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RESEARCH PAPER

Holocene environmental change and archaeology, Yangtze River Valley, China: Review and prospects

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Abstract Holocene environmental change and environmental archaeology are important components of an international project studying the human-earth interaction system. This paper reviews the progress of Holocene environmental change and environmental archaeology research in the Yangtze River Valley over the last three decades, that includes the evolution of large freshwater lakes, Holocene transgression and sea-level changes, Holocene climate change and East Asian monsoon variation, relationship between the rise and fall of primitive civilizations and environmental changes, cultural interruptions and palaeoflood events, as well as relationship between the origin of agriculture and climate change. These research components are underpinned by the dating of lacustrine sediments, stalagmites and peat to establish a chronology of regional environmental and cultural evolution. Interdisciplinary and other environment proxy indicators need to be used in comparative studies of archaeological site formation and natural sedimentary environment in the upper, middle and lower reaches of the Yangtze River Valley. Modern technology such as remote sensing, molecular bioarchaeology, and virtual reality, should be integrated with currently used dating, geochemical, sedimentological, and palaeobotanical methods of analysis in environmental archaeology macro- and micro-studies, so as to provide a greater comprehensive insight into Holocene environmental and cultural interaction and change in the Yangtze River Valley area.

1. Introduction

In 2003, the International Geosphere-Biosphere Programme began the second 10-year stage (IGBP II) of investigation. This programme is one of the two new integrated studies of the Past Global Changes (PAGES) project (Alverson et al., 2003; Steffen et al., 2005; Zhu et al., 2006; Research Group of China's Earth Science Development, Geoscience Department of the CAS and Geoscience Department of the CAS, 2009). Holocene environmental change and environmental archaeology are important aspects of PAGES' research plan. Following a preliminary study of the topography and climate in the Yangshao archaeological

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excavation by Anderson in 1923, and subsequent work on Quaternary Geology by the Loess research group of Tungsheng Liu in the late 20th century (Heller and Liu, 1982; Liu, 1988; Liu et al., 1999; Liu, 2009), a solid foundation was laid for palaeoenvironmental and archaeological research. Before the 1980s, environmental archaeology mainly focused on reconstruction of the human living environment. This was followed by the advent of palaeoclimatic reconstruction as an interdisciplinary science, as represented by the environmental archaeology studies of Kunshu Zhou in Beijing and Hong Kong since 1987 (Zhou, 1989a,b), which has greatly enhanced the progress of PAGES in China.

Located in the southeast part of the Asian continent (Fig. 1), the Yangtze River Valley is important with respect to intensity variations of monsoon rainfall (Xiao et al., 2006), which has had a great impact on the rise and fall of early Chinese civilizations (Wu and Liu, 2004). The Yangtze River is the physical and cultural line dividing North and South China (Zhao and Chen, 1999), flows through a wide variety of ecosystems, and is the habitat to several endemic and endangered species (Li et al., 2007; He et al., 2010b). The climate and environment of the Yangtze River Valley are affected by three global-scale climate systems: (1) the East Asian monsoon which is associated with El Niño-Southern Oscillations (ENSO) (Zhang et al., 2007a), the Mongolian High Pressure Zone (Zhu et al., 2010), and the Inter-tropical Convergent Zone (ITCZ) (Tudhope et al., 2001); (2) the Indian monsoon which is characterized by exceptionally strong inter-hemispheric transport (An et al., 2011); (3) the westerlies which are modulated by the North Atlantic Oscillations (Visbeck, 2002). Situated at the junction of these three large-scale climatic systems, the Yangtze River Valley is important for recording and thus retrieving the Holocene global climatic sequence; whilst a large number of Neolithic age archaeological sites in the region provide excellent material for high-resolution study of man-land relationships. However, despite the importance of environmental change and environmental archaeology in the Yangtze River Valley for understanding large-scale regional Holocene climatic change and cultural evolution, the temporal and spatial Holocene palaeoenvironmental and Neolithic cultural sequences within Yangtze River Valley have not been well established. This paper synthesizes a large body of published materials since the 1980s regarding environmental change and archaeology throughout the Yangtze River Valley during the Holocene. Comparison with existing research in the Yangtze River Valley and adjacent areas, chronological controls in this study are all converted to calendar years.

2. Holocene environmental changes in the Yangtze River Valley

2.1. Evolution of large freshwater lakes

The Taihu Plain is located in the Yangtze Delta, which is adjacent to the Maoshan and Tianmu Mountains in the west and Hangzhou Bay to the south. The formation and evolution of the plain have long intrigued researchers both in China and abroad. The concerns can be summarized in four different theories of the origin of the Taihu Plain. A lagoon origin proposes that the whole Taihu Plain was a large coastal bay during the highest Holocene sea-level. During subsequent regression, residual seawater that remained in many low-lying areas gradually evolved first into lagoons and then into large freshwater lakes; Taihu Lake was the largest of these lakes (Chen et al., 1959; Pan et al., 1984). A tectonic origin infers that the ancient Taihu Lake was a tectonic lake in its early stage as the lake basin has the characteristics of a continental margin extensional rift basin (Chen, 1986; Yang et al., 2000a). A multi-origin (Yang et al., 1985) suggests that the evolution of Taihu Lake was complicated and changeable, and involved many factors including endogenic and exogenic geological processes, particularly sea-level fluctuation during the Holocene. Taihu Lake was a barrier freshwater lake with morphological and sedimentological characteristics of tectonic subsidence and marine-continental interaction. Chen and Yang (1991), and Chen et al., (1997) have argued that, with the continuous rising sea-level and evolvement of the Yangtze River delta, the Taihu Lake area became a circular depression. With the rising of ground water level, backward flow of the Sanjiang River and high rainfall, ponding over a long period of time eventually led to the formation of a giant lake. An impact origin proposes that the Taihu depression is a Holocene meteorite impact crater. Wang et al. (2009) found evidence for a meteorite

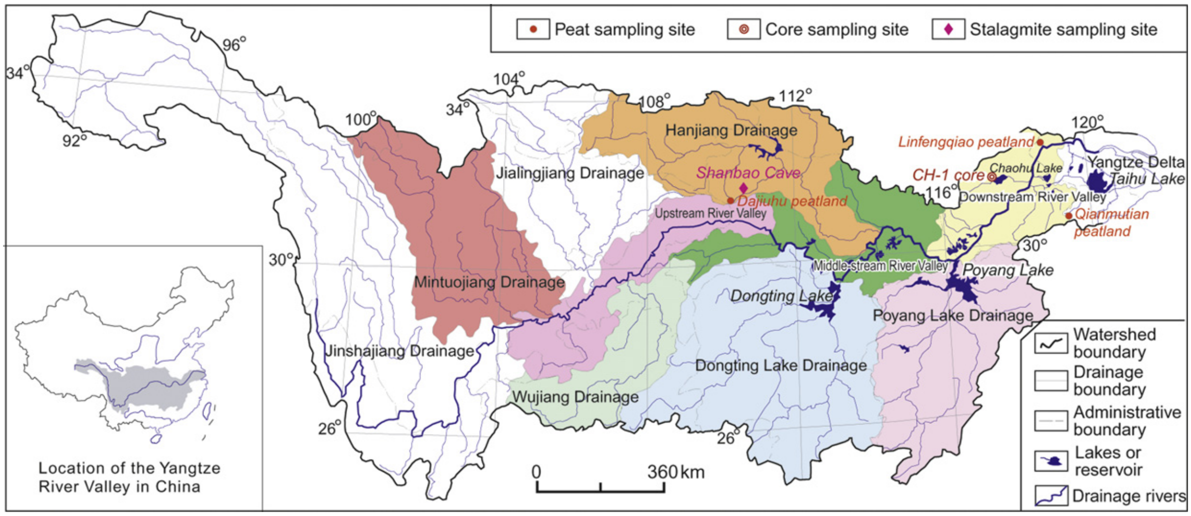


Figure 1 Drainage of the Yangtze River Valley, showing the locations of sites mentioned in the text and the distribution of large freshwater lakes.

impact origin such as shock-induced micro-features in deformed quartz in the sandstone of islands in Taihu Lake. With respect to the formation age and evolution of Taihu Lake, archaeological excavations and environmental archaeology have dated numerous Neolithic sites and a large number of palaeovertebrate skeleton fossils, at the bottom of Taihu and Dianshan Lakes at 10.0–6.0 cal. ka.B.P. (Wen, 1985; Yan and Hong, 1987; Jing, 1989; Zhang, 2007b). Hence, many scientists have concluded that there has been no transgression in the Taihu Plain area since the Holocene (Zhang, 1981; Wen, 1985; Yan and Hong, 1987; Xin and Xie, 2006). Ancient wells dating from the Neolithic to the Song Dynasty have also been discovered at the bottom of Chenghu Lake (Zhang, 1981), indicating that the Taihu Lake area has always been a low-lying plain environment alternating between lands and lakes suitable for human settlement. Excavation of large numbers of cultural relics, Neolithic sites and wells, as well as chronological data of sediment cores reveals that the formation of modern Taihu Lake was due to many factors, and that its age is less than 3.0–2.0 cal. ka.B.P. (William and Liu, 1996; Wang et al., 2001a; Zhang et al., 2005; Zhao et al., 2007; Chen et al., 2008). During the pre-Ch'in period, the Taihu Lake area was recorded as the *Zhenze* marsh in the ancient geographic book *Yugong* (Wei, 1993).

Chaohu Lake is a typical fault-controlled lake that was formed within a tectonic basin during the latest Pleistocene (Wang, 2007). The bottom sediments of the basin consist of Late Pleistocene (Q_3q) clay of the Xiashu Formation with coeval clay-rich lakeshore sediment ^{14}C dated at ca. 12.0 cal. ka.B.P. (Gao et al., 2005a). During the Holocene high sea-level, the water level of the Yangtze River rose from estuarine to upper reach so that water became ponded in the Chaohu depression (Yang et al., 2000a; Wang, 2007; Xie, 2009). Recently, Holocene environmental change of the Chaohu area has been studied in greater detail (Wang et al., 2008a,b; Wu et al., 2008; Chen et al., 2009; Xie, 2009), especially with respect to evidence from two lacustrine cores. One core (ACN core) is from the Hangbu delta plain of southwest Chaohu Lake (Shi, 2006). Sedimentology and geochemistry of the core indicate that the downstream part of Hangbu River was part of a palaeo-Chaohu Lake between 8.73 and 2.15 cal. ka.B.P. with a warm lake expansion sub-stage from 7.4 to 4.3 cal. ka.B.P., followed by a cold and dry sub-stage with lake shrinkage during 4.3–2.7 cal. ka.B.P. In contrast, the other core (CH-1) from the centre of the western Chaohu Lake (Zhang, 2007a; Wu et al., 2010) showed that there was a long warm and humid climate stage in the Chaohu Lake basin since the Holocene. From about 4.9 cal. ka.B.P., the climate changed gradually to one of drought conditions associated with continuous lake shrinkage and lowering of water level of the lake to exposure of the lake bed at around 2.17 cal. ka.B.P. Since 1.0 cal. ka.B.P., the climate was cold and dry with obvious fluctuations, and the natural environment was subjected to prolonged human influence. Based on geomorphology and remote sensing (RS) image analysis of this area, the 10 m contour above present Wusong elevation represents the maximum level of the Chaohu Lakeshore (Gao, 2006), which is also supported by archaeology (Gao et al., 2009; Wu et al., 2010). However, contraction of the lake started around 5.0 cal. ka.B.P. and was accompanied by a climatic change from warm-moist to a relatively warm-dry conditions during the Middle Holocene. The lake level rose again since 2.2 cal. ka.B.P. with a return to warm-moist conditions so that the modern Chaohu Lake was formed around 3.0–2.0 cal. ka.B.P. (Dou and Jiang, 2003; Shi, 2006; Wang, 2007; Zhang, 2007a; Xie, 2009; Wu et al., 2010).

2.2. Holocene transgression and sea-level changes

The sea-level change caused by changes in global climatic conditions is an important topic of current environmental research in the Yangtze River Valley, especially in the Yangtze Delta area. Studies of the Holocene transgression and sea-level highstand in the Yangtze Delta have focused on whether sea-level fluctuation in the Yangtze Delta was consistent with the global sea-level changes. Three patterns of Holocene sea-level changes have been proposed (Morner, 1980). One is a continuous pattern, in which sea-level rose gradually from 13.0 cal. ka.B.P. and reached its present level at about 4.0 cal. ka.B.P. However, Fairbridge (1961) argues that 6.0–4.5 cal. ka.B.P. was the interval of highest sea-level during the Holocene. The Greenland Ice Core records support this viewpoint (Houghton et al., 1990). Oxygen isotopic records indicate that 7.0–4.0 cal. ka.B.P. was the Holocene Thermal Maximum, which might have caused an accelerated melting of the Antarctic Ice Sheet, thereby leading to the Holocene sea-level highstand. Recently, using coral at Ryukyu Islands as the reliable palaeodepth indicators, Hongo and Kayanne (2010) show that there was a rapid sea-level rise between 8.0 and 6.0 cal. ka.B.P., followed by a lowering of sea-level between 6.0 and 5.0 cal. ka.B.P., implying a Mid-Holocene highstand at around 5.0 cal. ka.B.P.

Most Chinese scientists have held the view that the Holocene sea-level highstand in East China occurred at between 7.0 and 5.0 cal. ka.B.P. (Wang, 1982; Yang and Xie, 1984; Shao, 1987; Yan et al., 1993; Zhao et al., 1994; Yu et al., 1998; Chen et al., 2008; Xu et al., 2010), but it was not until the 1990s that a consensus on sea-level changes in the Yangtze Delta was reached (Table 1). However, since the middle of the 20th century, archaeological evidence for this has been contrary.

Analysis of the temporal-spatial distribution of 205 Neolithic sites and identification of marine foraminifera indicate that there was a long period of absence of Neolithic sites during the Early Holocene in the Yangtze Delta, and that the area has not been colonized until 7.0 cal. ka.B.P., corresponding to the beginning of the Majiabang Culture. Furthermore, since 7.0 cal. ka.B.P., foraminifera are not present in Neolithic cultural layers at the Maqiao site east of the Chenier Ridges in Shanghai, that suggests a widespread transgression between 10.0 and 7.0 cal. ka.B.P. Neolithic sites are densely distributed in the area east to the ancient coastline of Maoshan Mountain, where rice cultivation began, as evidenced, for example, by a radiocarbon age of 6275 ± 205 cal. ka.B.P. of fossil rice grains excavated from the base layer of Caoxieshan Site in Suzhou, and are also distributed widely in the Yangtze Delta (Zhu et al., 2003). Supporting evidence is the identification of foraminifera, plant debris and seed fossils, as well as four ^{14}C dated samples at the Luotuodun site in Yixing, Jiangsu, which demonstrate that between 7500 and 5400 BC, i.e. before the emergence of the Majiabang Culture, this site and nearby regions (the western part of the Taihu Plain) had ever experienced marine transgression (Li et al., 2009). A simulation model for the geomorphic evolution of the Yangtze Delta (Xin and Xie, 2006) also shows that Holocene coastline evolution can be divided into three stages by assuming 7.0 cal. ka.B.P. and 3.0 cal. ka.B.P. as reference ages: an early rapid transgression stage, a middle repeated transgression-regression stage, and a late

Table 1 Selected examples of Holocene sea-level highstand studies of China.

References	Holocene sea-level highstand (cal. ka.B.P.)	Description
Wang (1982)	5, 3.5, 2.6, 1.1–0.7	Amplitude of these fluctuations varies from 3 to 4 m.
Yang and Xie (1984)	7–6.5	Sea-level rose rapidly and reached the current level along with the maximum transgression.
Shao (1987)	7.5–6.4	Coastline shifted westward to the line along Wangxian-Pangu-Zhulin-Qingchun-Tangwang-Shetou-Xiangyang to the east of Mt. Maoshan.
Xu et al. (1987)	9.0–6.8	High temperature period occurred in the Late Holocene optimum, and was not consistent with Holocene sea-level highstand.
Yan et al. (1993)	6.5–5.5	A front delta-shallow sea landscape developed in the northern Yangtze Delta.
Zhao et al. (1994)	7.5–4	Sea-level was 2–3 m higher than that present.
Stanley and Chen (1996)	8.0–7.5	Changes of sea-level and climate from Early to Mid-Holocene initiated a fertile delta plain.
William and Liu (1996)	11.0–6.5	From boreholes in Taihu Lake, marine foraminifera were not present after 6.5 ka.B.P., but some freshwater algae species continued to exist.
Yu et al. (1998)	7.2–6.1	Area was in a shallow sea environment.

regression stage. The core region of the Taihu Lake plain remained emergent throughout the Holocene. This conclusion has been tested by verification of archaeological site locations of different cultural periods and 73 tree-ring corrected ^{14}C ages. The evidence is not consistent with a Mid-Holocene high sea-level between 7.0 and 5.0 cal. ka.B.P. in the area of the Yangtze Delta, and implies that the Holocene climate optimum might not correspond to the high sea-level in the Yangtze Delta.

2.3. Holocene climate change and East Asian monsoon variation

Climate instability since late-glacial, especially since the Holocene, is the research emphasis of the Climate Variability and Predictability Program (CLIVA) and PAGES (Alley et al., 2003). In recent years, knowledge of climate changes in the area of the Yangtze River Valley since the Holocene has been obtained. However, because of their regional characteristics, a lack of understanding of whether some important climate events and phases in this area are the result of with global impacts, and responses to variations in the East Asian monsoon, important questions of Holocene environmental change in the Yangtze River Valley remain.

In the late 1990s, information on Holocene climate change was obtained from various terrestrial sediments in parts of the Yangtze River Valley, and a preliminary study on the relations of Holocene climate change and East Asian monsoon variation was made. Representative of these studies is a high-resolution and multi-proxy environmental change study of Gucheng Lake, Jiangsu, in the past 15 cal. ka.B.P. and its relation to palaeomonsoon conditions (Wang et al., 1996; Yang et al., 1996). This work found that the wet monsoon dominated regional climate conditions from 10.5 to 6.4 cal. ka.B.P., after which monsoon precipitation decreased. Later studies (Wang et al., 2005a,b,c; Shao et al., 2006; Xiao et al., 2007a,b; Wu et al., 2008; Chen et al., 2009; Ma et al., 2009) focussing on different areas, such as tributary river valleys at all levels, or fringe areas of the Yangtze River Valley, have used continuous high-resolution material, e.g. lake sediments, stalagmites, peat, to establish a sequence of environmental change and provide evidence of abrupt climatic events.

Lake sediments have recently become a focus of study in the PAGES programme because they can reliably document a high-resolution record of continuous climate and environment change (Shen et al., 2005a,b; Grygar et al., 2006; Wohlfarth et al., 2007; Xiao et al., 2007b; Yu et al., 2010). In the Taihu depression, records of sporopollen from the DGY core (Zhao et al., 2007) and other borehole data (Chen, 1991; Sun and Huang, 1993; Li and Wang, 1998; Wang et al., 2001a; Zhang et al., 2004a,b,c; Chen et al., 2005) have revealed climate, vegetation and geomorphological evolution since 8.0 cal. ka.B.P. Similar studies in the Chaohu Lake Basin also indicate a compatible variation of the Holocene environment. Pollen records from the CH-1 and ACN cores (Wang et al., 2008a; Wu et al., 2008; Chen et al., 2009; Wu et al., 2010) suggest that the Holocene Optimum occurred at 8.0–5.0 cal. ka.B.P. in the Chaohu Lake basin. Around 5.0 cal. ka.B.P., the warm-moist climate begin to change into relatively warm-dry conditions, along with decreasing temperature and humidity during the Middle Holocene.

Compared to other terrestrial sediments, peat has a fast deposition rate, represents a stable sedimentary environment, a long-time scale and broadly appropriate climate proxy indicator (Chanbers and Charman, 2004). Hence, peat provides a good record of climate and environment change (Tao et al., 1997; Blackford, 2000; Zhong et al., 2004; Zhou et al., 2004; Xu et al., 2006; Xiao et al., 2007a), especially peat in alpine mountain basins, which is less affected by human activity (He et al., 2003). Climate changes in East China since the Late Glacial inferred from high-resolution mountain peat humification records have recently been determined (Yin et al., 2006; Ma et al., 2009). Speleothems provide another record of climatic and environmental changes. With the development of the TIMS U-series dating method, many results of the palaeoclimate and changes of the East Asian monsoon have been reported (Wang et al., 2001b; Tan et al., 2004; Yuan et al., 2004; Wang et al., 2005c; Wang et al., 2008c; Zhang et al., 2008). A stalagmite from Qixing Cave in Guizhou Province, southwest Yangtze River Valley, has been TIMS U-series dated and its oxygen-isotope composition determined (Cai et al., 2001). The results have been used to reconstruct climate changes over the last 7.7 cal. ka.B.P. Another high-resolution oxygen-isotope record from a Th-U-dated stalagmite from Shanbao Cave in Shennongjia, reflects significant variations of monsoon precipitation from 11.5 to 2.1 cal. ka.B.P. in the middle Yangtze River area (Shao et al., 2006). The long-term trend of the Shanbao Cave stalagmite record appears to follow summer insolation at 33°N latitude. Moreover, an abrupt decrease in monsoon precipitation around 4.3 cal. ka.B.P. is synchronous with the collapse of Neolithic culture in Central China (Wu and Liu, 2004).

The temporal-spatial pattern of regional climate and environment in the Yangtze River Valley is thought to be controlled by the dual influence of the East Asian monsoon and the Southwest monsoon. However, from previous research (Wang et al., 1996, 2008b; Yang et al., 1996; Cai et al., 2001; Shao et al., 2006; Yin et al., 2006; Zhao et al., 2007; Overpeck and Cole, 2008; Ma et al., 2009; Wu et al., 2010), it could also be concluded that Holocene climate change occurred in response to solar radiation changes that affected the whole Yangtze River Valley (Fig. 2). Nevertheless, the summer monsoon pattern revealed by stalagmite, lacustrine sediments, peat and other high-resolution records is in accordance in and around the Yangtze River Valley (Dykoski et al., 2005; Wang et al., 2005c, 2008b,c; Shao et al., 2006; Ma et al., 2008, 2009; Dong et al., 2010; Wu et al., 2010; Zhu et al., 2010). The changing mode of climate and monsoon in the Asian monsoon region was very strong during the Early Holocene, and declined towards dry climate conditions of the Middle−Late Holocene. Further analysis indicates that tropical/subtropical monsoons respond dominantly to summer insolation changes in the Northern Hemisphere on orbital timescales (Kutzbach, 1981; Wang et al., 2008c).

3. Holocene environmental archaeology in the Yangtze River Valley

3.1. Relationship between the rise and fall of early civilizations and environmental changes

Research on the relationship between the rise and fall of early civilizations and environmental changes have mainly concentrated on the Neolithic and younger age in the Yangtze River Valley, especially with respect to the timing of the formation and early development of Chinese civilization between 3500 and 1500 BC (Department of Social Development, Ministry of Science and Technology of the People's Republic of China and Department of Museum and Social Cultural Heritage, State Administration of Cultural Heritage, 2009). Neolithic cultural sequences have been established in the upper, middle and lower reaches of the Yangtze River Valley (Fig. 3). Their names and chronological divisions are as follows:

(1) Neolithic sequence in the Upper Yangtze River. ***Chengdu Plain***: Baodun Culture (4.8−4.0 cal. ka.B.P.). ***Three Gorges Area***: Yuxi Lower Layer Culture (7.6−6.4 cal. ka.B.P.) → Yuxi Upper Layer Culture (6.4−5.8 cal. ka.B.P.) → Yuxiping Culture (5.5−4.8 cal. ka.B.P.) → Zhongba Culture (5.0−4.0 cal. ka.B.P.). ***Yunnan Province***: Baiyangcun Culture (5.0−3.7 cal. ka.B.P.).

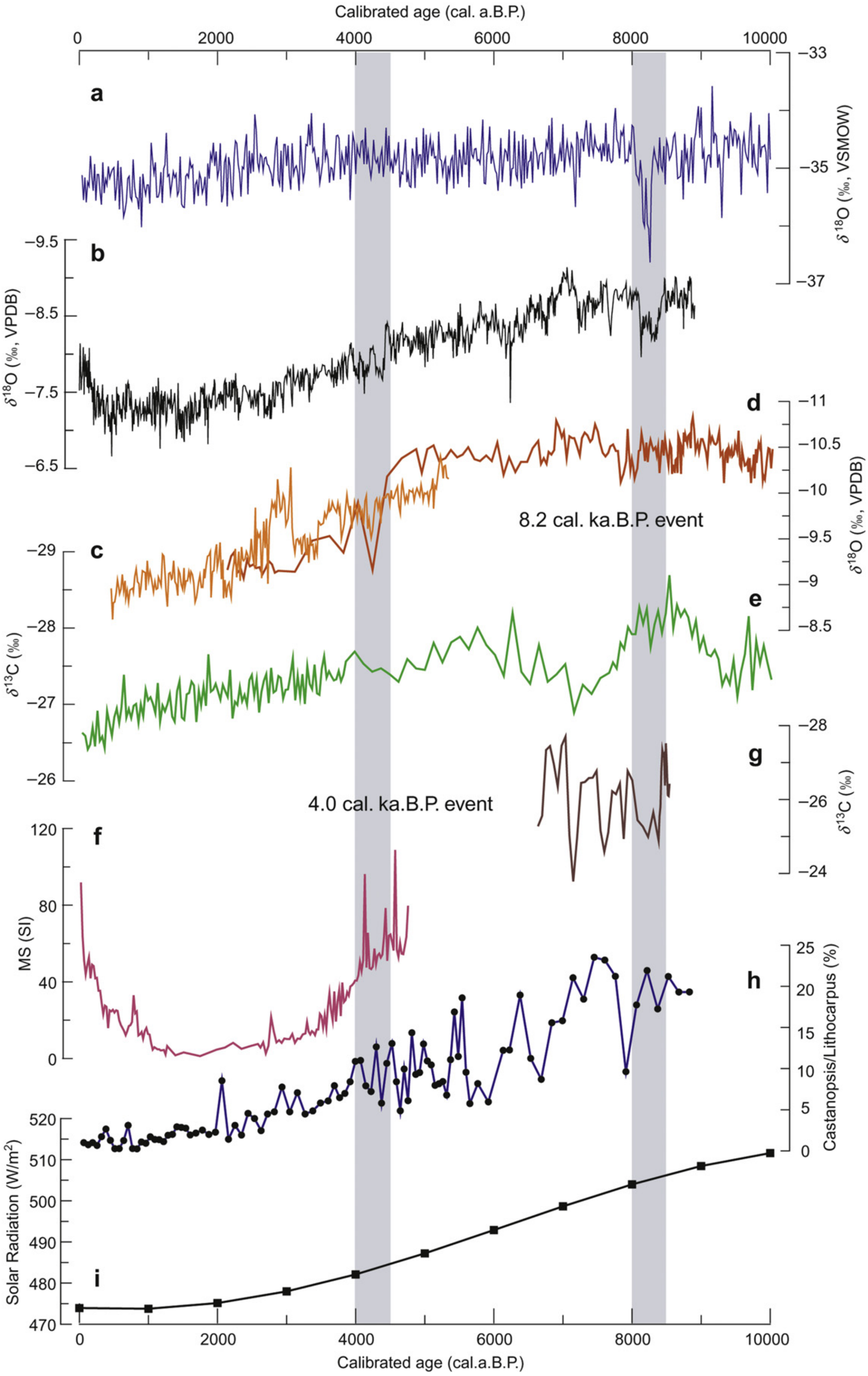
(2) Neolithic sequence in the Middle Yangtze River. ***Two-Lake Plain***: Pengtoushan Culture (8.5−7.5 cal. ka.B.P.) → Chengbeixi Culture (7.6−7.3 cal. ka.B.P.) → Zaoshi Lower Layer Culture (7.5−7.0 cal. ka.B.P.) → Daxi Culture (6.4−5.3 cal. ka.B.P.) → Qujialing Culture (5.3−4.6 cal. ka.B.P.) → Shijiahe Culture (4.6−3.9 cal. ka.B.P.). ***Jiangxi Province***: Shanbei Culture (5.0−4.5 cal. ka.B.P.) → Zhuweicheng Middle Layer Culture (4.5−4.0 cal. ka.B.P.).

(3) Neolithic sequence in the Lower Yangtze River. ***Southwestern Anhui Province***: Huangshanzui Culture (6.1−5.5 cal. ka.B.P.) → Xuejiagang Culture (5.5−4.6 cal. ka.B.P.) → Zhangsidun Culture (4.6−4.0 cal. ka.B.P.). ***Chaohu Plain***: Gugeng Lower Layer Culture (6.0 cal. ka.B.P.) → Lingjiatan Culture (5.6−5.3 cal. ka.B.P.) → Gugeng Upper Layer Culture (4.6−4.0 cal. ka.B.P.). ***Ningzhen Area***: Dingshadi Early Culture (7.0 cal. ka.B.P.) → Beiyinyangying Culture (6.0−5.0 cal. ka.B.P.). ***Yangtze River Delta***: Majiabang (7.0−5.9 cal. ka.B.P.) → Songze Culture (5.9−5.3 cal. ka.B.P.) → Liangzhu Culture (5.3−4.2 cal. ka.B.P.) → Guangfulin Culture (4.2−3.8 cal. ka.B.P.).

The nomenclature and chronological division of the Neolithic cultural sequence show significant differences between the upper, middle and lower reaches of the Yangtze River. Why did the earlier Neolithic culture appear in the middle reaches of the Yangtze River Valley? And why the archaeological site before 7.0 cal. ka.B.P. have not yet been found in the lower reaches of the Yangtze River Valley? Zhu (2005) consider that the answers to these questions are closely related to different geographical environments. In the upper reaches of the Yangtze River, human living space is limited and the environment more adverse than in the middle and lower reaches of the river. However, in the middle reaches of the Yangtze River, there are many plains and lakes suitable for the development of farming and human civilization; while the lower reaches of the Yangtze River, despite the presence of many broad plains, was greatly influenced by natural disasters, such as flooding, marine transgression, storm tides, and so on. The relationship between the rise and fall of early civilizations and environmental changes in the Yangtze River Valley can be explored from the following three aspects.

3.1.1. Influence of catastrophic events on the development of early civilizations

Environmental catastrophic events include but are not limited to abrupt climate events, extreme flood events, larger volcanic eruptions and earthquakes, and so on. With confirmation of abrupt Holocene climate changes recorded in the Greenland ice cores and North Atlantic deep sea cores (Dansgaard et al., 1993; Grootes et al., 1993; O'Brien et al., 1995; Bond et al., 1997), the influence of abrupt climate events on early civilizations have received wide attention. Rapid changes in climate could lead to interruptions in the development of early civilizations. Recently, many studies have focused on the collapse of Neolithic cultures in the area of the Central China Plain including the Yangtze River Valley (Yu et al., 2000; Wu and Liu, 2004; Yasuda et al., 2004; Shi et al., 2008); and these studies have demonstrated the importance of variations of the East Asian monsoon and climatic deterioration at 4.0 cal. ka.B.P. Extreme flood events are another important factor that has significantly influenced the decline of early Chinese civilizations. Recent work on the historical flood record and Holocene sedimentological evidence of extreme flood events suggest a link with the demise of many early civilizations in the Yangtze River Valley (Zhu et al., 1997a,b; Yu et al., 1999; Zhu et al., 2002; Shen et al., 2004; Wang et al., 2005a,b; Zhu et al., 2005a,b; Shi et al., 2010). From this, it would appear that


Calibrated age (cal. a.B.P.)
0
2000
4000
6000
8000
10000
a
−33
−35
−37
δ^{18}O (‰, VSMOW)
b
−9.5
−8.5
−7.5
−6.5
δ^{18}O (‰, VPDB)
d
−11
−10.5
−10
−9.5
−9
−8.5
δ^{18}O (‰, VPDB)
8.2 cal. ka.B.P. event
c
−29
−28
−27
−26
δ^{13}C (‰)
e
g
−28
−26
−24
δ^{13}C (‰)
4.0 cal. ka.B.P. event
f
120
80
40
0
MS (SI)
h
25
20
15
10
5
0
Castanopsis/Lithocarpus (%)
520
510
500
490
480
470
Solar Radiation (W/m^2)
i
0
2000
4000
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8000
10000
Calibrated age (cal.a.B.P.)

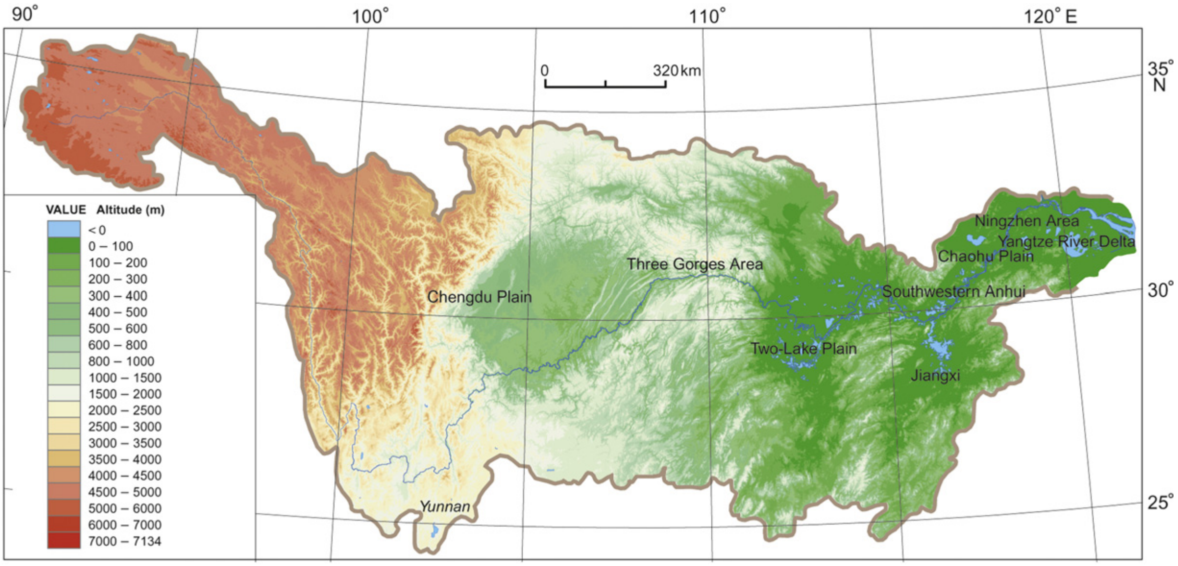

Figure 3 Map showing the topographical features and the main Neolithic cultural areas in the Yangtze River Valley.

environmental catastrophic events have caused great changes in early cultural evolution because the capacity of human response to such events was not well developed or organized.

3.1.2. Adjustment and response of ancient humans to environmental change

Although the capacity of human productivity and response must have been relatively low in the Neolithic, the population did respond to environmental changes in a passive manner. In the Yangtze River Valley, ancient humans mostly lived by the river and higher up on the second or third terraces bordering the river. Thus, the distribution of archaeological sites is affected to a great extent by changes of river level (Zhu et al., 2003; Zhang et al., 2004a,b,c; Chen, 2005a,b; Zhang et al., 2005; Zhu et al., 2007; Zheng et al., 2008; Wu et al., 2010). In the Yangtze Delta, analysis of altitude change of Neolithic cultural sites combined with the ^{14}C dating of buried palaeo-trees and peat have demonstrated that the elevation of human living places was closely related to the rise and fall of water level (Zhu et al., 2003; Zhang et al., 2004a,b,c; Zhang et al., 2005). In the middle-lower Yangtze Plain, the distribution of human sites was closely related to the changes in rivers and lakes, especially the frequent channel shifting of the Yangtze River and lake level fluctuations (Chen, 2005a,b; Zhu et al., 2007; Wu et al., 2010) and therefore stable land areas were important for both human survival and cultural development. However, it is possible that some archaeological sites have been buried by shifts in the river channel shifts or flood deposits (Cui et al., 2005). Natural processes dominated the timing and development of early civilization along the Yangtze River valley and delta; ancient humans kept adapting to nature and adjusting their survival strategies, especially through migration.

3.1.3. Influence of early human activity on the environment

One important direction of Holocene environmental change is how to distinguish anthropogenic or nature-induced changes. Chinese researchers have mainly focused on attempting to distinguish human-induced changes from environmental factors (Atahan et al., 2008; Shu et al., 2010; Wang et al., 2010a,b). Different environmental proxies have been analyzed and compared for reflecting the intensity of past human activity and its impact on the ecosystem (Gao et al., 2005a,b; Fan et al., 2006; Xie et al., 2006; Zhu et al., 2008a,b; Wu et al., 2010; Tian et al., 2011). Changes in the amount of erosion load and precipitation of specific watersheds can be reconstructed from the magnetism of sediments, thereby indirectly used to reflect human activity and changes in the East Asian monsoon (Zhang et al., 2007b). Pollen and charcoal concentration are the most commonly used biological indicators for elucidating the history of human activity in terms of deforestation and slash-and-burn cultivation (Atahan et al., 2007; Wang et al., 2008a; Wu et al., 2008). These activities generally result in a rapid change in vegetation from a mixed forest of deciduous broad-leaved and evergreen broad-leaved trees to grassland dominated by Gramineae

Figure 2 Contrast of environmental proxies of high-resolution records in the Yangtze River Valley. a: Holocene $\delta^{18}O$ records with mean resolution rate of 20 year from the Greenland ice sheet (Vinther et al., 2009); b: $\delta^{18}O$ records with mean distinguished rate of 5 year from stalagmite DA of Dongge Cave in Guizhou Province (Wang et al., 2005c); c: $\delta^{18}O$ records of stalagmite SB26 from Shanbao Cave in Shennongjia Mountains (Wang et al., 2008c; Dong et al., 2010); d: $\delta^{18}O$ records of stalagmite SB10 from Shanbao Cave in Shennongjia Mountains (Shao et al., 2006; Wang et al., 2008c); e: $\delta^{13}C$ records of Dajiuhu peat in Shennongjia Mountains (Ma et al., 2008); f: Magnetic susceptibility records of Qianmutian peat in Tianmu Mountains (Zheng, 2005); g: $\delta^{13}C$ records of Linfengqiao peat in Nanjing (Zheng et al., 2006); h: pollen percentage of *Castanopsis*/*Lithocarpus* from CH-1 core sediment in Chaohu Lake (Wang et al., 2008b; Wu et al., 2008); i: summer solar radiation changes since Holocene at 30°N (Berger and Loutre, 1991). The grey strips represent two abrupt climate events since Holocene.

(Wu et al., 2010). Human activity also has a marked effect on sediment geochemistry as a result of arable farming, stone wall building and mortaring, deposition of domestic garbage and salt production (Li et al., 2008; Zhu et al., 2008a). Human activities are a sustainable long-term factor that superimposes on natural factors, even though the influence may not be obvious during the time of early civilization, but the effects gradually accumulate to eventually reflect the evolution of such of early civilizations.

3.2. Cultural interruptions and palaeoflood events

As a general rule, if there are no significant changes to the environment around an archaeological site, cultural layers usually exist in undisturbed continuous horizons. However, evidence of cultural interruptions is widespread at many archaeological sites of the Yangtze River Valley (Wu, 1988; Zhu et al., 1996). Excavation has uncovered many unidentified Neolithic cultural interruption features, e.g. natural fine sand or mud, peat and bog-iron layers, the absence of cultural relics between two cultural layers (Zhu et al., 2000; Zhu et al., 2006). A pioneering study carried out at the Maqiao site, Shanghai (Zhu et al., 1996). However, more studies relied almost exclusively on historical textual evidence at that time (Lin, 2003; Cao, 2004; Chen, 2005b). Over the last 15 year, important advances have been made in geo-analysis techniques (Zhu et al., 1996; Zhu et al., 1998; Xie and Jiang, 2001; Zhang et al., 2002a,b,c; Zhang et al., 2004a,b,c; Zhang and Zhu, 2007). Therefore, more reliable results have been able to relate cultural interruptions to palaeoflood events and marine transgression (Zhu, 2005; Chen, 2008).

Sedimentological and geomorphological evidences indicate that floods have occurred throughout the Holocene, and historical floods have been observed and documented (Kochel and Baker, 1982; Baker, 2008). Slack-water deposits are considered to be the best evidence of a flood event. According to Kochel and Baker (1982), slack-water deposits are formed when the flood is at its lowest level. If a flood deposit site does not experience subsequent erosion, the later slack-water deposits would overlie the deposit of the previous event so that a somewhat bigger and longer flooding record might be preserved (Zhu et al., 2005a). Therefore, identifying single event palaeoflood deposits is the key to distinguishing separate palaeoflood events. As early as the 1990s, scholars have studied the features of palaeoflood deposits in the middle reaches of the Yellow River as well as the features of slack-water deposits by comparing grain-size and sediment texture of the 1984 flood event (Yang and Xie, 1997; Yang et al., 2000b). Subsequently, the deposits of at least five Holocene flood events were identified on the north bank of the Yangtze River in the Nanjing area using ^{14}C dating, buried palaeo-trees and sediment analysis (Zhu et al., 1997b; Yu et al., 2000; Yu et al., 2003; Zhu et al., 2003). Recent studies identifying palaeoflood slack-water deposits include those of Ge et al. (2004), Zhu et al. (2005a), Bai et al. (2008), Zhu et al. (2008a,b), and Zhang et al. (2009b). Representative achievement is the identification of palaeoflood deposits at the Zhongba site in the Three Gorges reservoir region of the Yangtze River (Zhu et al., 2005a), of which archaeological strata contain almost all the cultural layers over the past 5000 years in West China (Fig. 4). Detailed analyses including AMS ^{14}C dating, grain-size, component and morphology of heavy minerals, micro-morphology of zircon, Rb/Sr ratios, magnetic susceptibility and total organic carbon (TOC), were conducted and integrated to identify palaeoflood sediments at this site.

Other advances have been made in the identification of palaeofloods and their possible impact on early culture development in the Yangtze River Valley (Zhu et al., 1996; Yu et al., 2000; Shen et al., 2004; Zhang et al., 2008; Huang et al., 2009; Wu et al., 2009). These relate with respect to riverbed evolution that would greatly influence the distribution of archaeological sites, restrict human activity and the development of ancient culture (Zhang and Zhu, 2008), and the rivers response to climatic change. Many palaeoflood studies have documented the sensitivity of floods to climatic conditions (Zhang et al., 2002a,b,c; He et al., 2004; Zhang et al., 2007a,c; Jiang et al., 2008; Ge, 2009; Shen et al., 2010), and show that large floods often cluster in certain periods. This phenomenon was probably influenced by long-term trends in several physical processes, such as atmospheric circulation, soil moisture storage and high intermittency of precipitation (Fraedrich and Zhu, 2009; Cao et al., 2011). Such studies clarify hydrological response to climatic changes in the Yangtze River Valley.

In summary, palaeoflood research helps elucidate the history of regional palaeoclimate changes, reconstructs the palaeoflood sequence, and enables analyses of the flood cycle, all of which can provide important evidence for predicting climatic and environmental changes in the Yangtze River Valley. Such studies can also extend the time range of palaeoflood textual research to avoid the drawbacks of relying on extending modern flood frequency data, thus enabling the exploration of new approaches for research into both past and future flood frequency.

3.3. Relationship between the origin of early agriculture and climatic environments

The Holocene is an important evolutionary phase in the history of global climate. During this time mankind entered the Neolithic Age that evolved into modern civilization. Human cultures show a nonlinear evolutionary trend in the Holocene. The origin of agriculture, the invention of pottery and the using of sophisticated stone tools are the three most important characteristics of the Neolithic Age, and of these the origin of agriculture represents the core that has been referred to as the Neolithic Revolution (Childe, 1958). Over the past 30 years, many researchers have studied the origin of agriculture, mainly in relation to the origin of crop cultivation and the rise of primitive agriculture (Liu, 2010). Three main development stages of early agriculture have been recognized in the Yangtze River Valley (Wang et al., 2010a,b); an initial stage prior to 8000 BC, a developing stage between 8000 and 5000 BC, and maturating stage since 5000 BC (Fig. 5). However, environmental archaeologists generally pay more attention to the significance of climatic-environmental factors and their relationship to the origin of early agriculture.

The middle and lower reaches of the Yangtze River have become one of the most important areas in tracing the origin of early rice farming, as well as its relationship with climate conditions (Wang et al., 2010a,b; Yi et al., 2010). By analyzing animal skeletons and sporopollen from the Yuchanyan, Xianrendong and Diaotonghuan sites, it has been shown that warming climate to the Holocene Maximum that followed the last glaciations was the major factor that allowed the wild rice to spread northward, and with it an increasing population and the development of an early rice agriculture (Tang, 2004; Li et al., 2010; Wang et al., 2010a,b). In recent years, international collaboration on the study of early rice farming in China have resulted in new ideas (Li, 2007), while improvements in archaeobotany and dating

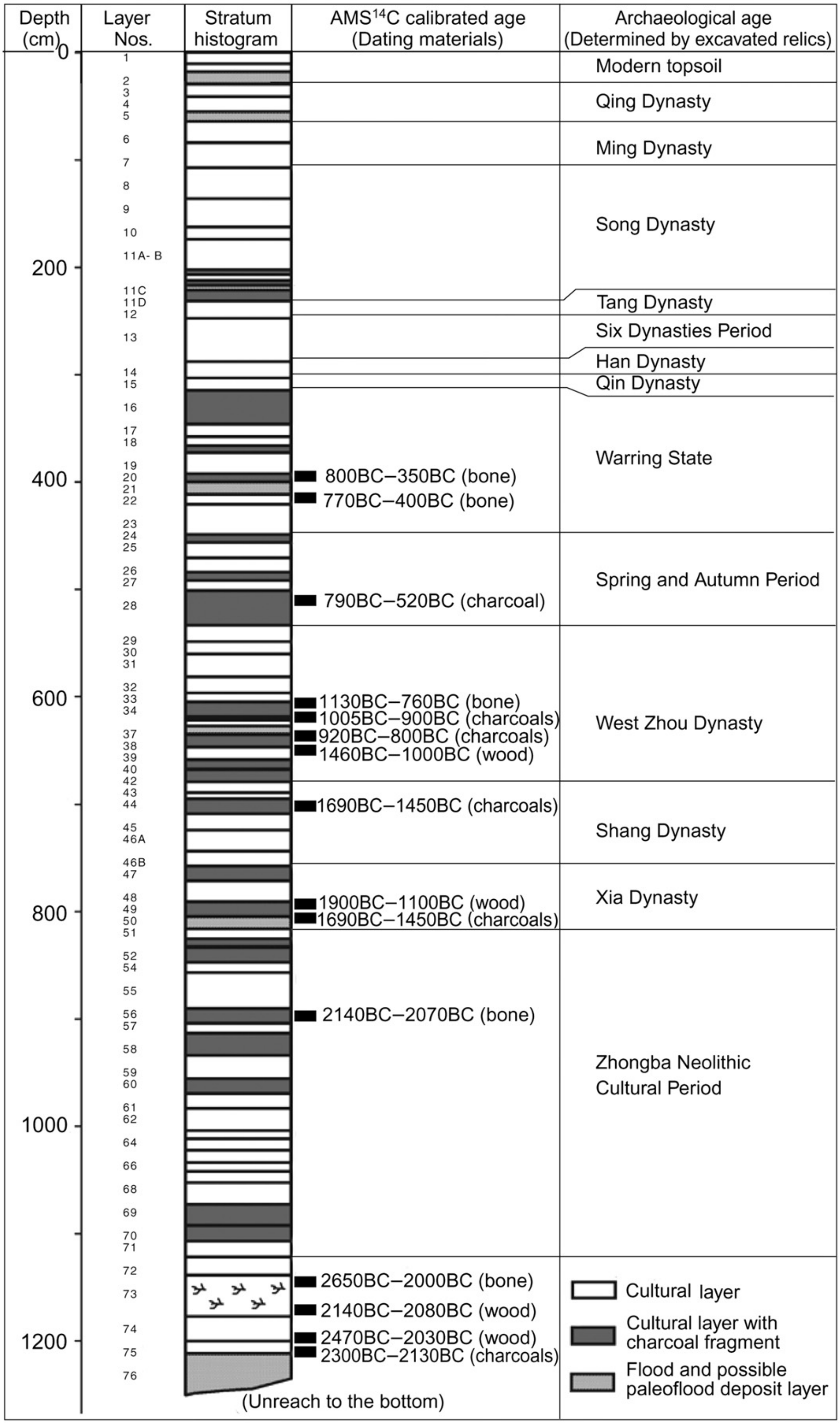

Figure 4 Flood slack-water deposit stratigraphy at Zhongba Site on the Three Gorges reservoir region of the Yangtze River Valley (Zhu et al., 2005a). The graphs are redrawn from the original publications.

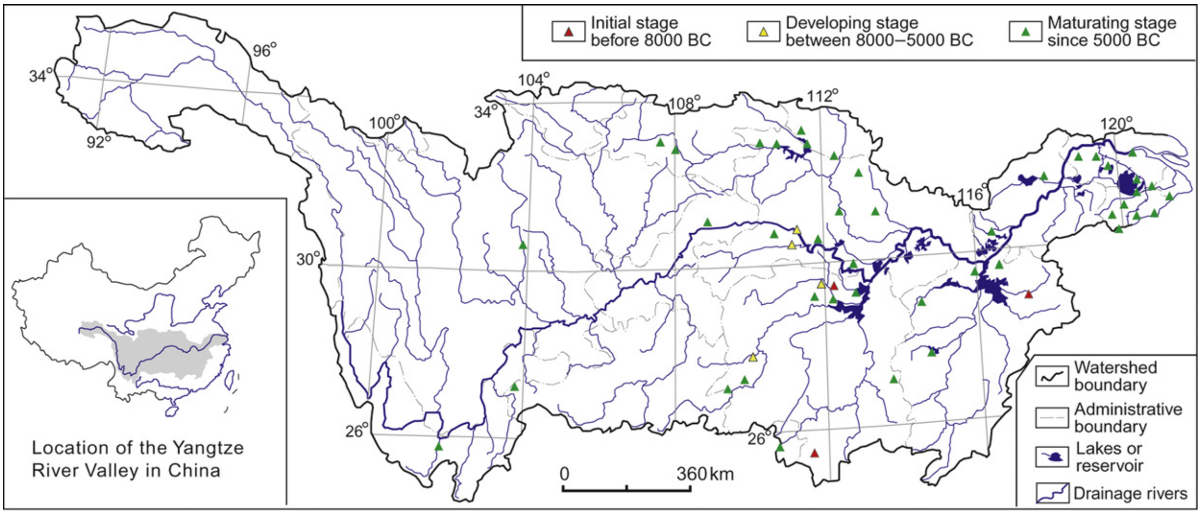

Figure 5 Map showing location of Neolithic sites with rice remains in the Yangtze River Valley.

techniques have greatly contributed to understanding the origin of early rice agriculture (Liu et al., 2008). Phytolith evidence of rice (*Oryza sativa*) domestication has been found at the Xianrendong and Diaotonghuan sites, Jiangxi Province, with ^{14}C dating of an upper occupation layer of between 13,000 and 7000 BC (Zhao and Piperno, 2000; Peng and Zhou, 2004). A few rice hulls were also excavated at the Yuchanyan site, Hunan Province, and have been ^{14}C dated at ca. 14,000 BC (Boaretto et al., 2009). Elsewhere, fossil rice phytoliths have been identified from a late-glacial to Holocene sequence of epicontinental sediments in the East China Sea that were probably transported by the Yangtze River from its middle and lower reaches (Lu et al., 2002). Rice phytoliths first appear at about 13,900 cal. ka.B.P.; they disappeared between 13,000 and 10,000 cal. ka.B.P., implying that they represent the earliest domesticated cereal crops so far reported worldwide. Based on these findings, two different viewpoints have emerged concerning the relationship between the origin of early rice farming and its environmental background (Zhang and Kong, 2007). One view argues that a cold climate and limited food supplies stimulated the beginning of original agriculture and wild rice breeding during the Late Glacial, when wild rice was transformed into cultivated rice. The other view is that the warm interstadial stages during the Late Glacial prompted the origin of early rice agriculture. So far is difficult to determine which idea is more likely to have been the case. On a 10,000-year scale, rice remains of the Yangtze River Valley could have appeared in the Late Glacial, while on the millennium scale, rice agriculture began during one of the warm phases of the Late Glacial. Radiocarbon ages of rice found in cave sites have the carbon reservoir effect in the karst areas of South China, so that more precise dating and calibration are essential in future research on the question of the date of origin of cultivated rice. And obviously, people who lived in these cave sites were still mainly hunter-gatherers, lacking agriculture tools, and with more primitive social structures.

After experiencing an initial stage of development, early agriculture entered a maturating stage, i.e. the rise of primitive agriculture, when group effort made irrigation and transplanting possible and fine agricultural production tools were brought into use (Cowan and Watson, 2006). Communications and combinations occurred between different farming systems. Rice farming was already widespread in the middle and lower reaches of the Yangtze River Valley during mid-Neolithic time (Zheng et al., 2000; Tang, 2004; Yang et al., 2006; Liu, 2010). The Holocene megathermal humid subtropical climate is regarded as the major factor contributing to the development of a Neolithic rice agriculture-based economy in the area, whilst an increasing density of population and land use greatly promoted this middle-stage economy (Stanley and Chen, 1996). Early evidence of this agricultural stage comes mainly from the Yangtze River Delta where, after widespread transgression before 7.0 cal. ka.B.P. (Zhu et al., 2003), rice cultivation began from the initiation of the Majiabang culture (Wang et al., 2010a,b). Two irrigation systems were created water wells and ponds (Shen et al., 2003). The structure of early Majiabang culture paddy fields at the Caoxieshan site reflects an evolutionary process from natural planting to an early stage of cultivation (Zou et al., 2000; Ding, 2004). The Songze cultural period marked the transition from Si (an ancient tillage form) agriculture to plough agriculture (Cao and Wang, 2005). The plough-shaped device invented in the late Songze period was used on a large scale. The circular depression with Taihu Lake at its centre was developed since 5.5 cal. ka.B.P. and provided a more extensive area for human habitation and agriculture (Sun and Wu, 1989; Zhao et al., 2007). Rice farming became more robust during the period of the Liangzhu Culture as indicated by a large amount of rice remains, along with more diversified tools. In addition to the plough-shaped device, there was a complete tool kit supporting agricultural production in the Liangzhu Culture, such as stone shovels and stone hoes for soil preparation, stone sickles or half-moon knives for harvesting, and other tools for dehusting rice. After the Liangzhu Culture had developed an advanced form of rice farming (Zou et al., 2000), its civilization collapsed at about 4.2 cal. ka.B.P. Low sea-level, abnormal climate and increased frequently of floods and droughts between 4.3 and 3.8 cal. ka.B.P. might have major factors in affecting early rice farming and the decline and fall of the Liangzhu Culture (Shi et al., 2008). The complicated relationship between the collapse of early agriculture civilization and changing climate is a topic meriting further intense study (Li et al., 2010).

4. Discussion

4.1. Prospects for research

(1) Dating of lacustrine sediments, stalagmites and peat to determine a high-resolution environmental chronology is an important research direction of Holocene environmental change in the Yangtze River Valley. At present, academia disputes greatly on the dating method of lacustrine sediments and peat. This situation in the Yangtze River Valley is no exception, such as the radiocarbon dating of Chaohu Lake sediments (Zhang, 2007a), Dajiuhu peat and Qianmutian peat (Ma et al., 2009), etc. It is already convinced that dating results are different on different components. Moreover, lacustrine sediments and peat may have "Carbon reservoir effect" and the age of mixture may be older for several hundreds years, so dating by AMS technology on terrestrial plant remnants is better than bulk sediments (Zhou et al., 2002). Some new radiocarbon calibrated methods of lacustrine sediments and peat have also been proposed recently (Zhou et al., 2006; Yu et al., 2007a,b, 2010). These new achievements should be applied widely in the Yangtze River Valley area.

(2) Quantitative study of regional environmental evolution. This research would be strengthened by improving temporal-spatial resolution. This provides theoretical support for future global change; and also improves both temporal and spatial resolutions of regional environmental archaeological research. For example, based on the study of 121 surface spore-pollen samples from Shennongjia and a 30 year meteorological data base from 7 meteorological stations around Dajiuhu, Zhu et al. (2008c) selected 55 common spore-pollen species based on space fitting and stepwise regression to construct a pollen-climate factor transfer function of annual mean temperature. From this, the annual mean temperature record was constructed for the Dajiuhu area for the last 15.753 cal. ka., which is in agreement with the pattern of climatic change since the Last Glacial.

(3) Stable isotope analysis on mammal bone fossils from archaeological site. This is a new and hot field of environmental archaeology (Wang and Deng, 2005; Hu et al., 2006; Fu et al., 2010; Guo et al., 2011; Tian et al., 2011). The ratios of carbon and nitrogen stable isotopes from animal tissues can be well preserved in collagen of bone fossils. The δ^{13}C and δ^{15}N values of the bone collagen reflect the mean carbon and nitrogen stable isotopic compositions in bone collagen during the mean lifetime, which provides information about the dietary preference of an individual (Tian et al., 2011). Climate may influence the δ^{13}C and δ^{15}N values of terrestrial mammals through its effect on plant δ^{13}C and δ^{15}N values (Vogel and van der Merwe, 1977; Ambrose, 1990; Drucker and Bocherens, 2004). Thus, since the 1960s, many studies on palaeodiet, palaeoenvironment and human activities have been conducted by using carbon and nitrogen stable isotopic compositions in bone collagen (Deniro, 1985; Hobson and Schwarcz, 1986; Iacumin et al., 2000; Stanley et al., 2003; Robert et al., 2004). However, few were conducted in the Yangtze River Valley area at present. Carbon and nitrogen isotope analyses on mammal bone collagen of deer, cattle and pigs, etc. from archaeological sites can well reconstruct mammal palaeodiets, palaeoecology, palaeoenvironment and human activities in the Yangtze River Valley area. The minimum number of specimens to estimate mean δ^{13}C and δ^{15}N values of deer, cattle and pigs, etc. can also be provided herein (Kathryn et al., 2005; Tian et al., 2011).

(4) Metal content of archaeological sites reflecting man-land relationships. This is the key to solve problems of man-land relationships at archaeological sites. Because of human disturbance and natural catastrophes, archaeological sites preserve information of complicated man-land interaction reflected from metal content changes. Based on X-ray fluorescence, X-ray diffraction, and scanning electron microscopy (SEM) analyses, metal content (Mg, Ca and Na) changes provide an early example of salt production discovered at Zhongba site in the upper Yangtze River Valley (Flad et al., 2005). This is the first scientific chemical evidence for early salt production in China, which can be used to reveal the process of rise and decline of ancient salt industry (Zhu et al., 2008a), and also presents a methodology for evaluating salt production sites in other regions of the Yangtze River Valley. Recently, hyperspectral reflectance models were also been constructed for retrieving heavy metal content in the archaeological soil (Xu et al., 2011). In sum, choosing a typical archaeological site to determined metal content changes for this relationship is crucial to a time series analysis of regional environment and human activities.

(5) Pioneering research on geographic passageways for archaeological cultural exchange. Observable routes formed when communication and exchange occurred among different ancient cultures, tribes or early states (Ma and Yang, 2007), especially during the late Neolithic when Chinese civilization began and by which the Xia, Shang and Zhou dynasties achieved an early Chinese union (Ma, 2006). Investigation of the trade and communication routes may be a way of not only identifying the geographic distribution of a specific archaeological culture, but also for research on historical geography. A number of studies have focused on typical site archaeology or site distribution principles, and their relations with palaeoenvironment (Zhu et al., 2003; Zhu et al., 2005b; Zhu et al., 2007; Zheng et al., 2008). Less attention has been paid to geographic passageways as a means of archaeological cultural exchange, and more rarely have considered the relationship between palaeoenvironment and the evolution of early civilization. This is one of the new research fields for the Tracing Origin Project of Chinese Civilization.

(6) Virtual reality and reconstruction of palaeoenvironment. Virtual reality involves many disciplines and is a new research field that gradually developed at the end of the 20th century (Sun, 2006). Virtual reality provides a new way of representing all forms of data visualization. Many geo-data simulation models involving the palaeoenvironment of an archaeological site could be reconstructed by using virtual reality techniques, thus helping environmental archaeologists examine temporal-spatial changes and geological, geomorphologic, hydrometeorological, soil and vegetation relationships of archaeological sites (He et al., 2010a). Virtual world construction and dynamic simulation could also broaden understanding of past man-land relations and evolvement mechanisms.

4.2. Prospects for research methods and techniques

Many proxy indicators are ambiguous in the interpretation of palaeoenvironment because of the influence of many factors, such as human activity, climatic and hydrological conditions, etc. Furthermore, the response time and intensity of climatic conditions are not consistent. Thus, combined with regional cultural characteristics and archaeological research results, more proxies and multidisciplinary approaches should be used, such as comparative studies of archaeological sites and their natural sedimentary environments, to improve the reliability of research results. Stratigraphic analysis should also be carried out. Through environmental proxy analysis of standard natural profiles, the environmental background of human activity can be reconstructed. By combining these data with a few typical archaeological sites, representative formations of an area could be established for setting up a benchmark to better understand regional environmental changes.

Dating methods such AMS ^{14}C, OSL and palaeo-geomagnetism are now routinely used to provide chronologies of archaeological sites (Zhang et al., 2009a; Bronić et al., 2010; Lu et al., 2011). Reconstruction of palaeoenvironment changes is mainly based on bio-lithostratigraphy, geochemistry, environmental magnetism and sedimentology (Zhu et al., 1996; Yu et al., 1998; Zhu et al., 1998; Yu et al., 1999; Zhang et al., 2000; Zhang et al., 2002a,b,c). Pollens and phytoliths are used to determine palaeo-vegetation, and in turn, palaeotemperature and precipitation (Yu et al., 2007a). Foraminifera and ostracoda provide direct evidence of palaeosalinity, palaeotemperature and palaeo-waterdepth, and they have been widely used to identify transgression and sea-level change (Zhu, 1991; Li et al., 2009). Molecular bioarchaeology is the discipline that has benefited most from ancient DNA analyses of archaeological human, animal and plant remains (Yang et al., 2005). It has been successfully applied to numerous archaeological problems in many parts of the world (Yang and Watt, 2005; Moss, et al., 2006; Yang and Speller, 2006), but is yet to be applied in environmental archaeology of the Yangtze River Valley. Environmental remote sensing archaeology is another emerging interdiscipline in China (Guo et al., 2000; Wang et al., 2004; Wang et al., 2005b; Gao et al., 2008; Gao and Jin, 2009; Gao et al., 2009; Ruan et al., 2010), and provides a new tool to better understand Holocene environmental change and environmental archaeology in the Yangtze River Valley.

5. Conclusion

The Yangtze River Valley is an important area for examining the birth of civilization and plays an irreplaceable role in research on global environmental evolution and environmental archaeology. Because of its unique geographical location and long history of human activity, the Yangtze River Valley preserves rich cultural deposits of Chinese civilization.

After nearly three decades of research, Holocene environmental change and environmental archaeology in the Yangtze River Valley, there is still much more to learn about the complex relations, time and spatial scales that are preserved in this area. With developments in interdisciplinary studies, increasing academic exchanges and cooperation among scientists from all over the world, improvements in currently available analytical techniques (AMS ^{14}C, OSL, sedimentological and geochemical) as well as application of new techniques (remote sensing archaeology and bioarchaeology), the progress of Holocene environmental change and environmental archaeology macro- and micro-research in the Yangtze River valley will accelerate and make an important contribution to the study of global climatic change.

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