Three abrupt climatic events since the Late Pleistocene in the North China Plain

Lin Jingxing¹,²,*, Chen Lei²,³, Yang Mei², Qu Ming⁴

¹. Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China.
². College of Earth Science, University of Chinese Academy of Sciences, Beijing 100049, China.
³. Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China.

Abstract Based on the data from 121 boreholes (9552 samples) and the distribution pattern analysis of foraminifera, ostracods, pollen, spores, wooly rhinoceros, elephants, water buffalo and beachrocks in time and space, three abrupt climate change events since the Late Pleistocene are recognized in the North China Plain. These climatic events caused three very warm periods and two severely cold periods. During the two warmest periods, the mean temperature was about 7°C higher than at present, and during the two extreme cold periods, the mean temperature was some 6°C lower than today. Moreover, the last warm period was in the Middle Holocene; its mean temperature was 3°C higher than now in the region.

Key words biota migration, climate change, Late Pleistocene, North China Plain

1 Introduction *

The data presented in this article mainly came from a study on “Quaternary marine transgressions in eastern China” (Lin and Dai, 2012). The study area includes Liaoning, Hebei, Shandong, Jiangsu, Zhejiang, Fujian, Taiwan, Guangdong, Guangxi, Hainan, Beijing, Tianjin, Shanghai, the Bohai Sea, the Yellow Sea, the East China Sea, and the South China Sea (Fig. 1). The entire area approximately covers 6.25 million km² (2.65 million km² on land, 3.6 million km² in the sea). In the present study, information on three new boreholes has been added; one is from Tianjin (T1, 50 m deep), other one is from the East China Sea (E1, 56 m deep), and the third is from the South China Sea (LH19–4–1, 2630 m deep); with the addition of these boreholes, the number of boreholes has increased to 121 and the number of samples now totals 9552 (Fig. 2). This research focused on the distribution pattern of foraminifera, ostracods, pollen, spores, wooly rhinoceros, elephants, water buffalo and beachrocks both in time and space. Results demonstrate that three abrupt climatic events had taken place since the Late Pleistocene in the North China Plain, which caused three great migrations of biota.

2 Three abrupt climatic events

Based on a detailed analysis of the distribution pattern of typical warm-water foraminifera in time and space, the migration of warm mammalian fauna, as well as the dispersal of cold-water ostracoda, cold mammalian fauna, and cold flora, three very warm periods and two very cold periods, termed the three abrupt climatic events (ACE), have been distinguished since the Late Pleistocene in the North China Plain.

2.1 The great migrations of the cold mammalian fauna and cold flora

Abrupt climatic changes in the Late Pleistocene caused
oscillating migrations of species that could adapt to either low or high temperatures.

During the two very cold periods, cold *Coelodonta antiquitatis* mammalian fauna extended from North China to Qinling Mountain and the Huaihe River region in the south (Fig. 3; Zhou, 1978; You and Xu, 1981). The *Abies* and *Picea* flora moved from North China to the Hangzhou area and the southern Yangtze River delta region (Xu *et al.*, 1980; Kong and Du, 1991). *Abies* and *Picea*, which are still living today in the area of northern Beijing, moved about 1200 km, or 10° latitude from north to south (Fig. 4). Considering the change of the mean temperature along a latitudinal gradient (0.7°C per 1° latitude in eastern China), the mean temperature dropped about
7°C (at least 6°C) during that time in the North China Plain; the difference of the present annual mean temperature is about 6.4°C between Hangzhou (18°C) and Beijing (11.6°C).

2.2 The great migrations of the warm mammalian fauna

During the two very warm periods in the Late Pleistocene, Elephas sp. was found at Shandingdong (Fig. 5), and Struthilitus sp. (ostrich) was found at Malantai, both in western Beijing (Ji, 1987). The elephant Palaeoloxodon naumani was found at 13 sites in the northern Jiangsu Province (Fig. 5; Fang, 1988). The water buffalo Bubalus wansjocki occurred at Salawusu, Inner Mongolia (Ji, 1987). At present, elephants mainly appear in the southern part of Yunnan Province, ostriches, which disappeared
Three abrupt climatic events since the Late Pleistocene in the North China Plain

Lin Jingxing et al.

Vol. 2 No. 4

425

Fig. 3 Distribution of *Coelodonta antiquitatis* during the Late Pleistocene in eastern China (data from Chow, 1978; You and Xu, 1981). 1–Suxian; 2–Xincai; 3–Jinan; 4–Xi’an; 5–Anyang; 6–Linyi; 7–Dingchun; 8–Salswusu; 9–Xijie; 10–Shuidonggou; 11–Nihewan; 12–Beijing; 13–Dalian; 14–Chaoyang; 15–Chifeng.

from China occur in tropical Africa, and the water buffalo is restricted to a rough life along the north–south boundary formed by the Qinling Mountains–Huaihe River (Fig. 6). During the last very warm period in the Holocene, *Elephas* sp. occurred in the lower reaches of the Yellow River at 2490 a B.P. (Fig. 5; Zhu, 1973). Three beachrock layers were found in the coastal plain of the Lushan County, Shandong Province, between 5350 a B.P. and 3600 a B.P. (Fig. 5; Lin, 1985; Bi and Yuan, 1991). Beachrock can only be found in the southern part of the Xisha Islands, South China Sea, at present. All this evidence demonstrates that the warm fauna migrated in a great distance from South
China to North China during the warmest period since the Late Pleistocene.

2.3 The great migrations of the typical warm-water foraminiferal species group (APC)

As the migrations of the typical warm-water species group of foraminifera have been studied in great detail, we concentrate our discussion mainly on their patterns and the palaeotemperature inferences of the three warm periods which may be drawn from them (Lin, 1977; Lin et al., 1989; Lin and Dai, 2012).

The typical warm-water foraminiferal species group APC at present is also called the APC species group during the ice age. Therefore, A stands for the four species...

The APC species group of foraminifera is presently living in the South China Sea and the southern part of the East China Sea. The northern limit of the species Group APC is at 26° N latitude near Fuzhou, Fujian Province (Figs. 7–10). Its geographical location is the same as the northern limit of the subtropical snake Bungarus fasciatus.

The northern limit of the species Group APC during the ice age remains unknown, but considering that the mean temperature was some 6°C lower than at present, the north-
ern boundary of the species Group APC during the ice age should have shifted southward to the Palaeo-Taiwan Straits.

The species Group APC dominated in the South China Sea during the Pliocene, but their northern limit during this period is still in question. There is no doubt that the species group was indigenous tropical-subtropical at this time, because they are never found outside the tropical-subtropical zone during the Pliocene. For this reason, the latitudinal shifts of the northern limit of the species Group APC can be reliably used to reconstruct the prevailing palaeotemperature of the sea.

The A and P elements of the species group spread from the South China Sea to the southern Tianjin during MTS3 (MTS: Marine Transgression Stratum) in the early Late
Three abrupt climatic events since the Late Pleistocene in the North China Plain
Lin Jingxing et al.

The P components migrated from the South China Sea into the Tianjin area and the components A and C extended from the South China Sea to the Shanghai area during the MTS2 in the late Late Pleistocene (Fig. 9).

The C components moved from the South China Sea to the Fuding area of northern Fuzhou during the Holocene (MTS1). However, the northern limit of the components A and P remained the same during the Holocene (MTS1) as it remains today (Fig. 10).

Thus, there were two times of large latitudinal shifts in the northern boundary of the species Group APC. The first
occurred in the early Late Pleistocene, during MTS3, and probably began about 100,000 a B.P.; the second in the late Late Pleistocene, during MTS2, starting around 40,000 a B.P. During the climate optima, the species Group APC migrated from the Palaeo-South China Sea to the Palaeo-Bohai Sea; and during cold periods they moved back from the Palaeo-Bohai Sea to the Palaeo-South China Sea.

3 Discussion: Palaeotemperature estimation

Each species group of foraminifera is living under spe-

Fig. 8 Northern limit of the distribution of the Asterorotalia species group (A) and Pseudorotalia species group (P) in the third marine transgression stratum (MTS3) during the early Late Pleistocene. —Distribution boundary of species Group AP during the early Late Pleistocene. —Present-day limit of species Group APC.
specific environmental conditions defined by temperature, water depth and salinity, as the major factors influencing distribution. The temperature is one of the most important factors. Typical warm water organisms live only in a limited temperature range; *Globorotalia tumida*, for example, lives only at temperatures ranging from 18°C to 30°C. Therefore it provides a basis for interpreting the past oceanic temperatures.

Studying shifts of biogeographic boundaries is one of the most important methods to estimate the past oceanic temperatures. It involves identification of a great number of foraminifera. The study of their present ecology and
ecological history, and the investigation of the temporal and spatial distribution of those species, can be used as temperature indicators for each geological period. Based on the study of the expansion and retreat of biogeographic distributions in the past, compared with present-day distributions, the palaeotemperature can be estimated.

As mentioned above, the present northern boundary of the species Group APC is situated at about 26° N (near Fuzhou, Fujian Province) but during the two warmest periods of the Late Pleistocene, MTS3 and MTS2, it shifted to the Palaeo-Bohai Sea region (around 38° N). Their northern boundary thus shifted about 1400 km, corresponding
to about 12° in latitude (Figs. 8–10). By calculating the change rate of the mean seawater temperature per latitude (0.7°C in eastern China), the mean temperature in the area was about 8.4°C higher than at present. The present difference of the mean seawater temperature between Fuzhou (19.6°C) and southern Tianjin (~13°C) is about 6.6°C. Thus, the mean sea water temperature was about 7°C higher than at present during the two warmest periods of the Late Pleistocene in the southern part of the Palaeo-Bohai Sea (Fig. 11).

During the warmest period of the Middle Holocene, the palaeotemperature is estimated to be 3°C higher than at present (judged from the northern limit of the beachrocks and the elephant fauna; Fig. 11).

### 4 Conclusions

1) Three abrupt climatic change events happened in the North China Plain since the Late Pleistocene.

2) These abrupt climate changes caused three very warm periods and two severely cold periods. During the two warmest periods, the mean temperature was 7°C higher than at present; and during the two extreme cold periods, the mean temperature was some 6°C lower than today.

3) The last warm period was in the Middle Holocene, its mean temperature was 3°C higher than at present in the North China Plain.

### Acknowledgements

We are extremely grateful to Prof. Dr. Hao Yichun, Prof. Dr. Liu Tungsheng, Prof. Dr. Paepe R., Prof. Dr. Boski T. and Prof. Dr. Ferguson D. for their guidance, advices, comments, and critical remarks in reviewing the manuscript, which greatly improved the scientific level of the paper.

### References


(Edited by Liu Min, Wang Yuan)

--------------------------------------------------------------------------------

Congratulations on success of the 1st International Palaeogeography Conference

On September 14th–17th, 2013, the 1st International Palaeogeography Conference (IPC) was successfully held by China University of Petroleum (Beijing) (CUP), in Changping, Beijing, China.

Totally 109 registered palaeogeographers and experts of related disciplines from 36 affiliations, including universities, academic institutions and petroleum industries, from Ireland, the UK, Poland, the Netherlands, Germany, France, India, Australia, the USA and China, and the staff from the Editorial Office of the Journal of Palaeogeography (JOP) attended this conference.

The conference had totally received 61 abstracts, 41 of which came along with full-text manuscripts and these 41 attendees gave oral presentations in the conference. There are 28 abstracts related with “Lithofacies palaeogeography and sedimentology”, 14 related with “Biopalaeogeography and palaeoecology”, 5 related with “Tectonopalaeogeography, palaeoequakes and seismites”, 2 related with “Physiogeographic palaeogeography”, 3 related with “Geochemistry and sedimentary environments”, and 9 related with “Palaeogeography and mineral resources”.

In the conference, four young attendees among nine applicants were awarded the “Awards for the Best Presentations by Young Scientists/Students”.

Three mid-conference field excursions and two post-conference field excursions (Qingdao of Shangdong Province, and Jixian of Tianjin) were favored by the attendees and cheerful results were obtained.

The 1st IPC showed high academic level, and all attendees enjoyed the passionate academic atmosphere. This conference covered the multidisciplines related to Palaeogeography, and showed prominent advance that had been achieved in recent years. Quite a few young scientist/student attendees gave excellent presentations. They are energetic, exhibiting new ideas and talent. We are glad to see there is no lack of successors of Palaeogeography.

The 2nd International Palaeogeography Conference will be hosted by the China University of Mining and Technology (Beijing) in October, 2014, in Beijing, China.

Detailed report and information about this conference will be published in the January issue of JOP in 2014.

The Editorial Office of the Journal of Palaeogeography
October, 2013