A Middle Miocene Pollen Flora of Core CB-20, Southwest End of Bohai Sea

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A Middle Miocene pollen flora was revealed from Core CB-20, Southwest end of Bohai Sea. Evidences were got to show that this flora chronologically follows the famous Shanwang flora in the Northern east China. It shares many features of the Shanwang flora, but includes more herbaceous forms and some other temperate types than the latter, inferring a possible climate deterioration or an enlargement of the seasonal variation. This flora is also suggested to be in correspondence with NP-3 Zone of Japan, while differences may have been raised from their specific geographic conditions.

Key words : Pollen flora, Middle Miocene, Paleoclimate, Bohai Sea.

Introduction

During the last two decades, a number of Neogene pollen data have been accumulated in the mainland China. But the Neogene deposits in China are mostly continental, with their outcrops isolated, while most of the research materials from the drilling holes are largely based on debris samples for productive purposes, thus causing difficulties in determining their ages and making precise comparisons among those world's most diverse floras. In the Northern east China, late Early Miocene-early Middle Miocene pollen flora is so far well represented by the Shanwang flora[1,2]. To further ascertain the floras after the Shanwang stage, we selected the present core for detailed study.

In the paper, pollen flora from Core CB-20 was established, and an effort was made to compare the present flora with the Shanwang flora and those of Japan. The reflected paleoclimate was also inferred.

Geological Settings

Core CB-20 lies to the southwest end of Bohai Sea, offshore of Chengbei area, Shandong Province of China (Fig. 1). Stratigraphically, it belongs to the North China Plain region which includes the Lower Liao River Plain, Bohai Sea area and the North China Plain. Within this vast land, Tertiary deposit is well developed with a general thickness about 4000-5000m, mainly represented by dark sandstone and mudstone of lacustrine facies, intercalated with purple and mottled sandstone and mudstone of fluviatile facies or shallow lacustrine facies, and several basalt beds in some local places. The Tertiary deposit in the region is in unconformity with its base rocks, and in conformity or parallel unconformity with the Quaternary deposits[3].

Within the region, Neogene sedimentary sequence was named as Guantao and Minghuazhen Formations in ascending order. The Guantao Formation is mainly composed of a set of grayish white rudaceous sandstone, fine sandstone and grayish green fine sandstone, interbedded with grayish green and brownish red mudstone. Its upper part is indicated by sandstone and mudstone interbedding, while its lower part by thick clumpy sandy conglomerate, intercalated with mudstone, and its base by quartziferous sandy conglomerate and dark flint. The thickness of this formation is mostly within 200-500m, and amounts to 1100m in some local sites. The Minghuazhen Formation is combined with brownish red, grayish green siltpelite, interbedded with brownish red, grayish green and grayish white mudstone, commonly containing the ferromanganese concretions, The general thickness of the formation is about 600-1200m. The formation is thickening towerd the Bohai Sea side to reach a thickness of 2500-3000m. It is conformable with the underlying Guantao Formation in most localities[3,4,5,6]. The Guantao Formation is generally considered as Lower Miocene in age, while the Minghuazhen Formation represents the Neogene except the Lower Miocene[5,7].

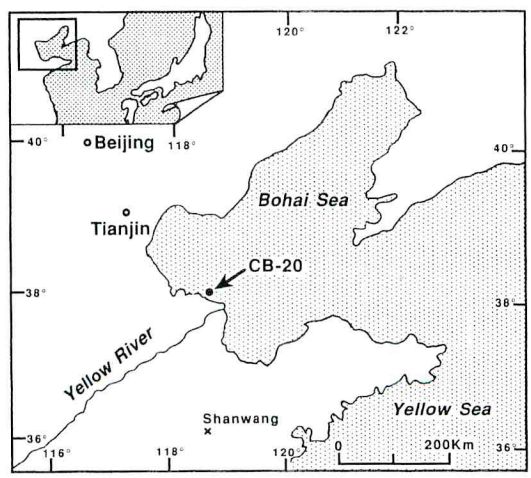

Fig. 1. Index map showing the location of Core CB-20.

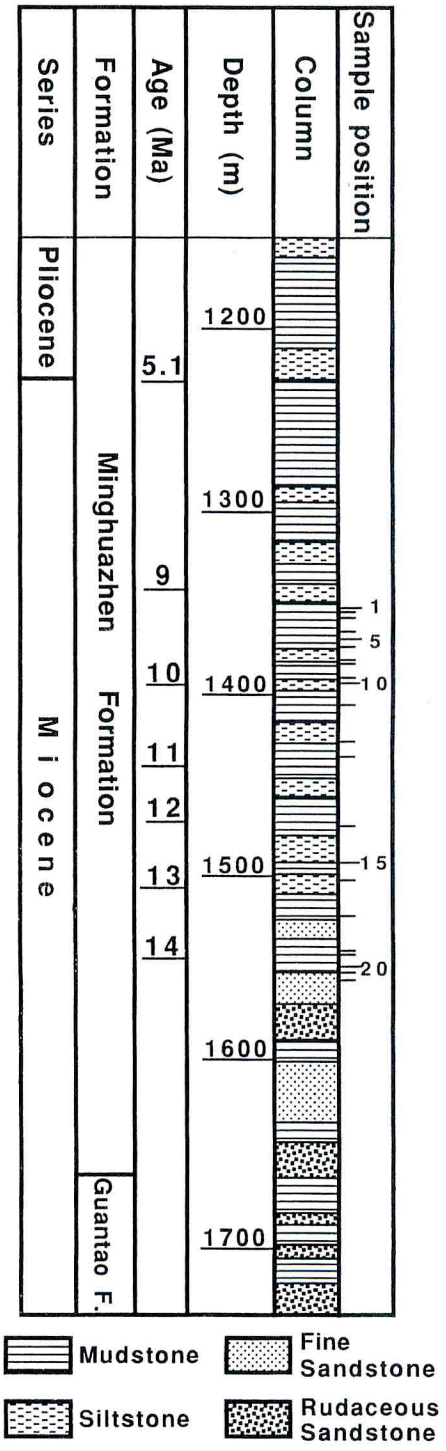

Fig. 2. Stratigraphic column and sample location of Core CB-20.

Materials and Methods

Twenty-two samples for pollen analysis were taken between the depths 1348.24-1554.50m of Core CB-20 , with an approximate time range of 14.5-9Ma (Fig. 2). Age control for the interval analyzed for pollen from the core derives from paleomagnetic measurements and other biostratigraphic data (unpublished).

Samples were sieved through a screen (half 60 mesh, half 30 mesh) after being powdered. All of the samples were first macerated with KOH (10%) for one day, and next with HF (47%) for half day, then treated with acetolysis method, and finally their residues were soaked in a solution of $ZnCl_2$ (specific gravity of 2) to concentrate the pollen grains. Slides were prepared for light microscope (LM) study by mounting the pollen grains in glycerine jelly.

During the procedure of microscopic examination of each sample, 100 pollen grains were classified in order to obtain a Pinaceae (vesiculate type) pollen and spores vs. other pollen ratio, and 200 pollen grains were taxonomically identified without the consideration of the vesiculate Pinaceae pollen and spores.

Results of Pollen Analyses

Sixteen samples among the total twenty-two ones contain rich pollen. Pollen flora is featured by the consistent dominance of *Ulmus, Carya, Liquidambar*, E. (evergreen type) *Quercus*, and *Juglans*. Meanwhile, *Persicaria* (*Polygonum*), *Fupingopollenites* and *Ceratopteris* gradually play a major role upwards to become the predominant elements in some separate samples. Pinaceae pollen mostly consists of *Pinus* and *Tsuga* in moderate amount (Fig. 3). Spores in the assemblage of pollen grains of the Fig. 3 are mostly represented by *Ceratopteris*, while *Osmunda*, Polypodiaceae and *Lycopodium* are scattered.

Among the woody pollen, the frequently occurred elements besides those dominant ones are: *Alnus*, D. (deciduous type) *Quercus, Corylus, Fagus, Acer, Celtis, Castanea, Lonicera, Tilia, Elaeagnus, Pterocarya*, Taxodiaceae, *Ilex, Ruta, Salix*, etc.

Shrub and herbaceous pollen display a slight increase upward, with *Artemisia* and *Ephedra* mainly occurring at the upper part of the section as *Trapa* declining . This flora is also featured by some other complex herbaceous types besides their low contents, such as Gramineae, Chenopodiaceae, Ranunculaceae, *Lemna*, Caryophyllaceae, Onagraceae and Cyperaceae.

Conclusion and Discussion

The present pollen flora bears a lot of resemblance to the Shanwang flora in characteristics. The prominent genera of the Shanwang flora are *Quercus* (mainly evergreen types), *Ulmus, Juglans, Liquidambar, Carya, Corylus, Fagus*, and *Pinus*. Less common taxa include *Fupingopollenites, Alnus, Acer, Zelkova, Picea, Tsuga*, etc.[8,9]. Almost all of the types could be found in the present flora and some of them can even be compared in contents. But in the Shanwang flora, there are still diverse forms of *Tricolpites* and *Tricolpopollenites* which are scarcely found in the present flora. Most pollen taxa in the present flora can be assigned to the natural genera or fomilies. On the other hand, herbaceous groups are very few and consistently rare in the Shanwang flora while quite a lot of types and numbers appeared in the present one.

In the Northern east China, late Early Miocene - early Middle Miocene pollen flora is so far

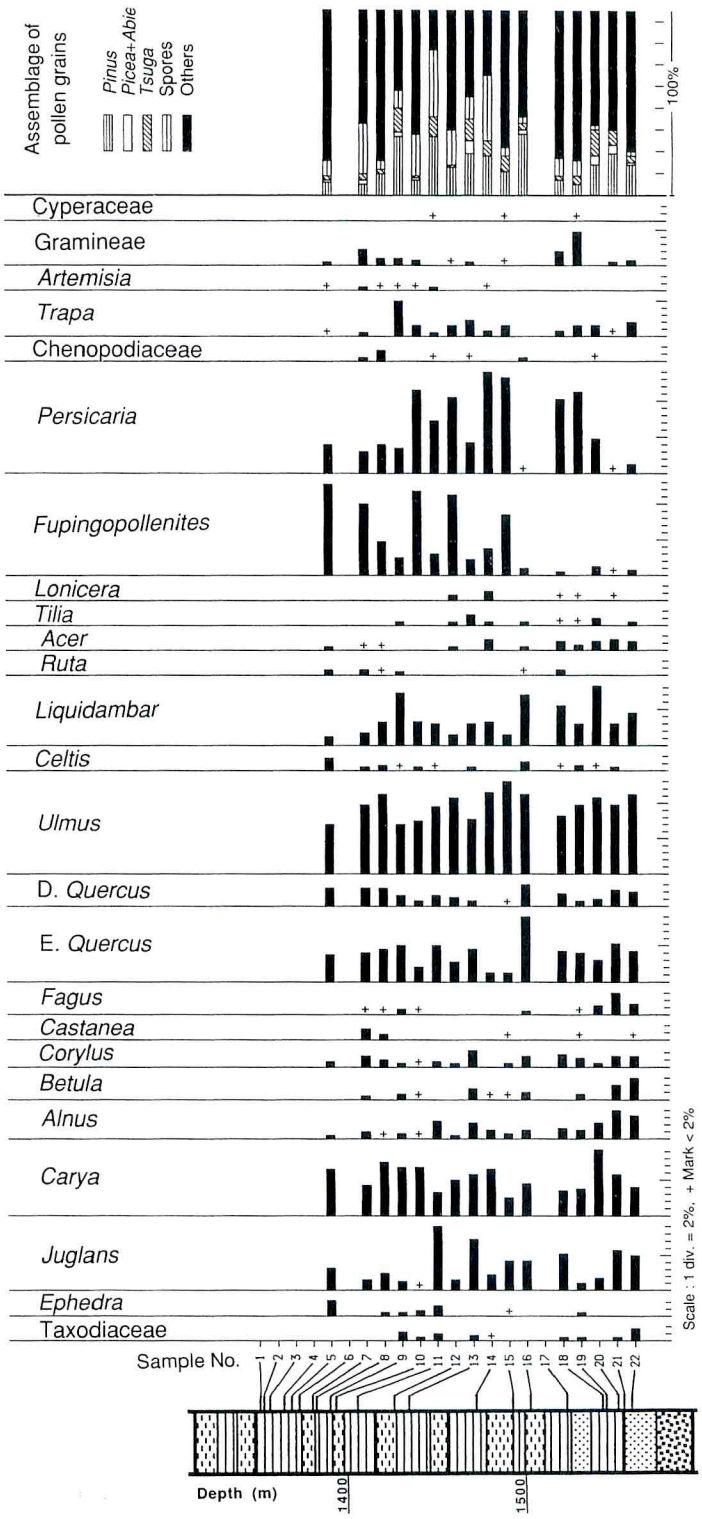

Fig. 3. Pollen diagram showing major floral components of Core CB-20.
Two fixed sums are represented: all pollen excepted for the vesiculate Pinaceae and spores, N = 200; and all pollen for the "Pinaceae, spores vs. others" diagram, N = 100 (shown on the right).

represented by the Shanwang flora, while the succeeding floras are featured by a gradually increase in herbaceous pollen, together with certain amount of *Ephedra*.The herbaceous pollen developed to exceed 50% of the total number in most of the Pliocene pollen assemblages[2, 10, 11].

It can be deduced from the above discussion that this flora chronologically follows the Shanwang flora. It not only inherited many features of the latter, but also displayed a further development, mainly represented by the development of herbaceous forms. Meanwhile, the moderate amount of the herbaceous pollen confines it to be further late. Therefore, age of the present pollen flora drawn from palynological study shows no difference with the results from paleomagnetic measurements and other biostratigraphic data. At the same time, a possible climate deterioration can be recognized from the present flora, as more temperate types and herbaceous forms raised in the flora. This change may still be on a small scale, mostly due to a slight climate cooling and drying, or an enlargement in the seasonal climate variation.

This flora can also be compared with the NP-3 Zone of Japan. The NP-3 Zone of Japan is distinguished by the large proportion of *Carya*, *Liquidambar*, Taxodiaceae and *Fagus*, while the major NP-2 Zone types *Dacrydium* become very rare and the pollen of mangrove plants are not known[12]. It also reflects a climate declining from the NP-2 Zone. There are still some differences between the NP-3 Zone and the present one. This may be mainly due to the Japanese one being under the marine climatic influence, while the one in China is rather continental. Thus herbaceous pollen begin to rise up in the latter. It is also due to their specific geographic positions and different floral backgrounds.

To sum up, the following conclusion can be got from the above discussion.

(1). Pollen flora from the depths 1348.24-1554.50m of CB-20 represents a successor of the Shanwang flora in the Northern east China.

(2). Pollen flora of the core suggests a possible climate deterioration or an enlargement in seasonal variation after the Shanwang stage.

(3). This pollen flora is also in correspondence with the NP-3 Zone of Japan. Both the floras show a climatic deterioration despite of some differences aroused by their respective geographic conditions and the floral backgrounds.

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渤海南西端，CB－20 試錐における中期中新世の花粉群集

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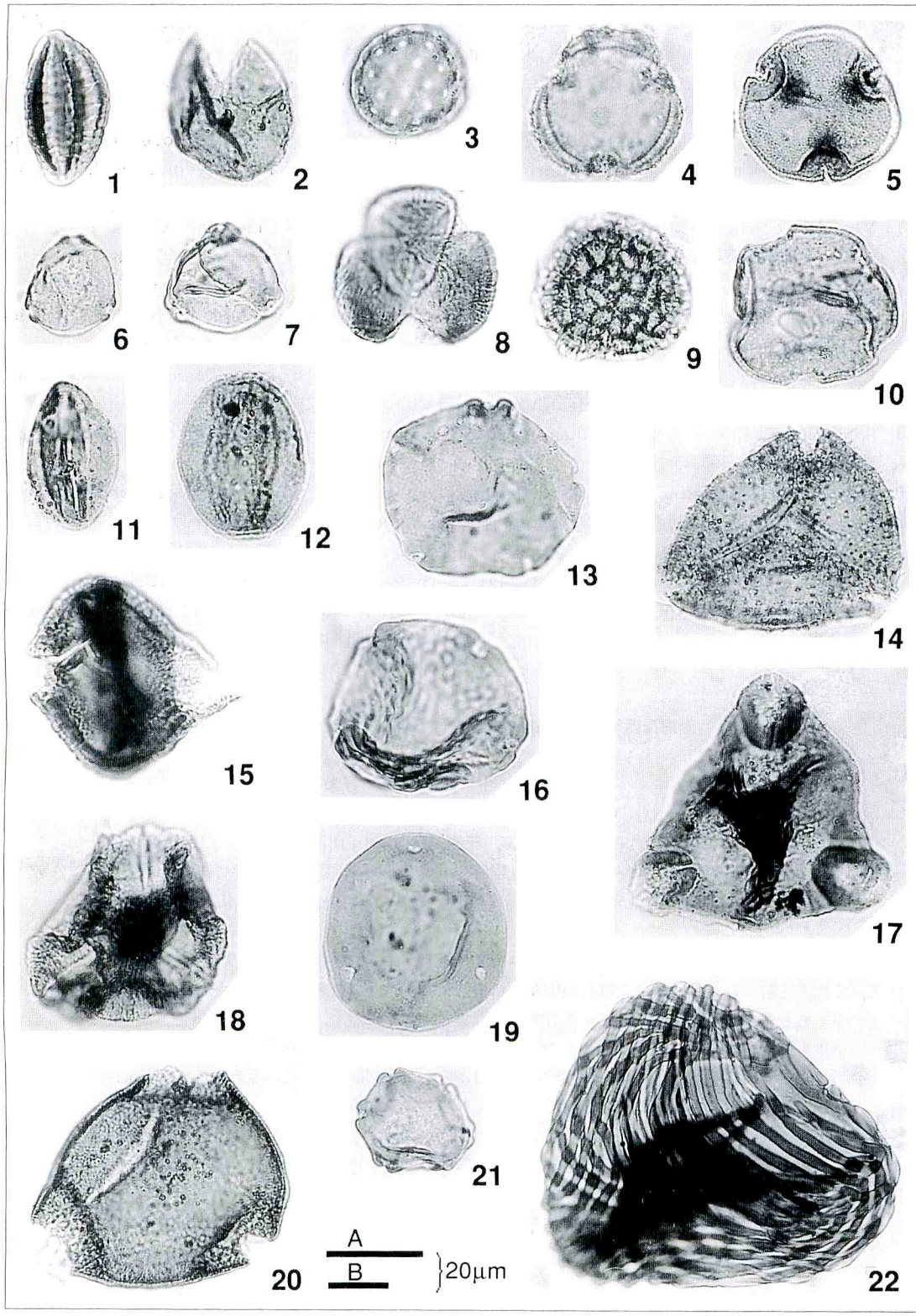
渤海の南西端で試掘された CB－20 のコアを分析し，中期中新世の花粉群集について扱った．ここの花粉フローラは中国北東部の中期中新世の植物群として有名な山旺フローラの後に続くものであることが明らかになった．ここの花粉群集は，多くの点で，山旺の花粉群集と共通するが，草本や温帯の植物の花粉が多いことで異なり，気候の悪化や，気温の年較差の拡大を示すものと考えられる．この花粉群集は，時代的には，日本の NP－3 帯に対比されるであろうが，内容の違いは，地理的な状況の相違によってもたらされたものであろう．

Bohai 渤海, Chengbei 埕北, Guantao 館陶, Liao River 遼河, Minghuazhen 明化鎮, Shanwang 山旺, Sangdong 山東.

Plate 1



Explanation of Plate 1

1. *Ephedra*, lateral view, Loc. No. 5.
2. Taxodiaceae, lateral view, Loc. No. 9.
3. Chenopodiaceae, Loc. No. 19.
4. *Artemisia*, polar view, Loc. No. 1.
5. *Tilia*, polar view, Loc. No. 16.
6. *Carpinus*, polar view, Loc. No. 21.
7. *Betula*, polar view, Loc. No. 22.
8. *Acer*, oblique polar view, Loc. No. 18.
9. *Persicaria*, Loc. No. 20.
10. *Liquidambar*, Loc. No. 10.
11. E.(evergreen) *Quercus*, equatorial view, Loc. No. 7.
12. E.(evergreen) *Quercus*, equatorial view, Loc. No. 8.
13. *Pterocarya*, polar view, Loc. No. 20.
14. *Lonicera*, polar view, Loc. No. 12.
15. *Trapa*, equatorial view, Loc. No. 10.
16. *Ulmus*, polar view, Loc. No. 8.
17. Onagraceae, polar view, Loc. No. 17.
18. *Fupingopollenites*, polar view, Loc. No. 10.
19. *Carya*, polar view, Loc. No. 7.
20. *Lonicera*, polar view, Loc. No. 14.
21. *Alnus*, polar view, Loc. No. 19.
22. *Ceratopteris*, polar view, Loc. No. 10.

Scale: 1～21＝A; 22＝B.