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ENVIRONMENTAL CHANGE AND ITS IMPACTS ON HUMAN SETTLEMENT IN THE CHANGJIANG RIVER DELTA IN NEOLITHIC AGE

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ABSTRACT: Dating data, altitude of Neolithic sites, climatic changes from sedimentary records and previous research results were collected and analyzed to detect possible connections between climatic changes and human activities in the Changjiang River Delta in the Neolithic Age. The results indicated that hydrological changes greatly impacted the human activities in the study region. Low-lying geomorphology made the floods and sea level changes become the important factors affecting human activities, especially the altitude change of human settlements. People usually moved to higher places during the periods characterized by high sea level and frequent floods to escape the negative influences from water body expansion, which resulted in cultural hiatus in certain profiles. However, some higher-altitude settlements were not the results of climatic changes but the results of social factors, such as religious ceremony and social status. Therefore, further research will be necessary for the degree and types of impacts of climatic changes on human activities in the study area at that time.

KEY WORDS: Changjiang River Delta; Neolithic Age; human activities; climatic events

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1 INTRODUCTION

The middle and lower reaches of the Changjiang River is a flood plain, with an area of $126\times10^3 km^2$. The plain takes Taihu Lake as its center, with an altitude of about 4–6m (WU, 1988). Such geographical location and low-lying geomorphologic characteristics make this region prone to be influenced by floods and sea level changes.

Observation and modeling of modern climatic changes suggest that what plays the key role in the rise and fall of human culture is not the average climatic changes, but the abrupt climatic changes (YU *et al*., 1999). Recently, evidences from tropical coral and mid-latitude tree rings indicate that the climatic changes in the Holocene epoch were characterized by fluctuations and complexity, even in the Megathermal maximum during the Holocene epoch (FENG and EPSTEIN, 1994; BECK *et al*., 1997). Therefore, appearance, development and collapse of the Neolithic culture, to some degree, demonstrate the human adaptation to the eco-environment changes and the environment threshold (YU *et al*., 1999).

2 DATA AND METHODS

The reports on archaeological sections and excavation sites in the Changjiang River Delta were collected and analyzed. Sedimentary records of climatic changes were also collected for getting more evidences showing the impacts of climatic changes on human activities in the study area. Sea level changes reconstructed from buried shell ridges and peat were also analyzed to detect possible relations between sea level changes, floods and altitude of human settlements. Comparison study between cultural hiatus layers and extreme climatic events recorded in the natural sections was also conducted in 1998–2002. The authors of this paper made a wide investigation on the study area, collecting lots of the first-hand materials. All the ^{14}C ages were calibrat-

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ed into calendar years using the program Calib4.1 (STUIVER *et al*., 1998).

3 RESULTS

3.1 Impacts of Hydrologic Evolution on Human Activities

Hydrologic conditions greatly affected the human activities because there existed a large number of rivers and lakes in the Changjiang River Delta, which can be confirmed by the paddies that were found in the Majiabang and Songze sites. These crops were different from those found in Peiligang, Cishan and Banpo sites in the Huanghe (Yellow) River drainage (JING, 1989). The crops in the Huanghe River drainage were mainly the millets suitable to drier environment; the paddies, however, were suitable to the warmer and wetter environment (AN, 1981). Archaeological excavation indicates that, early in 8000a B.P., human developed the production of paddies in the Taihu Lake region (AN, 1981; HUANG *et al*., 1998; WANG *et al*., 2000).

For convenience of comparison between climatic changes and human response, all four cultural types and climatic changes recorded in natural sections (KONG *et al*., 1991; ZHAO *et al*., 1990; ZHANG *et al*., 2001) are shown in Fig. 1. Archaeological excavations indicate that one site seldom contain these four cultural types; most of the sites lack a certain culture type. Evidences of climatic changes shown in Fig.1 are mainly extracted from natural sections and sea level fluctuations.

After the Last Glacial Maximum (18 000a B.P.), China entered the warm and humid climatic periods, therefore, human culture greatly developed under this suitable climatic condition. TANG Ling-yu *et al*. (1993) suggested, by pollen analysis, that the early Holocene was climatically warm and dry, with a mean annual temperature slightly higher than that today (the difference is <0.5℃). QU Wen-chuan *et al*. (1997) indicated that, during 10–9.5ka B.P., contents of TOC, TN, Saturated hydrocarbon, and arene were high, indicating warm, dry climatic conditions in the early Holocene.

In 9000–8000a B.P., the temperature in the eastern China was rising; the climatic condition was still warm and dry. ZHANG Qiang *et al*. (2001) pointed out, from the Linfengqiao section, that the Holocene Megathermal in Linfengqiao region began during 8000–5000a B.P. TANG Ling-yu *et al*., (1993) suggested, from Qingfeng section of Jianhu Lake, that in the Qingfeng Lake region the Holocene Megathermal started during 8500–3700a B.P. SHI Ya-feng *et al*. (1992) indicated that the Holocene Megathermal in China started during 8.5–3.0a B.P., and at that time the mean annual temperature was 2℃ higher than that today in the Changjiang River drainage. All in all, the starting and ending of the Holocene Megathermal was approximately the same. The human culture entered the flourishing stage just under this suitable climatic condition. Fig. 1 demonstrates that the human culture in the Changjiang River Delta emerged under this suitable climatic period. Beginning of the rice agriculture as early

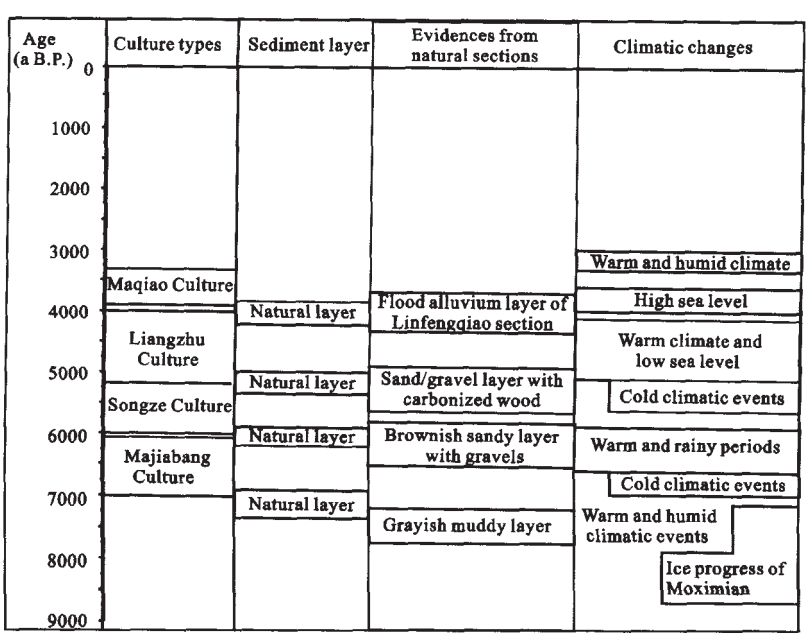
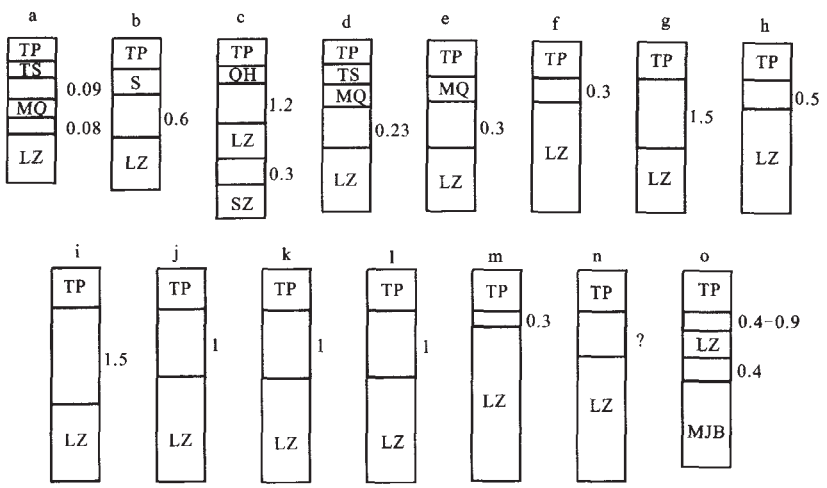


Fig. 1 Climatic changes and human activities in the Changjiang River Delta

as 8000a B.P. (WANG *et al*., 2000) in Taihu Lake drainage and the emergence of the Liangzhu Culture characterized by handmade basalt instruments and the fine jade articles (Shanghai Relics Management Committee, 1997) can serve as the good examples. Fig. 1 and Fig. 2 demonstrate that the cultural interruptions are easy to be found in the Changjiang River Delta, which are in close relation with the climatic changes. The research results from the tropical coral and tree ring records in the middle-latitude indicated that changing and complexity characterized the climate in the Holocene (FENG and EPSTEIN, 1994; BECK *et al*., 1997; O'BRIEN *et al*., 1995)

Abrupt climatic changes can easily lead to extreme climatic events, e.g., the floods. During 7500–7000a B.P., temperature and precipitation both reached the peak value (YANG, 1993), at the same time, an abrupt cold climatic event under the warm and wet climatic background resulted in larger-range paleo-flood, which just followed by the Majiabang Culture. This climatic event was reflected as the large ice progress in the Moximian in the western China (PU, 1991). O′BRIEN *et al.*(1995) suggested that this cold climatic period was the result of the expansion of the polar eddy and the intensified longitude circulation. Warm and humid climate, together with the abrupt cold climatic events,



a: Maqiao site in Shanghai
b: Tangwanli site in Wujiang of Jiangsu
c: Yuanjiadi site in Wujiang of Jiangsu
d: Wangjiashan in Danyang of Jiangsu
e: Shuitianfan site in Hangzhou of Zhejiang
f: Qianshanyang site in Wuxing of Zhejiang
g: Liangzhu site in Yuhang of Zhejiang
h: Dadong brickfield in Kunshan of Jiangsu
i: Chuodun site in Kunshan of Jiangsu
j: Xuxiang site in Wuxi of Jiangsu
k: Longtanhu site in Kunshan of Jiangsu
l: Zhengyi station in Kunshan of Jiangsu
m: Guoyuancun in Qingpu of Shanghai
n: Dasanjin in Wujiang of Jiangsu
o: Yuecheng site in Suzhou of Jiangsu
TP: top layer
TS: Tangsong Culture layer
MQ: Maqiao Culture layer
LZ: Liangzhu Cultural layer
S: Shang Dynasty layers
MJB: Majiabang Culture layer
QH: Qin-Han Culture layer
SZ: Songze Culture layer
Sections marked with shaded zones are natural layers; numbers besides the sections are the thickness of the natural layer in meter

Fig. 2 Distribution of cultural interruption and lithostratigraphical structure of some sites in the Changjiang River Delta (KONG *et al*., 1991).

resulted in expansion of surface water and extreme floods. The muddy layer below the Majiabang Culture layer in the Fuquanshan site of Qingpu can also serve as the evidence for the ground-surface water expansion during this period (Shanghai Relics Management Committee, 1990). The Neolithic sites of Majiabang and Songze Culture period (~7000–5200a B.P.) were usually found on the higher lands among the rivers and lakes (JING, 1989; WU, 1988; YU *et al*., 1999), which was beneficial for escaping from the floods. Some animal relics, like Asia Elephas, wapiti, Chinese alligator, softshelled turtle excavated from the Caoxieshan, Shuitianpan and Chenghu Lake (ZHANG *et al*., 2003), also indicate that the study region was characterized by expanded water surface and warm and humid climatic conditions.

The period of 6500–6000a B.P. was a warm and rainy period in the middle and lower reaches of the Changjiang River (Fig. 1), and also the largest-scale transgression period since the Holocene, which matched the Tianjin Trangression in the Northern China (KONG *et al*., 1991). During the Neo-Megathermal period, excessive precipitation produced rich surface flow; higher sea level, however, hindered the discharge

of flow (YANG, 1993). All these factors intensified the floods. About 2-m diluvialflood-related and alluvial sedimentary layer (brown yellowish mud layer with gravels) in the Huanshan-Chushan artificial channel can act as the evidence (ZHANG *et al*., 2003) (Fig. 2).

Fig. 1 indicates that in the late Songze Culture, a layer with a large amount of buried paleo-trees (5600–4800a B.P.) was widely distributed in the Changjiang River Delta. Previous research and field investigation indicated that this paleo-tree layer was formed under two sedimentary environments: mixed deposition of mud and paleo-trees, and mixed deposition of gravel and buried trees. This indicates two sedimentary dynamic environments: oxygen-proof environment and alluvial sedimentary environment. Guanzhou plaeo-trees can be taken as the example (the age is 4900a B.P.). The trunks, branches and roots of the paleo-trees were all preserved well, indicating a quick process of sedimentation (PU, 1991). The buried paleo-tree layers in Baohuashan, in Jurong of Jiangsu, were about 80cm in thickness (ZHANG *et al*., 2003), indicating the larger-scale and larger-range floods.

Pollen analysis results from Guoyuanlin, Tinglin, Maqiao, Fuquancun in Shanghai (Liangzhu Cultural types) (KONG *et al*., 1991) indicated that during the early Liangzhu Culture, the pollen was dominated by Polypodiaceae, *Pteris*, *Typha* and *Ceraopteris*, etc., indicating warm and humid climatic conditions (KONG *et al*., 1991). During middle Liangzhu Culture period, temperature and humidity decreased compared to the early Liangzhu Culture period, and surface water area shrank. Fig. 1 indicates that, during 5200–3800a B.P., the sea level was low, large area of land was exposed, providing unprecedented large space for the human activities, which greatly facilitated the human production activities and living activities. Moderate, dry and suitable climatic conditions in the early and middle Liangzhu Culture period, together with the shrinkage of the surface water area, widened the space for human activities, making the culture and economy flourish in the period.

In the late Liangzhu Culture, the pollen of the evergreen trees increased again. Aquatic plants grew exuberantly again and *Typha and Ceraopteris* still dominated the vegetation in the period (KONG *et al*., 1991). The climate tended to be warm and humid again. This climatic transition from cold to warm leaded to excessive precipitation and expansion of the lake surface in the Changjiang River Delta (WANG *et al*., 1996).

In the delta, there were large amounts of paleo-trees buried during the late Liangzhu Culture period. These paleo-trees sediment were mostly mixed with gravel and mud, which was an important evidence of flood function. YANG (1993) referred this flooding period as the "second Holocene deluge in China", and suggested that the dominant driving factor of this flooding period was the northward shift of the southwestern monsoon and the higher sea level. This extreme flood threw the flourished Liangzhu Culture into collapse. In most of the sites in the delta, there was usually a natural layer following the Liangzhu Culture (Fig. 2).

3.2 Correlation Between Human Activities and Sea Level Changes

Fig. 3, which is based on climatic records from natural sections and archaeological excavation reports, shows the relation between the altitude of human settlement and climatic changes in the Changjiang River Delta. Just as what mentioned above, in the study region "water" serves as the connection belt between human activities and environmental changes. The Changjiang River Delta is a low-lying plain with a large number of lakes and water systems; it is neighboring to the East China Sea. These geomorphologic characteristics make the human activities susceptible to hydrological changes (e.g. development of the rice agriculture, pole-supported building). The ancients in the Hemudu region built long-pole-supported house to shelter themselves from harsh environment like strong typhoon, rain storm and flooding, showing human adaptation to environmental changes (ZHOU and ZHENG, 2000).

Fig. 3 indicates that the flooding periods matched approximately the high-sea-level period, and during these periods people moved to the higher regions; during the low-sea-level period, people moved to the lower places. In the Changjiang River Delta, high-temperature and pluvious climatic conditions, together with sea-level changes, were responsible for the floods, and lake expansion. Higher sea level also prevented surface flow from the discharging and intensified the flooding hazards (YANG, 1993). Sea-level changes and flooding events affected the altitude of the human settlement and they are also the results of the multi-cultural interruptions.

4 CONCLUSIONS AND DISCUSSION

The Changjiang River Delta is of low-lying terrain, making the study region susceptible to the sea level changes and floods. Sea level fluctuations, water-land changes of lakes and frequent floods influenced greatly the human living styles and living altitude. Multi-

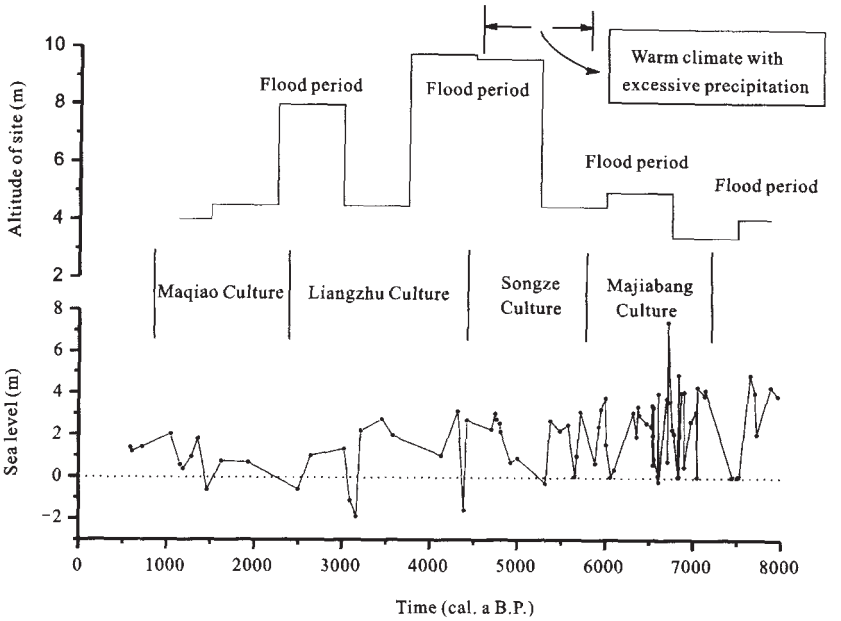


Fig. 3 Relation between altitude of human settlement and climatic changes in the Changjiang River Delta
(The sea level changes are from ZHANG *et al*., 2003)

ple-period cultural interruptions in the delta were the results of the extreme climatic events. During the Majiabang Culture and Songze Culture (7000–5200a B. P.), the climate was characterized by high temperature and high humidity. The settlement in this period was usually distributed in the high lands in the lacustrine area, indicating the human adaptation to the living environment.

Correlation between human settlement altitude and environment changes mentioned in this paper indicates that flooding periods matched roughly the high-sea-level periods, and excessive-precipitation-induced floods forced people to live on higher places; during the low-sea-level periods, people moved to the lower lands, indicating that lower sea level made land exposed, which provided wide space for human activities.

Neolithic sites in the Changjiang River Delta are classified into three categories: plain-type site, earth-mound-type site and slope-type site. These three types of sites usually occurred at the same periods, therefore, changing altitude of the human settlement may be the results of the expansion and shrinkage of the water, the sea level changes and the floods. People of Majiabang and Liangzhu Culture lived behind the shell ridges, escaping the negative influences of rising of sea level (JIANG *et al*., 1999). It should be mentioned here that climatic change was not the unique factor influencing the altitude of the human settlements. Higher altitude of some sites may be in no connections with the environmental changes. For example, Fuquanshan site, Caoxieshan site, Zhanglingshan site, Chuodun site, Sidun site, Luodun site, etc. were found on higher land, but these higher sites are related to social factors like the wealth conditions and social positions (CHEN *et al*., 1997). Scholars have different viewpoints concerning sea level changes, natural or social factors influencing human activities during the Neolithic cultural periods because of different proxy indicators used in research. Therefore, further research will be necessary for the degree and types of impacts of climatic changes on human activities in the study area at that time.

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