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ENVIRONMENTAL CHANGES IN THE EASTERN CHINA DURING THE LATE PLEISTOCENE

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ABSTRACT: The environmental changes during the Late Pleistocene were more obvious in the eastern China than in other areas at the same latitude, which either between northern and southern, or between land and sea of the eastern China were mostly non–synchronous. The transitional period prior to the last glaciation came about in the northern part of the eastern China about 115,000 yr. ago. The desert environments of the inland of the north China were developed both in the glacial maximum and in the warm interglacial period, but the loess accumulation mostly took place during the glacial period. The sand dunes and the periglacial solifluctions in the lower Changjiang (Yangtze) River region were formed during the last glacial period. The event of lowest surface temperature occurred at 98,000 yr. B.P. and 59,000 yr. B.P. in the northern part of the South China Sea but not during the full–glacial stage. The phenomena mentioned above were the result of the following reasons that the paleo–environmental changes in the eastern China were controlled by the common factors leading to the changes of global environment, on the other hand, the different changes were related to the particular of East Asia as well as a time lag required by the adjusting process of varied changes themselves.

KEY WORDS: the eastern China, late Pleistocene, environmental changes

In the last decades, the studies of terrestrial deposits and marine sediments proved that there existed an all–round cycle change about 10^5 year in the changes of the global climate and environment during the Late Pleistocene, including the second alternations of cold–warm and dry–moist. But, due to the particular position geographically and East Asia monsoon climate, the environmental changes during that time in the eastern China were different obviously in comparison with the other regions at the same latitude.

I. DEEP SEA SEDIMENTS AND ENVIRONMENTAL CHANGES IN THE NORTHERN SOUTH CHINA SEA

The latitude of the northern South China Sea is similar to the Caribbean Sea and the Red Sea. From the core V3 situated on the lower–middle continental slope (19° 00.5′ N, 116° 05.6′ E, 3,809 m below the present sea level and drilling core of 12 m in depth), it is possible to estimate the changes of sea surface temperature in the Late Pleistocene based on the analysis of the fossil foraminiferal assemblage variations[1](Table 1 and Fig.1). And the investigators also provided the data in the Oxygen isotope ratio derived from the *Globigermoides sacculifer* shells found in 61 samples collected from V3 drilling core (Fig.1)[1].

Table 1 The surface water temperature in the northern part of the South China Sea during the Late Pleistocene

High temperature		Low temperature	
Age (yr.B.P.)	SST (℃)	Age (yr.B.P.)	SST (℃)
5,000	−21.7		
11,000	−20.5		
		16,400	−17.8
22,000–23,000	−20		
		47,000	−18
		53,000	−18
		59,000	−17.3
−62,000	−20.6		
		78,000	−18
−86,000	−20.7		
		98,000	−17.2
−120,000	−22		

* Age was estimated based on the Oxygen Isotope Stage and the average sediment rate.

The environmental changes reflected by these mentioned two curves have following features.

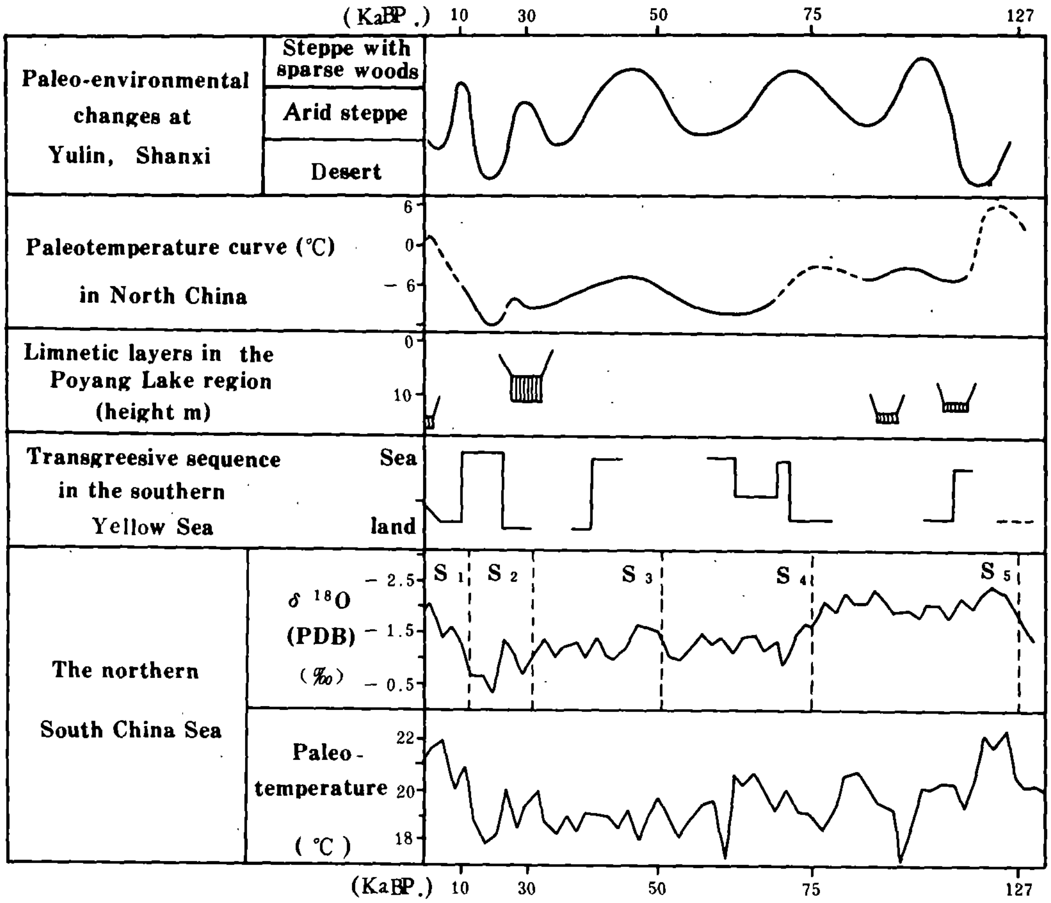

Fig.1 The environmental changes in the eastern China during the Late Pleistocene

1. The cyclic changes approximately in the ages of 41,000 yr. and 23,000—20,000 yr. were more apparent in the northern South China Sea than that of the other marine areas at the same latitude. Although, that of these tropical marine regions about 10^5 year were all very marked.

2. The lowest surface temperature was not in the full—glacial between about 20,000 and 15,000 yr.B.P., but in the ages of about 98,000 yr.B.P. and 59,000 yr.B.P. Contrarily, it emerged about 50,000 yr.B.P. in the western Caribbean Sea.[2]

3. The surface water temperature in the peak of the last glaciation was 3—4℃ lower than that at present in the northern South China Sea, which was approximate to the level of the Red Sea region but higher than that of the Caribbean Sea and the Pacific region at the same latitude.[3,4]

II. DEPOSITIONS AND ENVIRONMENTAL CHANGES IN THE LOWER REACHES OF THE CHANGJIANG RIVER AND THE INNER SHELF REGION OF THE YELLOW SEA

The sedimentary section of 40 m in depth situated in the shallow sea region of the southern yellow Sea east of 122° E are made up of the tidal current sand and the alternating layers of riverbed deposit and delta front sediment. Based on some radiocarbon dating, the tidal current sand of the surface layer of the section was constructed since 11,340 ± 55,000 yr.B.P. And a sample indicated the formation of the upper riverbed deposit at 19,980 ± 36,000 yr.B.P. Moreover, The upper delta front facies was deposited between 24,60 yr. and 4,000 yr.B.P.[5] There are three transgressive interlayers in the drilling core of upper 50 m in depth near Yancheng, Jiangsu Province. From top to bottom, the third interlayer developed between 70,000 yr. and 100,000 yr.B.P. based on magetostratigraphic dating, but the lower limit of the third interlayer was at least 106 m below the present sea level, with the magetostratigraphic dating of about 110,000 yr.B.P. near Shanghai.[6] The second transgression had reached Taihu Lake region, with the radiocarbon age of 3,309 ± 370 yr.B.P. from a sample of core 827 at Ducun, Suzhou, Jiangsu Province.[7] In addition, one of the transgressive interlayers, distributed once in the shelf region beyond 50 m of water depth at present, was found, with the estimated age of 60,000 yr. to 69,000 yr.B.P.[8] Thus, we can get a reliable transgression–regression sequence during the Late Pleistocene for the studied region (Fig.1).

The sea level changes corresponding to the transgression–regression sequence have a profound influence upon the geomorphic development of river valley and lakes in the lower reaches of the Changjiang River. In response to lowering of sea level correlated with the glaciation, the deep troughs was formed in the Changjiang River valley and in the lower course of its tributaries through so–called headward erosion. And the aggradation also took place in the valley during the sea level rise correlated with the interglacial or interstade. The three paleotroughs indicated by the lower boundaries of the transgressive layers reach 60 m, 120 m, 160 m below the present sea level at Chongming Island located at the mouth of the Changjiang River, and the corresponding relative depths are 35 m, 55 m, 55 m, respectively. The paleotrough correlated with the lowest position of sea level during the last full–glacial stage reached below −55 m near Nanjing.

The rising of the water level in the lower reaches of Changjiang River, caused by the rising of sea level, certainly, leads to the origin of the lake being so–called the lateral lake in the erosional depression on the banks of the lower reaches of the Changjiang River. Based on the drilling completed in Poyang Lake region, there are four lacustrine formations overlaid on the river deposits formed in the different time, one of them has been formed since the Mid–Late Holocene, likewise, the other three are located on the elevation of +11.10 — +6.92 m with the radiocarbon age of 26,130 ± 560 yr.B.P., +15.29 — +14.27 m (the available thermoluminescent (TL) dating of 90,900 ± 4,500 yr.) and +12.54 — +11.74 m (the available TL dating of 112,000 ± 5,600 yr.) (Fig.1), respectively.[9]

In addition, there exist widely the aeolian deposits formed during the Late Pleistocene in the lower reaches of Changjiang River, including the so-called "Xiashu" loess and "Shashan" sand dune. The interlaces consisting of calcareous concretions and paleosols are contained in the "Xiashu" loess sections near Zhenjiang, Nanjing, Wuhu, Jiujiang etc. The loess nodule of the upper interbed has the radiocarbon dating of 16620 ± 200 yr.B.P., in contrast, that of the second interbed was 30900 ± 1080 yr.B.P. near Nanjing. Besides, there are two interbeddings composed of the broken stones of silicious limestone, dolomite, sandstone which constitute local hills, with the thickness of 6–10 cm. Furthermore, in the interbeddings, there exist a lot of special structures produced by the periglacial solifluctions. The aeolian dunes, with the elevation of 40 m to 140 m, located on the south bank of the Jioujiang course of the Changjiang River and the margin of Poyang Lake, were grown from 26900 ± 1200 to 12900 ± 200 yr.B.P. according to the radiocarbon datings of the intercalated fine silt layers with rich organic matter. The majority of the sand grains constituting the dunes stemmed from the sandy beaches came forth out of the water surface during the time of the lower water level in accordance with the peak of the last glaciation.

III. DEPOSITION SYSTEM AND ENVIRONMENTAL CHANGES IN NORTH CHINA

The temperature curve of the last major climatic cycle in north China reconstructed by Sun Jianzhong recently,[10] demonstrates that the temperature from 114,000 to 70,000 yr.B.P. was 4℃ or so lower than that at present, and from 70,000 to 53,000 yr.B.P. was 10℃ lower. The coldest stage was between 23,000 and 13,000 yr.B.P., in which the southern boundary of the distribution of the Mammalian fauna indicated as periglacial permafrost had reached down to Kaifeng, Henan Province. In particular, the fauna and a lot of other periglacial phenomena such as the ice wedge and the periglacial flora show that the mean temperature of that stage was at least 12–13℃ lower than that at present in north China.

In the eastern part of the North China Plain the deposition column was characterized by the alternate changes of marine beds, transitional deposits, and terrestrial formations. The shelve of the northern Yellow Sea and the Bohai Sea were exposed as plains dotted with many lakes and swamps and overgrown with weeds during the regression stage, on which loess material accumulated. In the western part of the North China Plain and on the piedmont belt of the Taihang Mountain there developed a lot of pluvial–alluvial fans with intercalated solifluction deposits during the glaciation, in which the detected pollen assemblages show that the dry steppe or desert–steppe occurred at that time.

The columnar profile, developed since the beginning of the Late Pleistocene at Yulin, located on the southeast margin of the Mu Us Desert regions, can be divided into seven layers, chronologically, such as drab sandy soil, loess with the TL dating of 124,000 ± 11,000 yr., fine sand with the TL dating of 102,000 ± 8,000 yr., loess with the TL ages of 38,000 ± 5,000 yr. and 35,000 ± 8,000 yr., fine sand and the Holocene black–sandy soil and the recent medium–grained sand dune corresponding to the semidesert–arid steppe climate.[11] It is noted that the desert had appeared from 121,000 ± 11,000 yr. to 102,000 ± 8,000 yr.B.P. later. However, a lot of fossil freshwater spiral cases were contained in the lacustrine formations formed with the radiocarbon age of 24 ± 120 yr. ago and 27900 ± 600 yr. ago in the Mu Us depression of the southeastern Ordos Plateau (from Li Baosheng et al., 1985).

In summary, it seems that the environmental changes occurred in the Late Pleistocene in north China were very complicated, especially, there existed the greater longitudinal gradients varying with the passage of time in the temperature and the precipitation from the western Loess Plateau to the coast of the North China.

IV. MECHANISM ANALYSIS OF THE ENVIRONMENTAL CHANGES

Fig.1 indicates that the environmental changes occurred in the Late Pleistocene in the eastern China were very complex, in the other word, there existed the mostly non–synchronous features either in northern and southern parts or in lands and seas of the eastern China.

1. The transitional period prior to the last glaciation occurred at about 114,000 yr. ago in the northern part of the eastern China had lasted for about 45×10^3 years. The temperature from the last interglacial to the last glacial lowered approximately 12–13℃, far exceeding that of other coastal regions at the same latitude. Besides, the climate was also particularly dry during the full–glacial stage.

2. The desert in the Yulin region had expanded not only in the peak of the last glaciation but also in the last interglacial. Accordingly, it seems that there existed both the heat and drought features during the stage of warm climate.

3. The lowest surface temperature in the northern South China Sea occurred at 98,000 yr.B.P. and 59,000 yr.B.P., not in the peak of the last glacial about 18,000 yr.B.P. or so. But, the stage of the obvious lower temperature correlated with the beginning of the last glaciation started about 60,000 yr. ago in the northern South China Sea, which was delayed about 10×10^3 years in comparison with that of the northern part of the eastern China. In addition, the lowering of the surface temperature during the full–glacial was lightly greater than that of the Caribbean Sea and the tropical Pacific region.

4. The three transgressions occurred in the Late Pleistocene in the costal plains of the Bohai Sea and the Yellow Sea were very similar in the expanding degree. But, the weather in the interstadial epoch corresponding to the second transgression was much colder than that of the last interglacial period corresponding to the third one and the Holocene corre-

sponding to the last one.

5. The southern boundary of the distribution of the loess accumulation and sand dunes related to the Norther occurred in the glacial period moved more southwardly on the eastern China than that of the other mainlands at the same latitude.

The illustrated facts show that the paleoenvironmental changes in eastern China took place under the influence of many factors, such as special geographical position, topographic condition, monsoon circulation, tectonic movement, natural regulation and so on, besides, the common factors led to worldwide environmental changes.

Based on the calculation of many scholars,[12] the variations of solar radiation volume for 65° N resulting from the changes of the Earth's orbital parameters reached to the summit at 127,000 yr.B.P. in the Late Pleistocene, and then at 104,000 yr., 82,000 yr., 55,000 yr. and 11,000 yr. in order, in the same way, went to the nadir at 115,000 yr.B.P., and then at 71,000 yr., 55,000 yr., 23,000 yr., 93,000 yr., successively. Thus, the environmental changes in the inland of north China were to a large extent controlled by the variations of the solar radiation, meanwhile, to a certain degree by the effect of dry ground.

The second transgression range of the coastal plains was similar to the third one and the first one, which resulted from the variations of the tectonic movement through the deformation analysis of the transgressive sedimentary layer.[6]

There was a sharp lowering of global sea level following the event of the higher sea level at 105,000 yr.B.P. Thus, the oldest riverbed deposits in the Late Pleistocene were developed on the inner shelf of the Yellow Sea at that time. Because of the lowering of sea level which can lead to the upwelling of deep water in the closer marginal sea, the event of the coldest surface temperature in the northern South China Sea might be happened in 98,000 yr.B.P. The reason for the differences among the oxygen isotope curve, the paleo–temperature curve of the northern South China Sea and the transgression–regression alignment of the southern Yellow Sea is that the concentration of oxygen isotope in sea water was influenced by both the salinity level of sea water and the sea temperature.[13]

As to the paleo–environmental change in the eastern China, one of the most important factors was the variation of monsoon circulation. During the glacial or the interstadial, with the lowering of the global temperature and the sea level, and as well as the increasing of the high pressure of the Siberia–Mongolia and the intensifying of the frequency and the strength of the southwardly moving dry–cold air flow, the "East Asian Cold Trough" made the southward East Asian climate belt move a longer distance than that of the other areas at the same latitude, even had a further influences on the northern South China Sea linking with the East Asian continent.

Nevertheless, the expansion of Poyang Lake was mainly controlled by the rising of the water level in the lower reaches of the Changjiang River, and the rising of the water level was caused, by both the sea level rise and the feedback of the aggradation in the river bed.[14] Thus, between the expansion of Poyang Lake and the sea level rise, there existed a time lag required by the adjusting process of the river water level rise upward from the estuary.

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