https://doi.org/10.1051/e3sconf/202122802001

On the Evolution of Paleoclimate and Paleoenvironment in Eastern Beijing Plain in the Last 70,000 Years Based on the Sediment Chronological Framework

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Abstract: To study the paleoenvironment and paleoclimate of eastern Beijing Plain, this paper, based on particle size analysis and sporopollen analysis, constructs a sediment chronological framework. Combining with the analysis of previous research outcomes, it reveals the evolution process and rules of the paleoenvironment and paleoclimate of eastern Beijing Plain. The research shows that the climate and environment of the eastern Beijing Plain has changed from humid and cold, humid and warm to dry and cool, which provides some research basis for studying the paleoenvironment and paleoclimate of Beijing Plain, and even the world's paleoenvironment and paleoclimate, presenting a great significance.

1 Introduction

As the capital of China, Beijing is the center of the country's politics, culture, science and technology as well as international exchanges. The climate change in the city has also attracted much attention and research. Located in the southeast of Beijing, Beijing Plain is bordered to the north by Jundu Mountains, to the west by Western Mountains, and to the southeast by the North China Plain. The plain covers an area of more than 6,300 square kilometers, accounting for about 40% of the total area of Beijing [1]. A temperate monsoon climate dominates in Beijing Plain, with well-defined seasons, characterized by a hot, rainy summer and a cool, dry winter. Beijing Plain represents a transitional area from the semi-humid area to the semi-arid area. From the perspective of monsoon climate, the climate of the Plain is influenced by both the summer monsoon from the Pacific Ocean and the winter monsoon from the Mongolian Plateau. Its special geographical location, very sensitive to global climate change, presents a great research value, and is obviously representative of the research on paleoclimate and paleoenvironment [2].

Abundant data have been obtained about the paleoclimate study of Beijing so far, but there is few research on the eastern part of Beijing Plain with short research history. This paper, with the help of particle size analysis and sporopollen analysis, explores the climate change characteristics of the area and reconstructs its climate change process. This research is of great significance for understanding global climate change and predicting the future climate change trends.

2 Research methods

2.1 Particle size analysis

As an important indicator of sedimentation, environment and dynamic conditions, sediment particle size is affected by internal forces such as external wind erosion, water erosion and crustal movement. In the current research stage, sediment particle size can be study and analyzed through microscopy, dynamic light scattering, laser light scattering, electron microscope, sedimentation, sieve analysis, ultrasound and particle image method etc [3]. Among those, laser light scattering is often used in sediment particle analysis thanks to its advantages such as wide measuring range and fast speed. This paper, therefore, also adopts such analysis method. The general operation procedure of particle size analysis is as follows: air-dry samples; weigh samples; add hydrogen peroxide solution to the samples and heat them; add distilled water for precipitation; test whether the sample is neutral, if not, continue to change the water; add sodium metaphosphate for dispersion; conduct experimental measurement after precipitation [4].

2.2 Sporopollen analysis

Sporopollen analysis is designed to analyze sporopollen of a certain stratigraphic sample and collect the data in ways to study its characteristics and the rule of its content in the material, which can be applied to distinguish strata, determine the age and study paleovegetation and paleoclimate, etc [5]. The heavy liquid flotation method is adopted in this paper [6], and the data is obtained through

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isolation, identification and statistics of the sporopollen samples. The general operation process of sporopollen analysis is as follows: weighing and grinding samples; adding sporopollen; conducting acid treatment and alkali treatment; putting the treated pollen into a centrifuge tube for heavy liquid flotation; diluting the samples with glacial acetic acid; leaving them to stand and centrifuging them for sediment extraction; conducting hydrofluoric acid treatment and hydrochloric acid treatment; and finally putting them into a centrifuge and add glycerin for storage[7]. The experiment should be conducted in accordance with the relevant criterial, ensuring that the error of experimental results can be controlled within a small range.

3 Analysis of experimental findings

3.1 Analysis of experimental findings of particle size analysis

The particle size classification of sediments is influenced by hydrodynamic forces. If the climate was relatively dry at that time, the precipitation would be reduced then, leading to a drop in water level and weakened hydrodynamic forces, and the shallow water environment would thus lead to the deposition of fine particles to the shore. If the climate was warm and humid at that time, the precipitation would increase, with the rise of water level and the increase of hydrodynamic forces, and coarse particles would be deposited on the shore [8]. Particle classification is shown in Table 1[9]:

Table 1 Statistical table of particle classification

clay	silty sand	sand
<4μm	4~64μm	>64μm

Based on the distribution and variation of each particle size in the eastern part of the Beijing Plain, the part is divided into five stages from top to bottom, namely A, B, C, D and E, as shown in Figure 1 below:

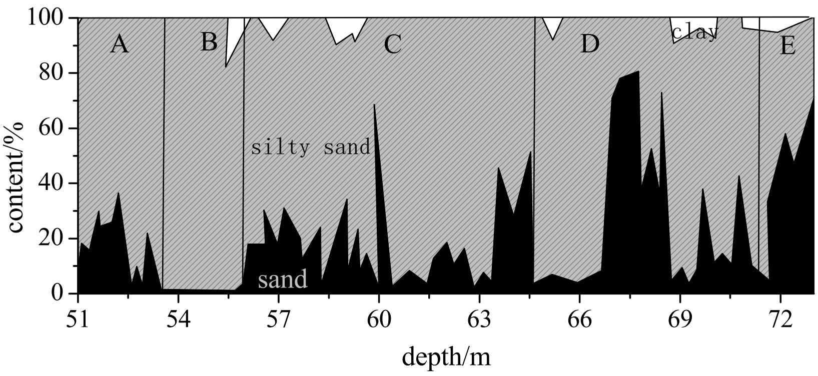


Fig. 1 Distribution and content of particles in 51~73m SG01 borehole

Stage A: Silty sand prevails in sediments with an average content of nearly 60%, followed by sand, with little clay content which is the lowest among the five stages. Such distribution of sediments in stage A indicates that hydrodynamic forces there is relatively strong, the climate is thus predicted to be relatively dry and cool in that period.

Stage B: Silty sand content dominates among all five stages, while clay content is the lowest. The content of sand however is much lower than silty sand content and higher than clay content. Such distribution shows that the hydrodynamic forces in this stage represents the strongest in all stages, and it is speculated that the climate in this period is warm and humid.

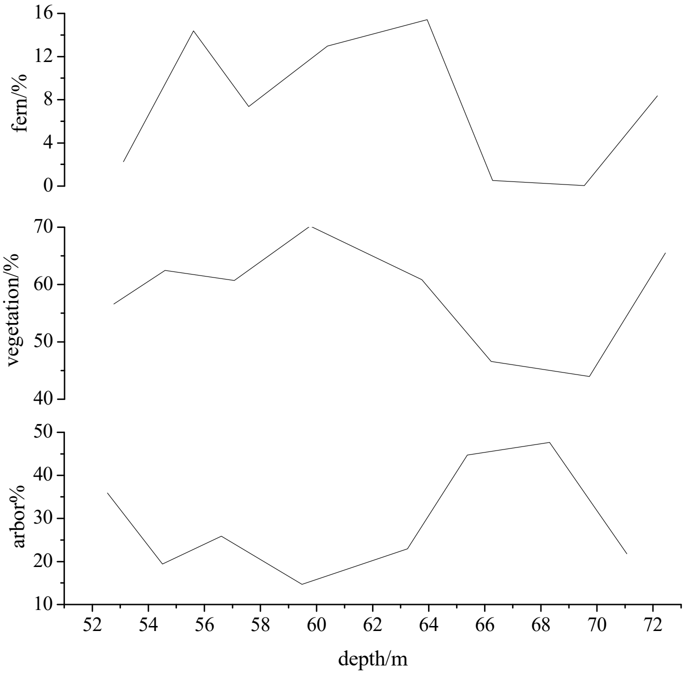
Stage C: Silty sand predominates, followed by higher sand content than stages A and B, and clay content is the lowest. That indicates that the hydrodynamic forces in this stage is moderate, and it is predicted that the climate in this period is slightly cold and dry.

Stage D: The content of silty sand is about the same as that of sand, and the content of clay is still the lowest in this stage. Such distribution of sediments shows that the hydrodynamic forces in this stage is relatively weak, and the climate in this period is speculated to be relatively cold and humid.

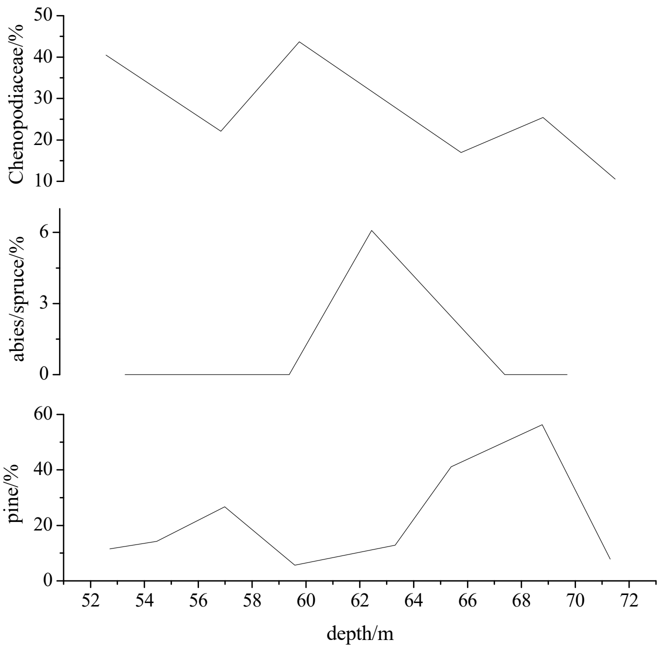
Stage E: The content of sand is slightly higher than that of silty sand, with a low clay content. The distribution indicates that the hydrodynamic forces in this stage is weak, and it is speculated that the climate in this period is the coldest and relatively humid.

3.2 Analysis of palynological experiment results

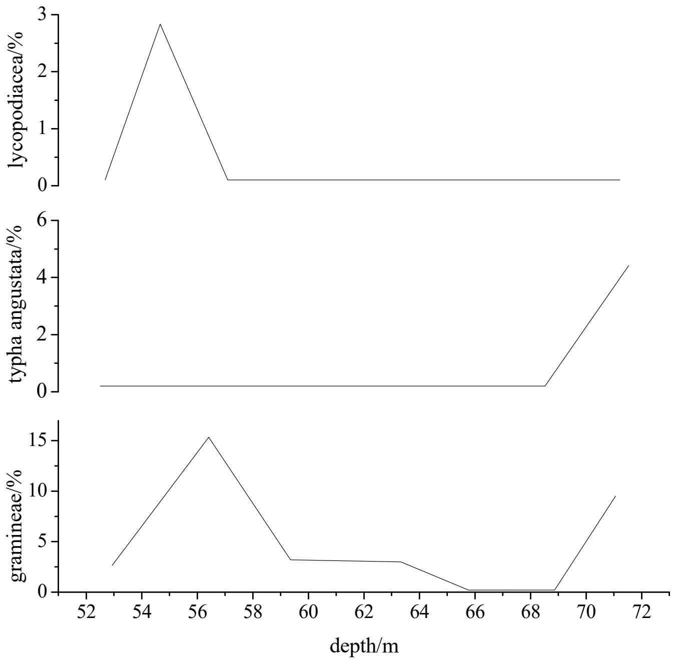
This paper selects sporopollen in 51-73m part of SG01 borehole in eastern Beijing Plain as samples and identifies them. It mainly uses microscope to magnify and analyze the samples in ways to obtain clear images, and takes *Chinese Plant Pollen Morphology* as main references. Images are strictly identified and compared with the images in the book to determine the quantity distribution and type of each species [10]. The 51-73m part of SG01 borehole is divided into two parts, namely, 51-60m and 61-73m for comparative study of sporopollen.



(a) Percentage of sporopollen content of arbor, herb and fern



(b) Percentage of sporopollen content in pine, spruce / fir and chenopodiaceae



(c) Percentage of sporopollen content in gramineae, typha and lycopodiaceae

Fig. 2 The percentage of sporopollen content in sediments in 51~73m SG01 borehole

According to Figure a, sporopollen content of herb represents the highest in the 51-60m part of SG01 borehole, accounting for 56%-70% of the total, followed by that of arbor (15%-35%), and fern has the lowest sporopollen content (2%-15%). Among those, drought tolerance, thermophilic and chimonophilous herb chenopodiaceae (Figure b) and gramineae (Figure 3) boast the highest sporopollen content, 20%-40%, 3%-15% respectively. Psychrophilic spruce or fir (Figure b) do not appear in this part, which shows that the climate in the 51-60m part of SG01 borehole is relatively dry and warm.

In Figure a, sporopollen content of herb is reducing gradually while that of arbor is rising in the 61-73m part of SG01 borehole, with the latter, up to almost 50%, surpassing the former at 68m depth. Sporopollen content of fern is still the lowest. Aquatic plant typha (Figure c) is active in this part, with its sporopollen content up from 0% to 6%, and the sporopollen is still rare in lycopodiaceae (Figure c). Psychrophilic theropencedrymion spruce or fir (Figure b) appear in the 60-78m part of SG01 borehole, showing that the climate in the 61-73m part of SG01 borehole is relatively humid and cold.

4 Conclusion

This paper is endeavor to study the evolution of paleoclimate and paleoenvironment in eastern Beijing Plain in the last 70,000 years based on the analysis of particle size and the characteristics of sporopollen. The main outcomes are as follows:

(1) The particle size analysis experiment studies samples of 51-73m part of SG01 borehole, and divides the part, from top to bottom, into five stages. The research shows that the climate of stage A is dry and cool, the climate of stage B, warm and humid, stage C, slightly cold and dry, stage D, relatively cold and humid, and stage E, cold and slightly humid. The result indicates that the evolution process of climate and environment in the eastern part of Beijing Plain is humid and cold—humid and warm—dry and cool.

(2) The sporopollen analysis experiment studies samples of 51-73m part of SG01 borehole, and divides the part, from top to bottom, into two stages, finding that the climate of 51-60m depth is slightly dry and warm, and the climate of 61-73m depth is moderately humid and cold.

There may exist a certain error in sample selection of the sporopollen analysis experiment because of the number and concentration of sporopollen [11]. The paper thus gives priority to particle size analysis, with sporopollen analysis as an auxiliary verification means. It is concluded that the overall climate change in eastern Beijing Plain is roughly: humid and cold— humid and warm—dry and cool, which is in line with the law of global climate change.

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