 24 from top line of forest, 20 from permafrost line and 22 from snowline of the latest glaciation) were selected (Table 1). We substitute snowline of the latest glacial epoch for modern one to analyse zonality of distribution of snowline, because modern snowline is only distributed in west China but data on the snowline in Lushan glaciation have been reported in all over China.

Table 1 Elevation of physico-geographical zones in China

No.	Area	Location			Elevation of distribution (m)			
		East longitude (degree)	S(km)*	North latitude (degree)	Bottom line of dark conifer forest	Top line of forest	Bottom line of permafrost	Snowline of the latest glacial epoch
1	Baitoushan, The Changbai Mountains	128.1	−671	42.0	1100[1]	2100[2]	1900[3]	2400[4]
2	Datudingzi, the Zhangguangcai Mountain	128.2	−651	44.6	900[1]			
3	Gaotaishan, the Xiao Hinggan Mountains	127(?)	−512	49.0	700[1]			
4	The Northern Da Hinggan Mountains(Fengshuisha	123.4	−231	52.4		1100[2]		
5	The Yushan Mountain, Taiwan	121.0	−102	23.5	3000[1]	3600[1]		3350[4]
6	Aershan, the Da Hinggan Mountains	120.0	1	47.1			900[5]	
7	Huanggangling, the Da Hinggan Mountains	117.5	202	43.5			1600[5]	
8	The Wuling Mountain, Hebei	117.5	212	40.6	1500[4]	1800[4]		1800[4]
9	The Xiaowutai Mountain	115.1	419	39.9	1900[1]	2500[2]		

Table 1 (continued)

10	The Wutai Mountain	113.6	553	39.1	2000[1]	2600[4]	2400[3]	3000[4]
11	The Luliang Mountains(Guandishan)	111.5	747	37.9		2700[2]		
12	Shennongjia, Hubei	110.7	881	31.7	2400[1]			
13	The Daba Mountains	109	1039	32	2500[4]	3500[4]		
14	Taibaishan, the Qinling Mountains	107.8	1126	34.0	2500[1]	3500[2]	3000[3]	3500[4]
15	The Helan Mountain	106.0	1215	38.8	2500[1]	3100[2]		
16	The Maji Mountain, Gansu	104.0	1447	35.7	2500[1]			
17	The Minshan Mountain	103.9	1510	32.6		3800[2]		4100[4]
18	The Maomao Mountain, Gansu	102.2	1579	37.2			3400[6]	
19	The Dalijia Mountain, Qinghai	102.5	1585	35.6			3800[6]	
20	The Emei Mountain, Sichuan	103.3	1619	29.5	2600[1]			
21	The Qionglai Mountain (Four girls Mountain)	103.0	1621	31.1	3000[1]			3500[4]
22	The Dahuang Mountain, Gansu	101.3	1634	38.3			3400[6]	
23	The Gongwang Mountain, Dongshuan	102.9	1710	26.1	3000[1]			

Table 1 (continued)

24	Reshui, Qinghai	100.5	1725	37.4			3480[7]	
25	The Xiqing Mountain, Qinghai	101	1735	35	2500[4]	3900[4]		4100[8]
26	The Loji Mountain, Xichang	102.4	1736	27.6	3000[1]	3500[2]		3800[4]
27	The Gongga Mountain	101.9	1753	29.6	2800[1]	4000[4]		3400[4]
28	The Zheduo Mountain, Sichuan	101.6	1766	30.5				4100[4]
29	The Qilian Mountains	98.6	1850	39.1	2450[1]	3200[2]	3500[7]	4000[8]
30	The Ela Mountain, Qinghai	99.4	1861	35.8			3800[6]	4500[9]
31	The Yulong Mountain, Yunnan	100.2	1962	27.1	3200[1]	3800[4]		3900[4]
32	The Haizi Mountain, Sichuan	99.5	1965	30.6	3200[1]			4700[4]
33	The Chola Mountain, Sichuan	99.0	1987	31.8	3200[1]	4000[4]		4700[4]
34	The Diancang Mountain, Yunnan	100.1	1998	25.6	2300[4]	4000[4]		3900[4]
35	The Bilo Snow Mountain, Yunnan	99.0	2086	26.8	2900[1]			
36	The lower Yuqu River,Tibet	98.2	2123	29.0				4500[10]
37	The Gaoligong Mountain, Yunnan	98.8	2137	25.2	2900[1]			

Table 1 (continued)

38	The Chayu Area, Tibet	97.5	2199	28.6	3000[1]			
39	The Altay Mountains	90.3 (?)	2257	47	1800[1]	2600[4]		
40	The Halasi Gla– cier, the Altay Mountains	87.8	2350	49			2200[7]	3000[8]
41	Xidatan, Qinghai	94.0	2352	35.7			4150[3]	
42	The Lanjiabawa Mountain, Tibet	95.0	2423	29.5		3800[2]		
43	The Bogda Moun– tain, the Tian shan Mountains	89.2	2489	43.5	1900[1]			
44	The north from the Tuotuo River, Qinghai	92.5	2533	34.2			4529[11]	
45	The south from Amdo, Tibet	92.3	2601	32.5			4640[12]	
46	The East Tianshan Mountains	87	2688	43	2000[2]	2400[4]	2700[7]	
47	Gulu, Tibet	91.6	2720	30.7			4800[3]	
48	The eastern Himalayas	92 (?)	2752	28		3800[2]		
49	The Tianshan Mountains (Yining)	82	3046	44	2500[1]			
50	The Alatao Mountains	80.0	3154	45.0			2450[7]	
51	Mount Qomolangma	86.4	3302	28.0	3100[1]	3900[2]	4900[12]	5100[8]

Table 1 (continued)

52	The West Tianshan Mountains	80	3311	42		2700[4]		
53	Mukute Himalayas	83.5	3561	28.8			4950[12]	
54	The Kunlun Mountains (Mushi Mountain)	80.3	3577	36.0	3000[1]			4200[8]
55	The Pamirs	75	3922	38.5				4200[8]

Note: * 120° east longitude as 0°, westward as positive and eastward as negative.

II. LATITUDE ZONALITY

The regular change of solar incident angle along latitude results in surface heat distribution increase from two poles to the equator, consequently, atmospheric temperature shows latitude zonality. Correspondingly, heat distribution is related with the global pattern of atmospheric current, so precipitation also regularly changes along latitude. Latitude zonality of physico-geographical zone was formed by the combination of hydrothermal differences along latitude. Both mean annual temperature and precipitation in the same longitude gradually decrease with the increase of latitude from south to north in China except Tarim and the northern Tibet Plateau, correspondingly the distribution of physico-geographical zone shows latitude zonality.

1. Bottom and Top Lines of Dark Conifer Forest

The zone of dark conifer forest consisting of Picea and Abies represents vertical vegetated zone of mountain in China. The lines of dark conifer gradually decline with the decrease of average summer temperature from south to north, showing latitude zonality.

The zonal model of global normal frequency distribution (Gaussian) curve is adopted:

$$H = ae^{-b(\Phi - d)^2} + c$$

For dark conifer forest, elevation of the bottom line (Fig.1A) is:

$$H_1 = 3544e^{-0.001832(\Phi - 27.5)^2} - 630 \qquad R = 0.869$$

Elevation of the top lines (Fig.1B) is:

$$H_2 = 3094e^{-0.03219(\Phi - 28)^2} + 750 \qquad R = 0.906$$

In which H is calculated in meter and Φ is in degree. Characteristic parameters are shown in Table 2.

Table 2 The characteristic values of zonality of dark conifer forest lines

Line of physico –geographical zone	Limit latitude Φ_l	Limit height (m)	Inflection–point latitude Φ_2	Zero latitude Φ_0
Bottom line of dark conifer forest	27°30′	2914	44°01′	58°12′
Top line of forest in China	28°00′	3844	40°28′	
Top line of forest[13] in East Asia	15°30′	4226	41°59′	71°38′

The limit values of latitude are the same (27.5°–28°) for bottom and top lines of dark conifer forest in China, corresponding to one of summer high–temperature zones in the south of the middle and lower reaches of the Changjiang (Yangtze) River. The limit value of latitude is low for forest line in East Asia because of numerous data are at the coastal area in the eastern China, Japan and Malaysia etc. The limit values of distribution model of the two lines for dark conifer forest approach to practical values (3,200 m, 4,000 m), and inflection–point latitudes correspond to forest line of East Asia (both in the middle latitude region of 40°–45°). Zero latitude of bottom line of dark conifer forest corresponds to the reality that mountain dark conifer forest is transited to zonal Taiga in northern latitude 57°

So, the distribution of bottom and top lines of dark conifer forest in China shows latitude zonality of global Gaussian Curve, which heights present reserved–S type curve with the increase of latitude. For the latitude zone across China, the model of curve mentioned above may approximately represent linear in the first order (Fig.1)

For bottom line of dark conifer forest:

$$H_1 = 5149 - 79.12\Phi \qquad R = -0.832$$

For top line of forest:

$$H_2 = 6521 - 95.23\Phi \qquad R = -0.873$$

The decrease rate of bottom and top lines of dark conifer forest with latitude are 80 m, 95 m per 1° Φ respectively.

2. Permafrost Line

The bottom line of perennial frozen earth in high elevation is a line of spatial facies change of soil water, which sensitively reflects the combination of hydrothermal conditions, among which the first factor is temperature and the second is aridity. Therefore, the distribution of permafrost line shows both zonality with latitude and difference between east and west because of difference of humidity. By analyzing respectively the more moisture area in the east of and arid area in the west of the Da Hinggan Mountains, the Luliang Mountains, the Qinling Mountains and the Guizhou Plateau, we discovered that elevations of permafrost line are both in decline linear proportion to latitude (Fig.1C).

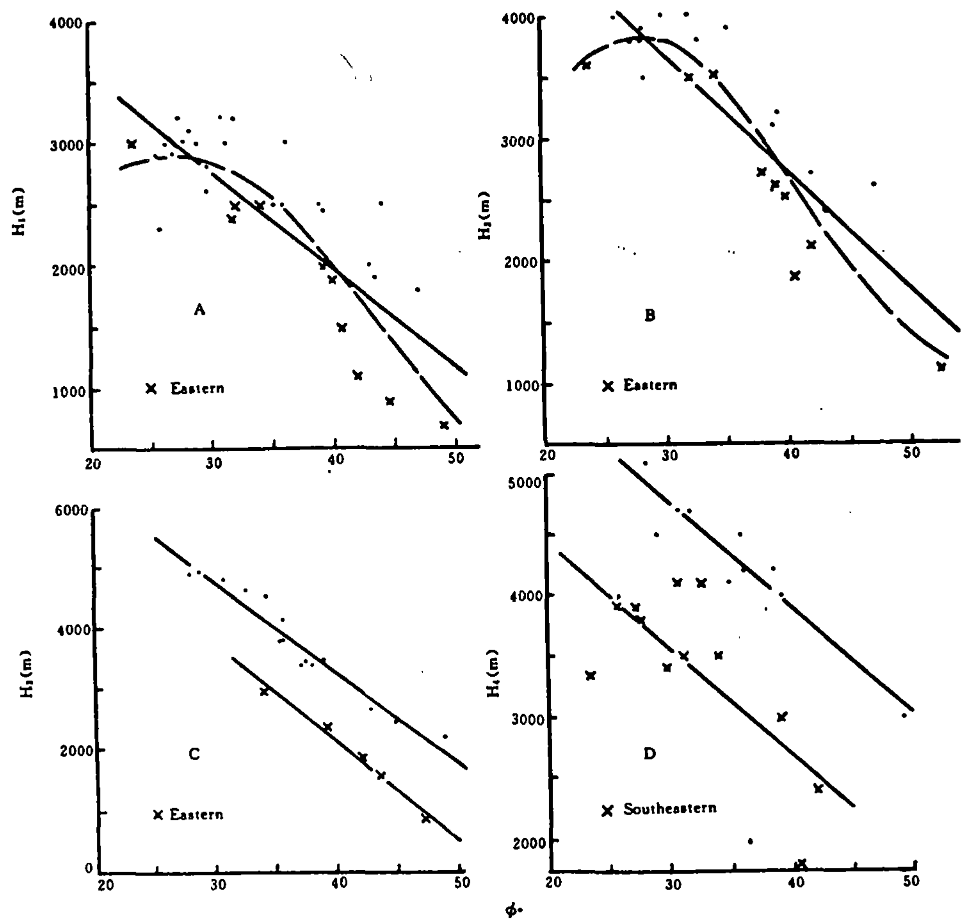

Fig.1 Relationship between height (H) of physico-geographical zone and latitude (Φ) in China
(A and B:Bottom and top lines of dark conifer forest respectively,C:Permafrost bottom line, D: Snowline of the latest glacial epoch)

East area :

$$H_3 = 8554 - 160.3\Phi,\ R = -0.992^{**},\ n = 5$$

significant at 0.01 level.

West area :

$$H_3 = 9214 - 148.9\Phi,\ R = -0.973^{**},\ n = 15.$$

The elevation of permafrost line is proportionally decreased with the increase of latitude, with a decline rate of 150–160 m per 1° Φ. The line is 1,000–1,200 m lower in the east area than in the west area and the decline rate with latitude is a little larger than in the west area.

3. Snowline of the Latest Glacial Epoch

For characteristic of latitude zonality of modern snowline distribution, the model of Gaussian Curve had been concluded, it was reported that elevation of the snowline is directly proportion to ΔT(mean annual temperature 18.1) Δh(the difference of possible maximum of ablation and precipitation above sea level)[14]. Therefore, the two main factors affecting elevations of the latitude zonality with temperature difference from south to north in China and longitude change with humidity difference from east to west in China.

By analysing respectively the snowline of Lushan Glacial Epoch in southwestern China including marginal mountains of Sichuan and Yunnan Plateau and northeastern China, we discovered that the elevation of snowline is also in inverse linear proportion to latitude (Fig.1D):

Southwestern China:

$$H_4 = 7363 - 86.81\Phi,\quad R = -0.944^{**},\quad n = 10.$$

Northeastern China:

$$H_4 = 6160 - 86.55\Phi,\quad R = -0.741^{**},\quad n = 12.$$

Slopes of the two straights are the same, and the decline rate on elevation of the snow line with latitude is 86.5 m per 1° Φ, which shows that the distribution of the snowline in each area of China complies with the same law of latitude zonality. The difference of intercept on the two straights is 1200 m, which shows that longitude difference on the snowline is large.

For modern snowline[15], characteristic values of Gaussian Curve's model on latitude zonality in northern hemispheres are 20° in limit value and 46° 40′ in infection–point, so decline straight is approximately shown in middle latitude. For examples, $H = 8151 - 107.5\Phi$ for western China (28°—50° northern latitude), $H = 10553 - 147.3\Phi$, 86.5°–88.5° east longitude zone in China. Compared with the snowline of the latest glacial epoch mentioned above, the laws of latitude zonality of the two snowlines are the same, but the paleo–snowline in the west is 210–250 m lower than modern snowline and its change rate with latitude is 20 m per 1° Φ lower than modern snowline's.

III. LONGITUDE ZONALITY

Only east of China faces the sea, and western mountains and plateau become the climatic barrier owing to excluding steam from the Indian Ocean. This kind of distribution of sea–land is almost only source of steam for China, so the tendency of precipitation in the same latitude gradually decreases from east to west, which makes the elevations of physico–geographical zone show longitude zonality with increase from east to west. For example, the elevation of bottom line of dark conifer forest $H_1 = 7674 - 50.95E°$ (E longitude) for 38.5 ° – 42 ° northern latitude, and the elevation of top line of forest $H_2 = 9620 - 63.14E°$ for 37.9 ° –41 ° northern latitude, and the change rates with longitude are –61 m and –63 m per 1 ° respectively.

For China, we propose that 120 ° average longitude of eastern coast is zero, the distance to east longitude 120 ° on same latitude is S (km), and westward (facing land) is positive and eastward (facing sea) is negative. It can be seen that the elevations H(m) of each physico–geographical zone in China are all directly linear proportion to S(Fig.2). Linear equations are :

Bottom line of dark conifer forest : $H_1 = 1547 + 0.6747S$, $R = 0.911$, $n = 26$

Top line of forest : $H_2 = 2247 + 0.7173S$, $R = 0.853$, $n = 20$

Permafrost line : $H_3 = 1823 + 0.9876S$, $R = 0.952$, $n = 17$

Snowline : $H_4 = 2493 + 0.8499S$, $R = 0.880$, $n = 18$

The data of the Yushan Mountain and Xinjiang are limited because their latitudes depart very much from other regions.

Longitude zonality of physico–geographical zone in China is obvious, which means that the elevations of each physico–geographical zone are caused by aridity from east to west (sea to land). According to the sequence of bottom and top lines of dark conifer forest, snowline of the latest glacial epoch permafrost line, their values of heightening are increased, generally 2/ 3 – 1 m per kilometer. The modern snowline in western China shows similar longitude zonality. In the Kunlun Mountains, the elevation of modern snowline is: $H = 3801 + 0.5537S$[15], and the rate of increase westward is lower than that of the latest glacial epoch.

IV. COMPREHENSIVE DISPLAYS OF LATITUDE AND LONGITUDE ZONALITIES

The comprehensive characteristics of latitude zonalities can quantitatively described from the first order trend surface obtained by binary regression analysis for Φ (latitude),

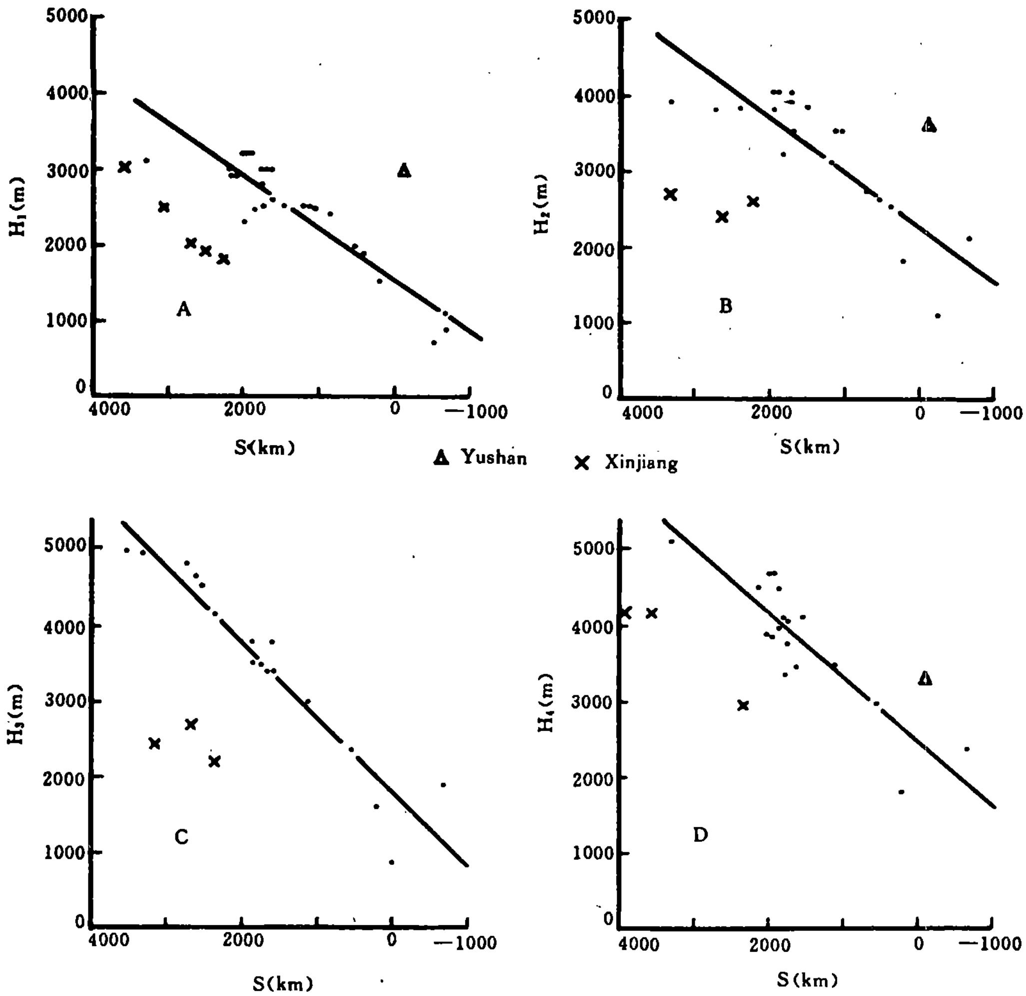

Fig.2 Relationship between elevation *(H)* of physico-geographical zone and distance *(S)* to east coast in China
(A and B : Bottom and top lines of dark conifer forest respectively,
C: Permafrost bottom line, D: Snowline of the latest glacial epoch)

S(distance from eastern coast) and *H*(elevation of physico-geographical zone). Conclusions of the first order trend surface analysis (Fig.3, 4) are :

Bottom line of dark conifer forest: $H_1 = 4224 - 64.54\Phi + 0.2890S$, goodness of fitting $C = 84.24\%$

Top line of forest : $H_2 = 5850 - 85.62\Phi + 0.2232S$, $C = 84.48\%$

Permafrost line : $H_3 = 7978 - 142.9\Phi + 0.4079S$, $C = 92.97\%$

Snowline of the latest glacial epoch : $H_4 = 4756 - 53.85\Phi + 0.4838S$, $C = 67.61\%$.

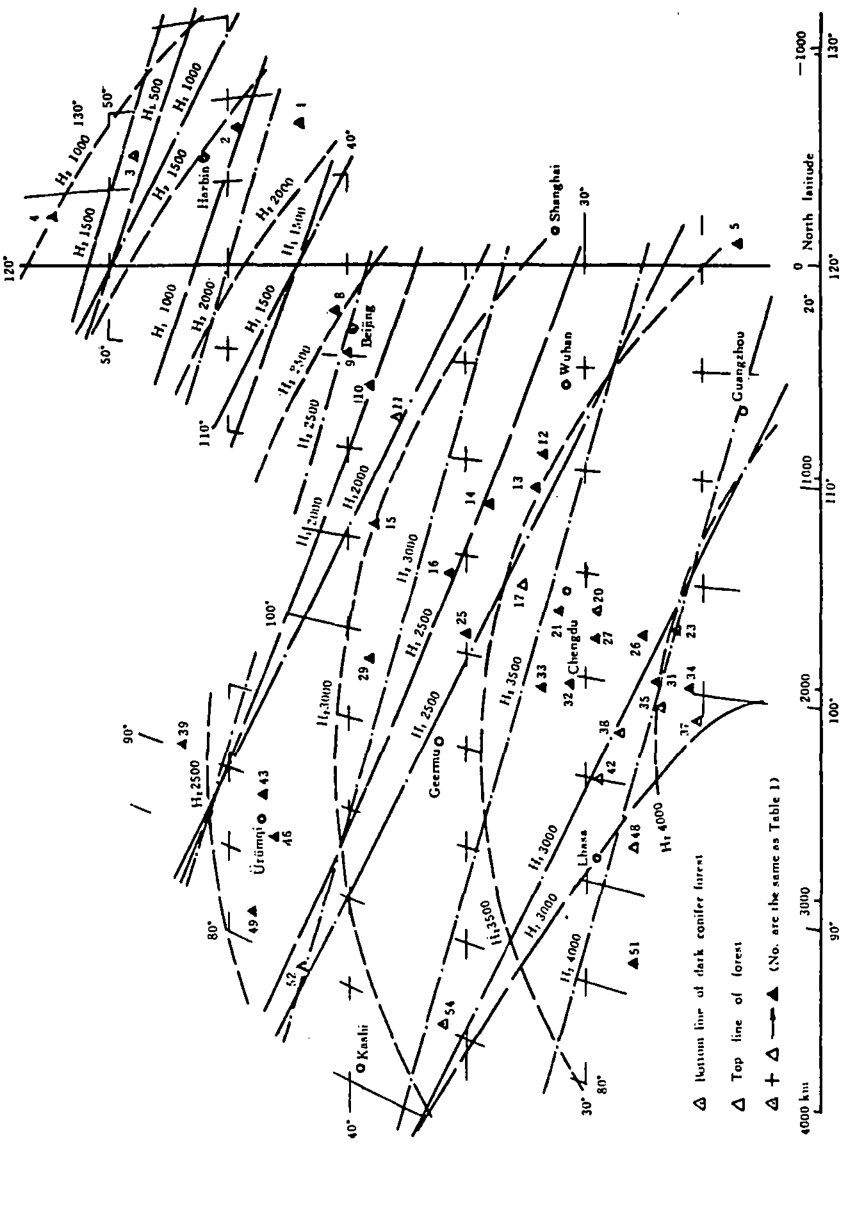

Fig. 3 Isopleths of the first order (dot and dash) and the second order trend surface (dash line) on bottom line (long line) and top line (short line) of dark conifer in China.

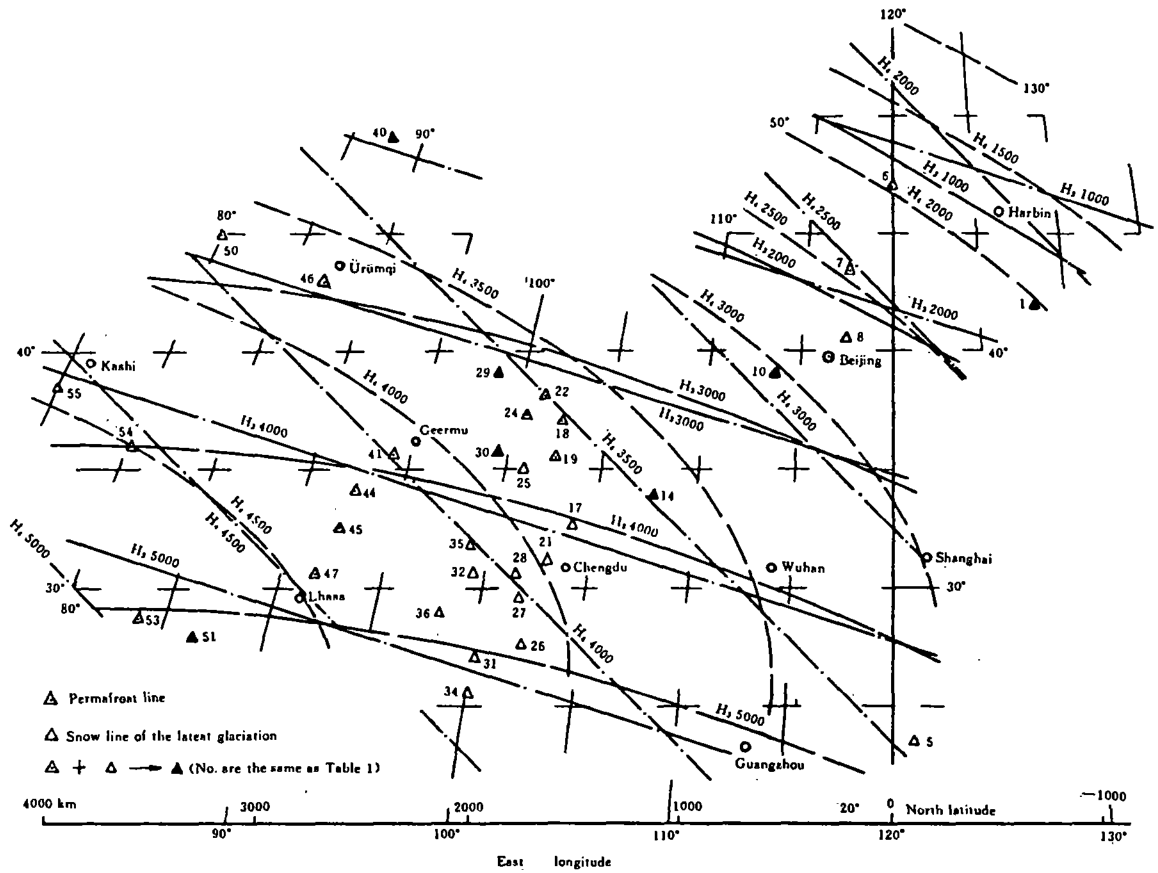

Fig.4 Isopleths of the first order (dot and dash) and the second order trend surface (dash line) on permafrost bottom line (long line) and snowline of the latest glacial epoch (short line) in China.

A general equation of the first order trend surface is $H = A - M\Phi + NS$. Its characteristic values are collected in Table 3.

The tendency planes on physico-geographical zone in China are all declining planes from southwest to northeast, obeying the law of same type of zonality which shows the latitude zonality with decline from south to north and the longitude zonality with rise from east to west.

Change rates with latitude (M) are 54-143 m/ Φ°, permafrost line is the largest, which indicates that it is the most sensitive to temperature difference of north-south, and snowline of the latest glacial epoch is little, which indicates that the snowline is little sensitive to temperature.

Table 3 The characteristic values of tendency plane on physico-geographical zone in China

Distribution line of physico-geographical zone	The decline rate with latitude M(m/ Φ°)	The increase rate with longitude N(m/ km)	The direction dip of plane θ	The dip angle of plane α	The change rate along θ V(m/ km)
Bottom line of dark conifer forest	64.54	0.2890	NE26°25′	2′14″	0.65
Top line of forest	85.62	0.2232	NE16°8′	2′46″	0.80
Permafrost bottom line	142.90	0.4079	NE17°34′	4′39″	1.35
Snowline of the latest glacial epoch	53.85	0.4833	NE44°54′	2′21″	0.69

Change rates with longitude (N) are 0.22-0.48 m/ km, of which the values of permafrost line and the snowline are larger, indicating that phase change's lines for these kinds of water are sensitive to humidity difference for east-west.The Nvalues of two kinds of forest line are little, which indicates that they are adapted for various moisture conditions.

Comprehensive display of latitude and longitude zonality is that elevation of physico-geographical zone declines from southwest to northeast. Declining direction, except that the snowline is near NE45°, all are between NE 16° and 27°. This indicates that two zonalities of latitude and longitude on the snowline are obviously same, but the change rates with latitude on other three lines are large than that with longitude. It means that zonality displays more clearly than longitude zonality.

Change rates of tendency plane along dip, except permafrost line, are 0.65–0.80 m/ km. But the change rate of permafrost line is 1.35 m/ km, which discloses that permafrost line is the most sensitive to the change of hydrothermal conditions and its variation is the largest.

Characteristic values of first order trend surface on modern snowline in western China [15] are : $M=110$, $N=0.444$, $\theta=$ NE22 ° 10′ , $\alpha=4'\ 3''$, $V=1.18$. Dip of the plane is NNE, which indicates that zonality of latitude is more clear than that of longitude, and longitude zonality of modern snowline is not so obvious as that of paleo–snowline and the decline rate of the plane is larger than that of the paleo–snowline.

V.AZONALITY EFFECT OF RELIEF

The most obvious characteristic of China's relief is that the Qinghai–Xizang(Tibet)Plateau forming the roof of the world takes up 30% of China's total area, which changes the atmosphere current and controls the combination of hydrothermal conditions and makes the hinterland of the plateau become cold–dry center. So azonality is added on horizontal zonality of distribution elevation of physico–geographical zone. This effect may be reflected on the second order trend surface of elevation physico–geographical zone.

A general equation of the second order trend surface is:

$$H = a_0 + a_1\Phi + a_2S + a_3\Phi^2 + a_4\Phi S + a_5S^2$$

. The equations of the second order trend surface on the lines in China (Fig.3, 4)are as follows:

Bottom line of dark conifer forest:

$$H_1 = 2293 + 73.52\Phi - 0.1856S - 2.188\Phi^2 + 0.01244\Phi S - 7.9\times10^{-6}S^2,\ C = 89.21\%$$

Top line of forest :

$$H_2 = 4268 - 5.506\Phi + 0.5358S - 1.030\Phi^2 + 4.593\times10^{-4}\Phi S - 1.191\times10^{-4}S^2,\ C = 89.56\%$$

Permafrost line :

$$H_3 = 8751 - 182.9\Phi + 0.5904S + 0.4620\Phi^2 + 1.693\times10^{-3}\Phi S - 8.481\times10^{-5}S^2,\ C = 94.10\%$$

Snowline of the latest glacial epoch:

$$H_4 = 1316 + 141.3\Phi + 0.6189S - 2.720\Phi^2 + 5.137\times10^{-4}\Phi S - 5.098\times10^{-5}S^2,\ C = 71.70\%$$

Goodness of fitting above are greater than that of the first order trend surface, which demonstrates real characteristic of distribution of physico–geographical zone. Remnant differences of the second order trend surfaceare shown in Table 4. The second order trend surface resembles a semiellipse–sphere which is projecting on NE or then descends quickly, and its characteristic are as follows :

Table 4 Remnant difference analysis of the second order trend surface equation of physico–geographical zone elevation in China

Distribution line of physico–geographical zone	Mean of residual error ΔH (m)	Mean of relative remnant error $\Delta H/H$ (%)	Sum of squares of regression $U(10^7)$	Sum of squares of residual $Q(10^6)$	Sum of squares of deviation $L_{HH}(10^7)$	Standard deviation of residual S	F	Multiple correlation coefficient R
Bottom line of dark conifer forest	165.1	7.85	1.26	1.52	1.41	229.2	120.0	0.945
Top line of forest	199.6	7.33	1.31	1.35	1.47	270.1	90.1	0.946
Permafrost bottom line	225.6	8.70	2.44	1.35	2.59	300.0	135.6	0.970
Snowline of the latest glacial epoch	338.6	9.93	9.06	3.58	1.26	433.8	24.1	0.847

Isopleths approximately show the semi–concentric circles with the centre of the larger value in the Qinghai–Xizang Plateau, which reflects azonality effects of cold–dry centre of the plateau and results in the distribution of horizontal zonality of physico–geographical zone.

The second order trend surface declining from SSW to NNE succeeds the dip of the first order trend surface and reflects combinative contribution of longitude and latitude zonalities, and shows that effect of relief is added on horizontal zonality.

Elevation of physico–geographical zone rapidly declines toward NNE and the descent is the largest in middle–latitude (northeast China). This is because that most inflection–points of Gaussian Curve model of physico–geographical zonality are distributed in middle latitude and the change rate near inflectin–point is the biggest.

VI. CONCLUSIONS

The elevation of distribution of physico–geographical zone in China has the characteristics of latitude and longitude zonalities and the factor of azonality is added.

Characteristic of latitude zonality of physico–geographical zone resulted from the regular change of temperature with latitude, which obeys the law of reserved type of Gaussian Curve and is approximate to descending straight within the latitude of China.

Humidity difference between east and west caused by distribution of the oceans and land in China results in longitude zonality, and proportional rise from east to west of physico–geographical zone is one of its displays.

One of the combinative displays of the latitude and longitude zonalities is that the elevation of physico–geographical zone appears a plane declining from SSW to NNE. The decline rate from south to north with latitude is 54–143 meters per degree, the rising rate from east to west with longitude is 0.22–0.48 m/ km and the declining rate along dip of the plane is 0.65–1.35m/ km.

The second order trend surface of physico–geographical zone in China resembles a semiellipse–sphere with cold–dry centre of the Qinghai–Xizang Plateau as a peak value region and declining toward NNE, which discloses additional effects of azonality by relief features.

The change rate of physico–geographical zone with latitude in China is bigger than that with longitude, reflecting that latitude zonality is more obvious than longitude zonality. Heat is the most important and water is the second factor controlling zonality.

The change rate of permafrost line is the biggest, indicating that this line is the most sensitive to hydrothermal conditions. The data of snowline of the latest glacial epoch are dispersive, and the dip of trend surface is most different from other lines, indicating that the data in east China are determined lower and have more errors.

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