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REANALYSIS OF PRINCIPAL COMPONENT ANALYSIS TO RESUME PAST VEGETATION AND ENVIRONMENT ——Taking Fenzhuang Profile in Beijing as an Example①

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ABSTRACT: In the paper 11 pollen types were selected from the original pollen and spore records of 54 samples in Fenzhuang profile of Beijing region, then 54 × 11 matrix was set up. Based on the pollen data of Fenzhuang profile from the Late Pleistocene to the Early Holocene, the paper gives a further analysis to subdivide zone of the pollen assemblages and changes of paleovegetation and paleoenvironment in this area using principal component analysis (PCA). PCA can play an complementary role for subdividing zone, at the same time, it can eliminate the difference to subdivide zone of the pollen assemblages caused by artificial factors. Finally to the biodiversity in plant communities and complex geographical environment in Beijing region, using great dispersal of accumulative percent of total in PCA (for cumulative rate only 57% from the first three factors of PCA), may sufficiently correspond to the environmental characteristic, so as to recover past climate condition much better.
KEY WORDS: Fenzhuang in Beijing, past flora and environment, principal component analysis, spore pollen

I. INTRODUCTION

At present, global climate change have been widely paid attention to internationally. Climatic and environmental changes from local to global extent are all influenced by physical, chemical and biological interactions, some of these changes are recorded in marine, terrestrial surface, glacial and biological environments. So that significant events in past environmental and ecological conditions can be reconstructed temporally and spatially.

The research on paleovegetation and paleoenvironment in Beijing region have been emphasized by Chinese scientists (Zhou *et al.*, 1978; Zhao *et al.*, 1984; Kong *et al.*, 1982; Zhu

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et al., 1996; Zhang *et al*., 1996) and some import progress has been made. Owing to complex environmental background and diversity of vegetation in Beijing area, it is necessary to use new methods, and mathematic analysis to further reveal the past vegetation and environmental changes in this area, and this will be essential for understanding past vegetation succession and the mechanisms and causes of climatic changes, and more correctly forecast climatic change in the future.

II. STUDIED AREA AND METHODS

1. Studied Area

Beijing region is situated at northwest of the North China Plain, its west, north and northeast parts are surrounded by the Taihang Mountains, Jundu Mountain, Yanshan Mountain and their branch ranges. From piedmont to plain, the Beijing plain can been divided into residual hills, proluvial platforms and fans and their marginal depressions, alluvial platforms, paleochannels, alluvial plain (Zhao *et al*., 1984). Beijing region has a continental warm temperate subhumid monsoon climate, the mean annual temperature is about 10 ℃, the annual precipitation is 500– 700 mm, of which about 70% of rainfall mainly occurs in the period from July to August, and has much rainstorm.

2. Methods

The Fenzhuang profile is located at 40.3°N and 116°E, altitude is about 49 m, about 50 km southwest of Beijing City. Through excavation and drilling, a 20-m profile was recovered from the Fenzhuang of Fangshan County in Beijing. The lithologic section of profile is composed of gray-green sand clay, dark muck, gray silt, silt, several layer peat and yellow sand-clay. From 4.64– 7.84 m samples consisting of peat, dark muck and gray silt, we discovered abundant pollen and spores of fern, bryophyte and algae, then reconstructed pollen sequence of North China based on ^{14}C age data (Kong *et al*., 1982). Pollen zones were delineated by a computer.

III. THE METHOD FOR SUBDIVIDING POLLEN ZONE AND RESULTS

1. The Method of Subdividing Zone

In the research on paleovegetation and paleoenvironment, through subdividing zone to order samples and describing their characters, we may obviously understand the vegetation historical succession process, and reveal the periodic paleoclimatic change trend. The methods of subdividing pollen zone include routine and mathematic ones. The ordered clustering method is

used in mathematic method.

2. The Result of Subdividing Zone

According to routine and mathematic methods, Kong Zhaochen (1982) subdivided the Fenzhuang profile into 4 zones. In zone FI, the herb plants, such as *Artemisia*, Chenopodiaceae, Gramineae, etc., were predominant. The climate was rather dry and cold. In FII, the vegetation during the past 13 000– 12 000 years was dominated by a subalpine conifer forest, consisting of *Picea*, *Abies*, *Larix* etc.. Hydrophytes *Myriophyllum*, *Typha*, *Sparganium* and some members of Cyperaceae and Green algae , *Mougeotia*, *Zygnema* apparently increased. Mean annual temperature was lower than that of the present. The climate was wet and cool with an annual precipitation about 800– 1000 mm. In FIII, the vegetation was represented by a warm temperate forest, predominated by *Pinus*, *Selaginella sinensis* and *Typha*. The climate of Beijing was rather wet and warm, with an mean annual precipitation more than that of the present. The lakes and bogs were better developed. In FIV, *Tilia* was still flourishing and hydrophytes were better developed at its initial stage but afterwards they were obviously reduced. Liu Kam-biu reinterpreted the data and divided Fenzhuang profile into 4 zones (Liu, 1988).

IV. PRINCIPAL COMPONENT ANALYSIS (PCA) ON THE FENZHUANG PROFILE

The original statistical data of 54 sample in Fenzhang profile was calculated with PCA, after mathematic treatment, the statistic pollen types classified into 11 types: 1. *Tilia*; 2. Cold Trees: *Abies*+ *Picea*+ *Larix*; 3. *Pinus*; 4. Other broad-leaved trees; 5. *Ephedra*+ *Nitraria*; 16. *Artemisia*+ Compositae; 7. Mestoptic Herbs; 8. Umbelliferae+ Gramineae+ Cyperaceae; 9. Hydrophytes and helophytes; 10. *Selaginella sinensis*; 11. *Polypodium*. After calculation of 54× 11 matrix, eigenvalues of the first six factors are shown in Table 1, standardized eigenvectors from the first six eigenvalues shown in Table 2.

Table 1 Eigenvalues of the first six factors

	1st	2nd	3rd	4th	5th	6th
Eigenvalue	2.8559	1.9680	1.4666	1.1067	1.0523	0.8777
Proportion (%)	26.0	17.9	13.3	10.1	9.6	8.0
Cumulative rate (%)	26.0	43.9	57.2	67.2	76.8	84.8

Table 1 shows that the dispersal degree of the samples is high, the cumulative rate of the first three factors of PCA only covers 57% of original statistic data, the eigenvalues of the first six factors of PCA cover 84.8% of original statistic data, showing complex vegetation ecologi-

cal types in Beijing region.

Table 2 Standardized eigenvectors from the first six eigenvalues

	1st	2nd	3rd	4th	5th	6th
Tilia	- 0.459	0.084	0.077	- 0.230	0.152	- 0.236
Abies+ *Picea*+ *Larix*	0.150	- 0.332	- 0.396	0.421	0.281	0.255
Pinus	- 0.265	- 0.476	0.307	0.274	- 0.050	- 0.133
Other broad- leaved trees	0.054	- 0.248	- 0.418	- 0.075	- 0.152	- 0.786
Ephedra+ *Nitraria*	0.120	- 0.106	- 0.046	- 0.463	0.723	0.092
Artemisia+ *Compositae*	- 0.213	0.268	- 0.344	0.169	- 0.307	0.304
Mesotrophic herbs	0.207	0.496	0.417	0.083	0.016	- 0.225
Umlelliferae+ Gramineae+ Cyperaceae	0.084	- 0.252	- 0.061	- 0.656	- 0.482	0.271
Hydrophytes and helophytes	- 0.285	- 0.396	0.452	0.038	- 0.044	0.133
Selaginella sinensis	- 0.519	0.174	- 0.149	- 0.084	0.106	0.016
Polypodium	- 0.483	0.122	- 0.209	- 0.009	0.102	0.032

The meaning of the different factors of PCA in palynology and ecology are as follows:

The first factor of PCA reflects mesotrophytic herbs, shrubs and cold tree pollen are dominant, indicating the development process intensity of herbs and cold trees, on the contrary, the development process intensities of *Tilia* and *Pinus* and ferns (*Selaginella sinensis*, *Polypodium*) were restrained, in which, mesophytic herbs (standardized eigenvector is 0.207), *Ephedra*+ *Nitraria* (0.120), cold trees (0.150), *Tilia*(- 0.419), *Pinus* (- 0.265), *Selaginella sinensis* (- 0.519), *Polypodium* (- 0.483). The second factor of PCA indicates the development process intensity of mesophytic herbs and *Artemisia*+ Compositae, in the meantime the development of hydrophytes and hydrophytes may be restrained. But mesophytic herbs (0.496), *Artemisia*+ Compositae (0.268), aquatic plant and hephtic (- 0.396), Umbelliferae+ Gramineae+ Cyperaceae (- 0.252), cold trees (- 0.332), *Pinus* (- 0.476) show a reverse trend. The third factor of PCA reflects hydrophytes and mesophytic herbs pollen is dominant, indicating the co-development of hydrophytes and mesophytic herbs in Beijing region, in which, hydrophytes (0.452), mesophytic herbs (0.417), *Artemisia*+ Compositae (- 0.344), other broad-leaved trees (0.418), cold trees (- 0.396) show an opposite trend.

The cumulativ rate of the first three factors of PCA is only 57.2%, in the meantime, the first three factors reflect the major vegetational ecology type in Beijing region. So factors 1 and 2 of PCA and factors 1 and 3 of PCA are selected to draw a scatter diagram of factor analysis. In the scatter diagram made of factor 1 and 2 (Fig. 1), the distribution of samples is generally classified into A, B, C and D types. In the scatter diagram made of factors 1 and 3 (Fig. 2), type A and C appear and are inlaied in the diagram, mainly distribute at the up-right side of the

diagram; and type B concentrates at the down right side of the diagram. Type A distributes in the positive direction of 1, 2 and 3 factors of PCA in the diagram 1 and 2, the pollen types were dominated of mesophytic herbs, lack of trees and hydrophytes. Type B distributes in the positive direction of 1 factor of PCA, the negative direction of factors 2 and 3, was dominated by cold trees, in the meantime a large number of hydrophytes pollen occurred. Type C mainly distributes four quadrant of the diagram composed of factors 1 and 2 and factors 1 and 3 of PCA, and show transition, generally the pollen assemblages were dominated by broadleaf tree (*Tilia*, *Quercus* etc.). Cold tree and hydrophytes descend. Type D distributes in the negative direction of factor 1 and 2, the positive direction of factor 3 of PCA was dominated by broad leaf tree (*Tilia*, *Ulmus*, *Quercus etc.*), hydrophytes an hygrophytes were abundant. From the scatter diagrams of factors 1, 2 and 1, 3, the 54 pollen samples were divided into 4 types

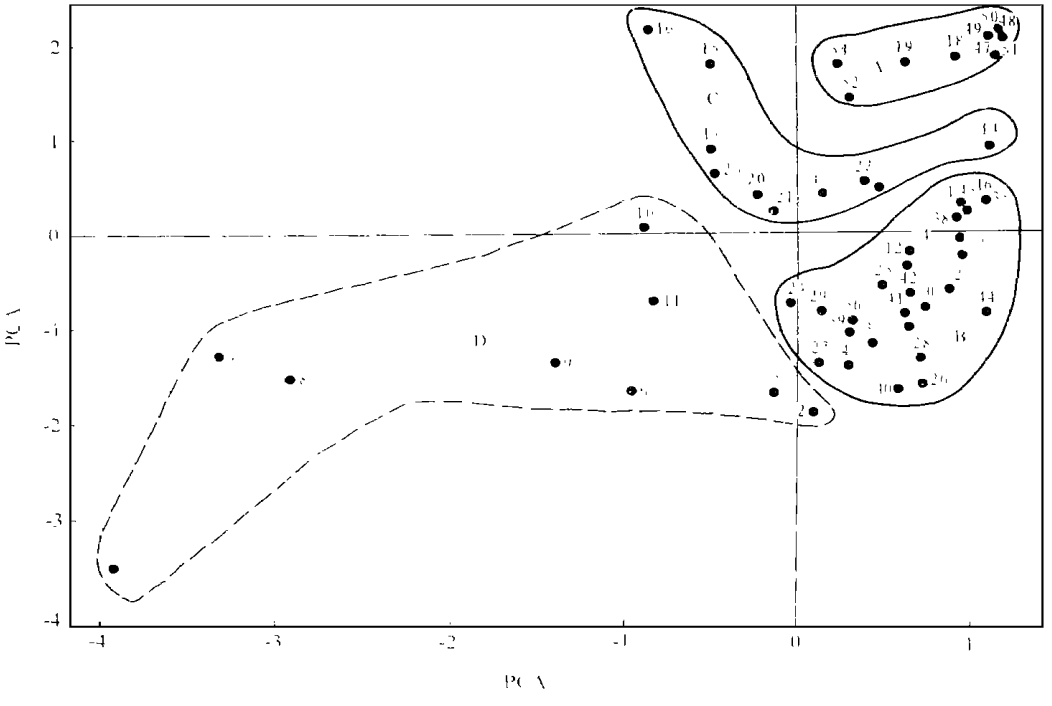

Fig. 1 Scatter diagram of factor analysis for pollen assemblages of Fenzhuang profile (factors 1 and 2 of PCA)

(corresponding to 4 zones). The time orders of four vegetation ecological types in Fenzhuang of Beijing since the late glacial period. is as fellows: In type A (zone 1, 13 000 a B. P.), the vegetation was steppe dominated by *Artemisia* and *Chenopodium*, the climate was dry and cold. In type B (zone 2, 13 000 a B. P. – 11 400 a B. P.), the vegetation was dominated by a subalpine conifer forest, hydrophytes increased, the climate was cold and wet. In type C (zone 3, 11 400 a B. P. – 11 000 a B. P), the vegetation was represented by temperate broadleaf tree such as *Tilia*, hydrophytes predominant too, the lakes and swamps declined,

the climate became warm and dry, In type D (zone 4), since 11 000 a B. P. trees and hydrophytes developed better at their initial stage, but afterwards they obviously reduced after 10 000 a B. P. .

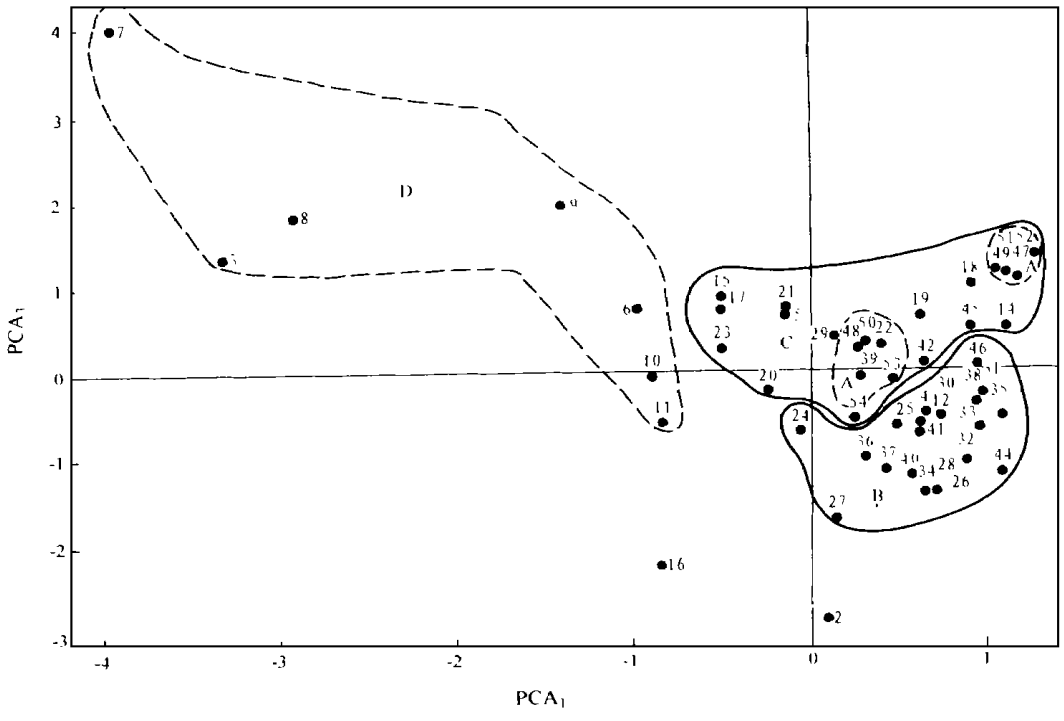

Fig. 2 Scatter diagram of factor analysis for pollen assemblages of Fenzhuang profile(factors 1 and 3 of PCA)

V. DISCUSSION AND CONCLUSION

1) The result of PCA shows that type C inlays the types A, B, D, reflecting the large fluctuation of climate change in this period. Different subdividing zones by Kong Zhaochen and Kamr biu Liu, also reflect the transition of this zone, the writer's analysis can explain the reason of the difference through with subdividing zone of Fenzhuang profile.

2) The result of PCA shows that the cumulative of factors is not high, which is related with diversity of vegetation and ecosystem in Beijing region, also reflects the character of temperate forest and forest grassland. For example, in the same period, the vegetation was dominated by coniferous forest in subalpine, consisting of *Picea*, *Abies* and *Larix* etc. In hills and plain area the vegetation was dominated by template coniferous and broadleaf mixed forest, consisting of *Pinus*, *Tilia* and *Quercus* etc., and in low-lying land hydrophytes and helophytes grew, but the grassland dominated by *Artimisia* and Compositae was possible aburrdant, accompanied with template forest. The research result of vegetation change in Qinghai Lake since the Holocene shows the analysis after PCA, the cumulative of factors is high, corre-

sponding to an complex vegetation in the same space and time in the region (Kong *et al.*, 1990).

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