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# Settlement distribution and its relationship with environmental changes from the Paleolithic to Shang–Zhou period in Liyang Plain, China

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A B S T R A C T

With increasing collaboration between archeology and natural sciences, research on past human–environment interactions has received more attention in recent years. This paper uses nineteen radiocarbon and OSL dates from three profiles to explore environmental evolution of the Liyang Plain, investigate the spatial and temporal distributions of archaeological sites from the Paleolithic Age to the Shang–Zhou period and discuss relationships between human cultures and environmental changes. The results show that Paleolithic sites are mainly distributed in surrounding mountainous and hilly areas, changing to the plain in the late Paleolithic Age. Climatic cooling during the Last Glacial Maximum did not cause severe damage to the regional vegetation and ecosystem, which allowed the continuous development of the late Paleolithic culture in the Liyang Plain. Suitable environmental conditions and progression of human activities facilitated rice cultivation in the early Holocene, and rice agriculture as an important food resource provided a solid material foundation for social development. The number of archaeological sites increased continuously and their distribution expanded considerably into eastern low-lying plain areas during the Neolithic Age. These trends reversed in the late Shijiahe culture, and social development did not recover until the Shang–Zhou period. Variation of site distribution in the Liyang Plain was primarily influenced by hydrological and geomorphological changes as well as climate change. However, it might also have been affected by broader regional political situations, especially during the Shang–Zhou period.



## 1. Introduction

With the increase in amount of collaborative research on environmental change and archaeology, researchers have realized that paleoenvironmental changes and paleocultures may be closely related. Past human–environment interactions have been increasingly studied in recent years (Mo et al., 1996; Gupta, 2004; Kuper and Kropelin, 2006). Changes of environmental factors, such as climate, landscape, and hydrology may affect human activities to some extent and even determine the rise and decline of cultures (Hodell et al., 1995; Dodonov et al., 2007; Turney and Brown, 2007). However, to adequately define the relationship between past human and their surrounding environment is still challenging, because of the lack of high-resolution environmental archives or archaeological materials.

The Liyang Plain which lies in the northwest of Hunan province, in the middle reaches of the Yangtze River, is an important area for the development of prehistoric cultures. It has a long habitation history that can be traced to the Paleolithic Age. During the Neolithic Age, ancient people intensively occupied the Liyang Plain, practicing rice cultivation and creating splendid cultures. During the last few decades, the quantity of archaeological field surveys and excavations has increased greatly, which has facilitated the establishment of an intact and successive Neolithic cultural sequence and accumulation of archeological materials. Several stalagmites collected from caves in southern China were

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fully studied, which provided precisely dated, high-resolution environmental records (Dykoski et al., 2005; Shao et al., 2006; Cosford et al., 2008; Hu et al., 2008). These reconstructed data laid the material foundation for environmental archaeology in this region. Yasuda et al. (2004) conducted environmental archaeological study at the Chengtoushan site and suggested that small-amplitude climate changes triggered technical innovation. A significant climatic cooling at 4200–4000 cal. BP brought about the collapse of the rice cultivating society in the Yangtze River basin (Yasuda, 2008). However, these studies were mostly concentrated in one single site or one special period, and comprehensive studies on the relationship between environmental changes and human activities were rare. During the last few years, the authors have made preliminary studies on depositional environments and paleoenvironmental evolution in the Liyang Plain, based on fieldwork and laboratory analysis (Mao et al., 2009, 2010; Guo et al., 2013). In this study, we investigated the spatial and temporal patterns of the distribution of archaeological sites from the Paleolithic Age to Shang–Zhou period. Combined with reconstructed environmental records, past human–environment interactions were the focus.

## 2. Study area

The study area is situated on the northwestern bank of Dongting Lake, the middle reaches of the Yangtze River. It covers a large area, including most of Lixian County and parts of Linli, Shimen, and Jinshi County (Fig. 1). The middle and eastern part of the study area is mainly alluvial plain with elevation of 30–50 m asl, while other parts are primarily uplands and mountains with relatively higher elevations. The Liyang Plain exhibits middle to northern subtropical monsoon climate, characterized by warm and humid summers, and cool and dry winters. The mean annual temperature is 16.5 °C and the mean annual precipitation fluctuates between 1000 and 1400 mm, mainly concentrated in spring and summer. The criss-crossing rivers (mainly the Li River and its branches, Cen River and Dan River) and canals, together with dotted lakes and ponds, constitute a complex and dense water network in the region (The Editorial Committee of local chronicles of Lixian County, 2010).

## 3. Materials and methods

Based on field survey, we selected six representative profiles to assist exploring the features of the strata and the process of paleoenvironmental evolution in the study area. Optically stimulated luminescence (OSL) and Accelerator Mass Spectrometry (AMS) radiocarbon dating methods were used to date samples from the Yucheng (YC), the Shanlong (SL) and the Yanbandang (YBD) profiles for constructing the time-scale. All the dating samples were pretreated and measured at Peking University in Beijing, China. All the radiocarbon ages reported here are relative to AD 1950 (referred to as 'cal. BP') for comparison with OSL ages. The IntCal04 curve (Reimer et al., 2004) and the Libby half-life of 5568 years were used in calculating all dates, with the calibration performed using the OxCal v3.10 program (Ramsey, 2005).

The information for 639 archaeological sites was collected mainly from 'the Atlas of Chinese Cultural Relics: Hunan Volume' and from other published documents (Bureau of National Cultural Relics, 1997). The chronology of these sites can be classified into nine stages based on their cultural and chronological sequences: the Paleolithic Age (before 10,000 cal. BP), the Pengtoushan cultural stage (10,000–7800 cal. BP), the Zaoshixia and Tangjiagang cultural stage (7800–6300 cal. BP), the Daxi cultural stage (6300–5500 cal. BP), the Qujialing cultural stage (5200–4500 cal. BP), the Shijiahe cultural stage (4500–3900 cal. BP), the Shang Dynasty (3550–2996 cal. BP), the Western Zhou Dynasty (2996–2721 cal. BP) and the Eastern Zhou Dynasty (2720–2171 cal. BP). The digital map images which were scanned from the atlas maps at high resolution were georeferenced and digitalized using ArcGIS 9.1. The SRTM4.1 DEM data set with a spatial resolution of 30 × 30 m (http://datamirro.csdb.cn/) were also used in this study. The digitalized sites layers and the DEM layer were overlapped, and the altitudes of archaeological sites were obtained using the 'Extract Values to Points' tool for further analysis.

## 4. Results

### 4.1. Dating results

The dating results for nineteen samples collected from the YC, the SL and the YBD profiles are shown in Table 1. A total of eight

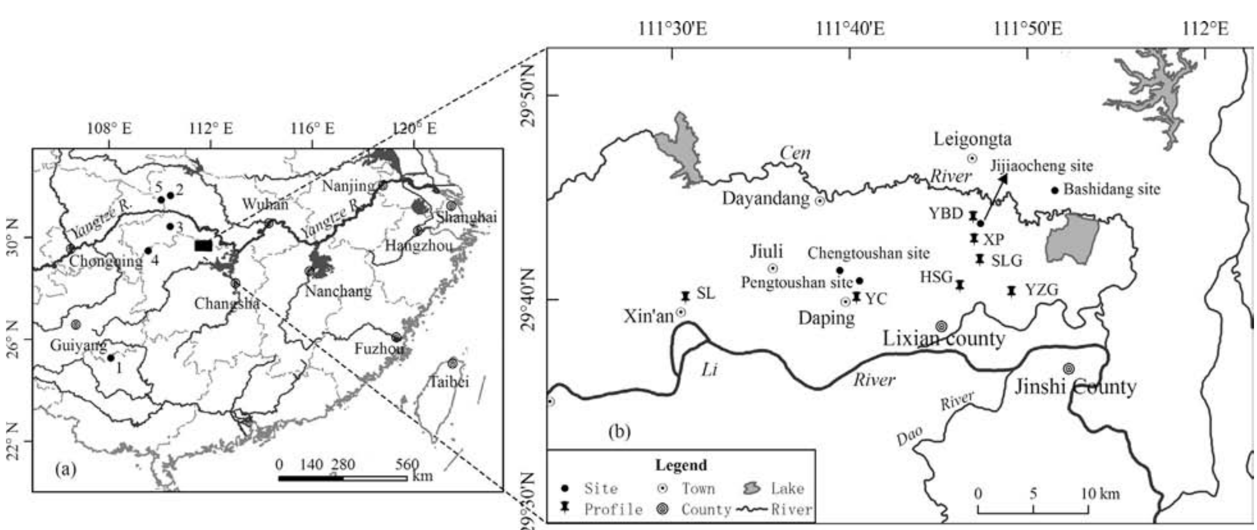


**Fig. 1.** (a) Maps of the southern China and surrounding regions showing provincial boundaries, large cities and location of Liyang plain; (b) geographic sketch of Liyang plain and locations of profiles and sites mentioned in the current study. The numbers 1–5 in the left map indicate locations of palaeoenvironmental records discussed in the text: 1- Dongge Cave, 2- Shanbao Cave, 3- Heshang Cave, 4- Lianhua Cave and 5- Dajiuhu Peat.

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radiocarbon dates and eleven OSL dates were obtained and the ages are in stratigraphic order.

**Table 1**
AMS-$^{14}$C and OSL ages for the YC, the SL and the YBD profiles.

| Laboratory code | Depth (cm) | Dating method | Dating material | Age | Profile |
|---|---|---|---|---|---|
| SL-C-03 | 84–86 | AMS-$^{14}$C | Charcoal | 10.96 ± 0.08 cal. ka BP | SL |
| SL-C-04 | 106–108 | AMS-$^{14}$C | Charcoal | 11.81 ± 0.05 cal. ka BP | SL |
| SL-C-05 | 128–130 | AMS-$^{14}$C | Charcoal | 12.40 ± 0.05 cal. ka BP | SL |
| SL-C-06 | 152–154 | AMS-$^{14}$C | Charcoal | 13.50 ± 0.05 cal. ka BP | SL |
| YC-C-01 | 30–32 | AMS-$^{14}$C | Charcoal | 8.72 ± 0.05 cal. ka BP | YC |
| YC-C-02 | 50–52 | AMS-$^{14}$C | Charcoal | 12.21 ± 0.05 cal. ka BP | YC |
| YC-C-03 | 60–62 | AMS-$^{14}$C | Charcoal | 14.86 ± 0.06 cal. ka BP | YC |
| YC-C-04 | 80–82 | AMS-$^{14}$C | Charcoal | 20.84 ± 0.09 cal. ka BP | YC |
| YC-OSL-01 | 110–120 | OSL | Clayey silt | 24.31 ± 1.43 ka | YC |
| YC-OSL-02 | 125–135 | OSL | Clayey silt | 30.20 ± 0.98 ka | YC |
| YC-OSL-03 | 150–160 | OSL | Clayey silt | 34.55 ± 1.36 ka | YC |
| YC-OSL-04 | 170–180 | OSL | Clayey silt | 51.82 ± 0.87 ka | YC |
| YBD-9-1 | 75–80 | OSL | Clayey silt | 6.11 ± 0.31 ka | YBD |
| YBD-9-2 | 90–95 | OSL | Clayey silt | 6.33 ± 0.32 ka | YBD |
| YBD-10 | 110–115 | OSL | Clayey silt | 9.92 ± 0.50 ka | YBD |
| YBD-12 | 140–150 | OSL | Clayey silt | 15.56 ± 0.80 ka | YBD |
| YBD-13 | 165–170 | OSL | Clayey silt | 21.17 ± 1.11 ka | YBD |
| YBD-14 | 190–195 | OSL | Clayey silt | 23.49 ± 1.20 ka | YBD |
| YBD-15 | 210–215 | OSL | Clayey silt | 26.73 ± 1.37 ka | YBD |

### *4.2. Spatial and temporal distribution of archaeological sites*

The distributions of archaeological sites by cultural period in Liyang Plain are shown in Fig. 2. Table 2 and Fig. 3e show the number and altitude variations of archaeological sites at different cultural stage. The fifty Paleolithic sites are mainly distributed in surrounding uplands and hills in the Liyang Plain, though there are a small number of sites of the late Paleolithic Age and the transitional period from the Paleolithic to the Neolithic located in plain areas. Altitudes of Paleolithic sites are relatively high, and up to 52% of the sites are distributed in areas above 50 m asl.

The Pengtoushan culture is the oldest Neolithic culture in the Liyang Plain. All of the fifteen Pengtoushan culture sites are concentrated in areas with elevation lower than 50 m asl, and 46.7% of them are distributed in areas with elevations of 35–40 m asl. The number of sites of the Zaoshixia and Tangjiagang culture increases to twenty-two and their distribution spreads to areas of lower elevation with nine sites located in areas below 35 m asl. During the Daxi cultural stage the development of prehistoric culture accelerated in the Liyang Plain. The number of the sites increased to fifty-one and their distribution expanded markedly eastward (Fig. 2 and Table 2). There are eighteen sites situated in areas below 35 m asl (Table 2). The following Qujialing culture continued to develop and expand with the number of sites increasing to sixty-one. Distribution of Qujialing culture sites moves toward low-lying plain with thirty sites below 35 m asl, taking up 49.2% of all the sites of the period. The number of the Shijiahe culture sites increased dramatically to 195. At this stage, archaeological sites were not limited to hillocks or mounds but spread across the entire plain, especially in the lowlands inside the plain. There are 103 sites distributed in areas below 35 m asl, accounting for 52.8% of all the sites of the Shijiahe culture (Table 2 and Fig. 3e).However, the growing trend of site number is interrupted by a striking drop in the late Shijiehe cultural period (~4000 cal. BP) and almost all the cities were abandoned abruptly. After that, sites of the period equivalent to the Erlitou culture (Xia Dynasty) were rarely found and cultural features were unclear.

The numbers of sites of the Shang Dynasty and the Western Zhou Dynasty are 52 and 32, respectively. Compared to the Shijiahe cultural stage, the scope of site distribution shrank significantly and fewer sites are located in low-lying areas. There are only 15 sites of the Shang Dynasty and 11 sites of the Western Zhou Dynasty below 35 m asl. Development of the culture accelerated again during the Eastern Zhou Dynasty when the number of sites increased to 161 and their distribution expanded to the entire plain. Altitudes of sites lowered significantly and the number of sites below 35 m asl increased to sixty-five.

**Table 2**
Sites and altitude variation for different cultural stages.

| Number of sites | Paleolithic | Pengtoushan | Zaoshixia-tangjiagang | Daxi | Qujialing | Shijiahe | Shang | Western Zhou | Eastern Zhou |
|---|---|---|---|---|---|---|---|---|---|
| Total no. | 50 | 15 | 22 | 51 | 61 | 195 | 52 | 32 | 161 |
| >50 m asl | 26 | 0 | 0 | 2 | 0 | 3 | 8 | 3 | 15 |
| <35 m asl | 11 | 6 | 9 | 18 | 30 | 103 | 15 | 11 | 65 |

## 5. Discussion

### *5.1. Environmental changes in Liyang Plain*

According to field surveys and comparative studies of strata of typical profiles (Fig. 4), pervasive loess deposition occurred in the Liyang Plain in the late Pleistocene. The western plain close to mountains is mainly composed of coarse sediments, and typical

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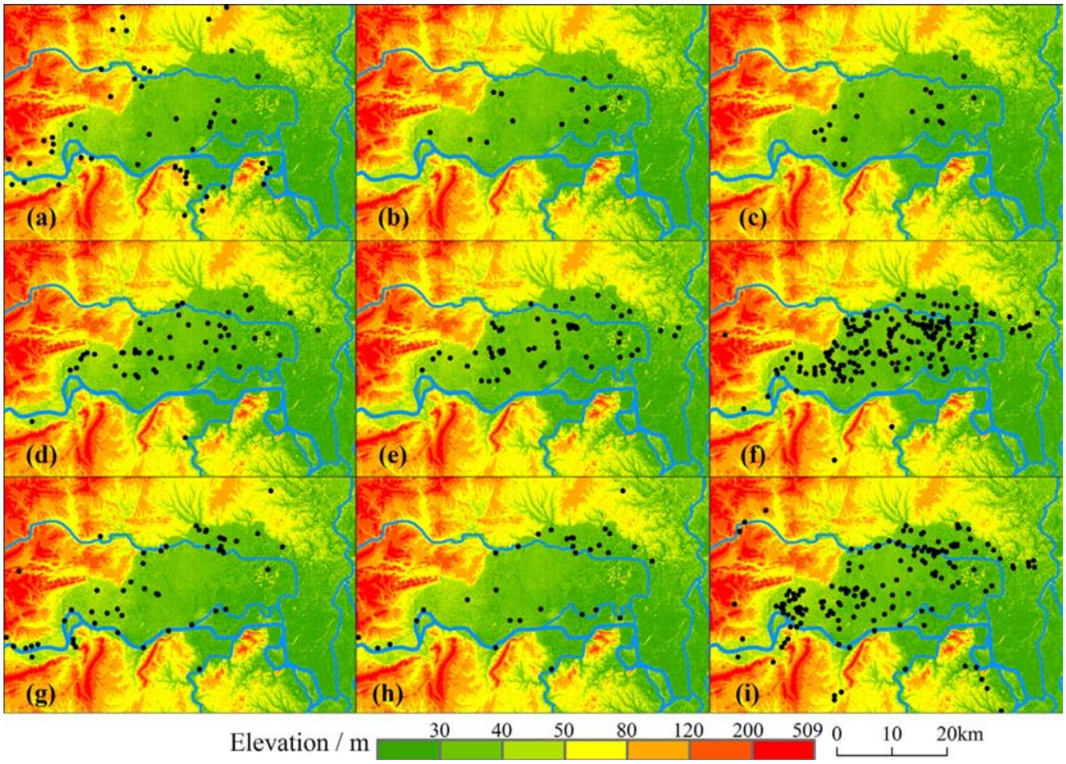


**Fig. 2.** Distribution of archaeological sites in Liyang Plain. (a) the Paleolithic stage; (b) the Pengtoushan cultural stage; (c) the Zaoshixia-Tangjiagang cultural stage; (d) the Daxi cultural stage; (e) the Qujialing cultural stage; (f) the Shijiahe cultural stage; (g) the Shang Dynasty; (h) the Western Zhou Dynasty; (i) the Eastern Zhou Dynasty.

fluvial gravel layers can be found in this region, such as the basal gravel layer in the SL profile (Fig. 4). The eastern plain is relatively far away from the mountain, which results in relatively fine deposition. Hillocks or mounds inside the plain received continuous loess deposition, such as the loess layers in YC and Shiligang (SLG) profiles. OSL ages of the YC profile indicate that loess accumulation started after 50 ka in Liyang Plain and then went through eluviation and illuviation under the relatively warm and humid climate (Mao et al., 2009; Guo et al., 2013). In this process, erosion and incision happened occasionally, for instance a 5 m wide gully was formed above the loess layer around 23 ka in the YBD profile. During the LGM, climate deteriorated with lowering temperature and decreasing precipitation, sea level dropped to the minimum, and the Yangtze River and its tributaries down cut with water level 20–45 m lower than today (Yang, 1986; Wang et al., 2001; Huang et al., 2002). A similar process occurred in the Liyang Plain, forming loess tablelands drained by rivers and gullies with the topographic relief much higher than the present.

Brown or dark-brown sediment overlaid the Pleistocene loess layer during 20–10 ka (Mao et al., 2009). A trench dug at the YBD site revealed that the dark-brown deposits gradually filled up the gully of previous stage and covered the nearby terrain. Grain size analysis suggested that these sediments were much coarser than the loess of the late Pleistocene. The reason for the darkened color might be that under a cool and wet climate decomposition of organic matter was restrained which resulted in much more storage of organic matter in sediments. On the whole, with the continuous filling and siltation, the topographic relief of the Liyang Plain was gradually reduced in the terminal Pleistocene.

A gradual climatic transition from cool and dry to warm and wet occurred in the early Holocene (Fig. 3a, b). The $\delta^{18}O$ record of stalagmite from Shanbao Cave demonstrated the continual increase of the monsoon precipitation between 11.5 and 9.3 ka (Fig. 3b). Pollen analysis of the Dajiuhu peat confirmed rising temperature by increasing concentrations of arboreal pollen and decreasing concentrations of coniferous pollen (Zhu et al., 2010). During this period the Liyang Plain continued to subside and accommodate fluvial and lacustrine deposits. Greyish-green or black clay deposition with horizontal bedding was found in several profiles (Fig. 4), which indicated that with the gradual increase in monsoon precipitation, large areas of wetland was formed and deposition was greatly influenced by hydrological process. Landscapes of the Liyang Plain at this time were mainly plains and hillocks with dense rivers and lakes and the topographic relief was further reduced.

During 9–6 ka, average $\delta^{18}O$ values of stalagmites were relatively light despite some fluctuations, indicating a period of abundant monsoon precipitation during the Holocene (Dykoski et al., 2005). Secondary loess sediments with finer particle size were deposited in Liyang Plain. Compared to the late Pleistocene loess, secondary loess of the Holocene was much grayer and was more affected by water. On the whole, the Liyang Plain of this period were characterized by relatively small areas of low hillocks and mounds, followed by the rivers and small lakes, and a vast low-lying flat plain as the main body of the region.

After 6 ka, $\delta^{18}O$ shifted towards heavier values, indicating a decreasing trend in Asian monsoon intensity in the mid-late Holocene (Dykoski et al., 2005; Hu et al., 2008). This trend became even more prominent around 4 ka, which was identified in $\delta^{18}O$ records from Shanbao Cave (Fig. 3b), Heshang Cave (Fig. 3c) and Lianhua Cave (Fig. 3d). After 4 ka, the climate gradually stabilized with occasional fluctuations. The $\delta^{18}O$ record of stalagmite from Shanbao Cave revealed a period of aridity between 4.4 and 2.1 ka (Fig. 3b). Geochemical study of the Dajiuhu peat indicated that the

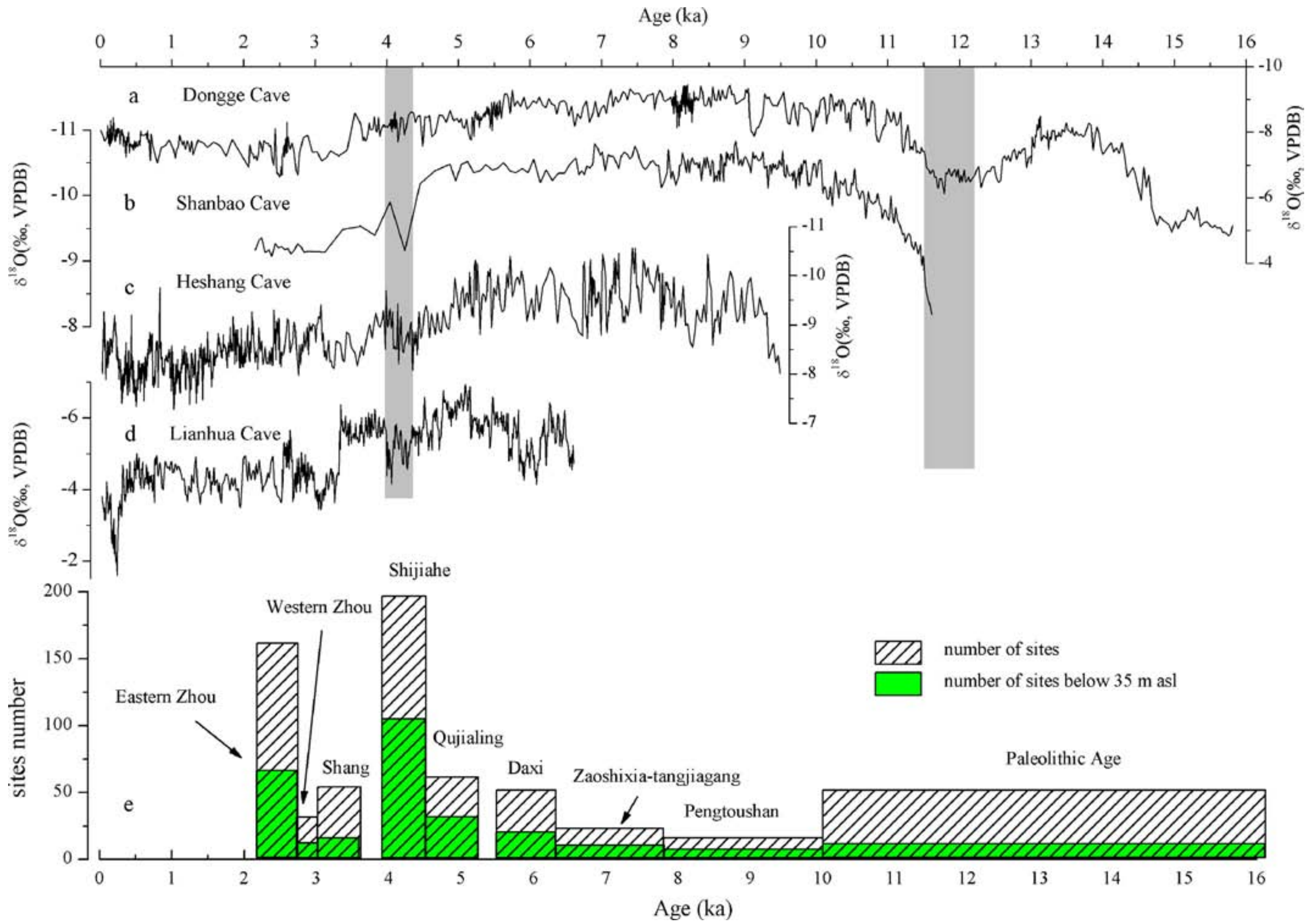


**Fig. 3.** Comparisons between climate records and human settlements in Liyang Plain. a. $\delta^{18}O$ values of stalagmite from Dongge Cave (Dykoski et al., 2005); b. $\delta^{18}O$ values of stalagmite from Sanbao Cave (Shao et al., 2006); c. $\delta^{18}O$ values of stalagmite from Heshang Cave (Hu et al., 2008); d. $\delta^{18}O$ values of stalagmite from Lianhua Cave (Cosford et al., 2008); e. Total number of sites and number of sited below 35 m asl. in Liyang Plain (Table 2). Gray shallows show periods of climatic cooling of the YD and 'the 4000 BP Event'.

climate was cool and dry during 3.5–0.91 cal. ka BP and then it became cool and wet (Ma et al., 2008).

### 5.2. *Impacts of environmental changes on the development of cultures*

#### 5.2.1. *The Paleolithic Age*

Climate was relatively appropriate during most of the late Pleistocene, which contributed to continual existence of human activity in the Liyang Plain. Human occupation in the Paleolithic Age was primarily concentrated in mountainous and hilly areas with gathering and hunting as the principal subsistence practices (Yin, 2003). Climate deteriorated during the Last Glacial Maximum (LGM). Previous studies showed that the amplitude of drop in temperature varied in different regions and it was larger in the north than in the south of China (Zhang, 1980; An et al., 1990). For instance, the temperature during the LGM was 7–10 C° lower than the present in the north of the Qinling Mountains–Huaihe River Line, 5–7 C° lower in the middle Yangtze River region and 4 C° lower around the Dajiuhu Lake in Hubei Province (Huang and Zhang, 2000; Hao, 2008). As the latitude and the altitude of the Liyang Plain are relatively low, its natural vegetation and temperature should have been favorable despite the temperature decreased to some extent. The climatic cooling would not have severely damaged the vegetation and ecosystem of the Liyang Plain, which might be an important reason for the continuous development of the late Paleolithic culture in the area. However, the cooling might still affect human activities. Archaeological studies found that human activities migrated obviously towards plain area, new microlithic technology (small microliths) was developed, and a broad spectrum of subsistence strategies was used for human survival during this period (Lixian Museum and Lixian Institute of Heritage Management, 1994). These cultural changes might demonstrate human responses to climate cooling.

The climate improved with rising temperature and increasing rainfall during the post-LGM deglaciation. Under this improved environment, the transition from the Paleolithic to the Neolithic was first completed in the Liyang Plain, and the Pengtoushan culture became the earliest Neolithic culture of the Yangtze River region.

#### 5.2.2. *The early Neolithic*

Rice cultivation as an important productive economy emerged in the early Neolithic. Toyama surveyed radiocarbon data on samples of rice remains from more than 100 sites and suggested that rice cultivation originated in the middle Yangtze (Normile, 1997). Signs of rice cultivation were also found in the Liyang plain. Archaeological studies confirmed that rice remains were mixed with clay to make pottery vessels at several sites of the Pengtoushan culture (Zhang, 1998); Approximately 15,000 grains of

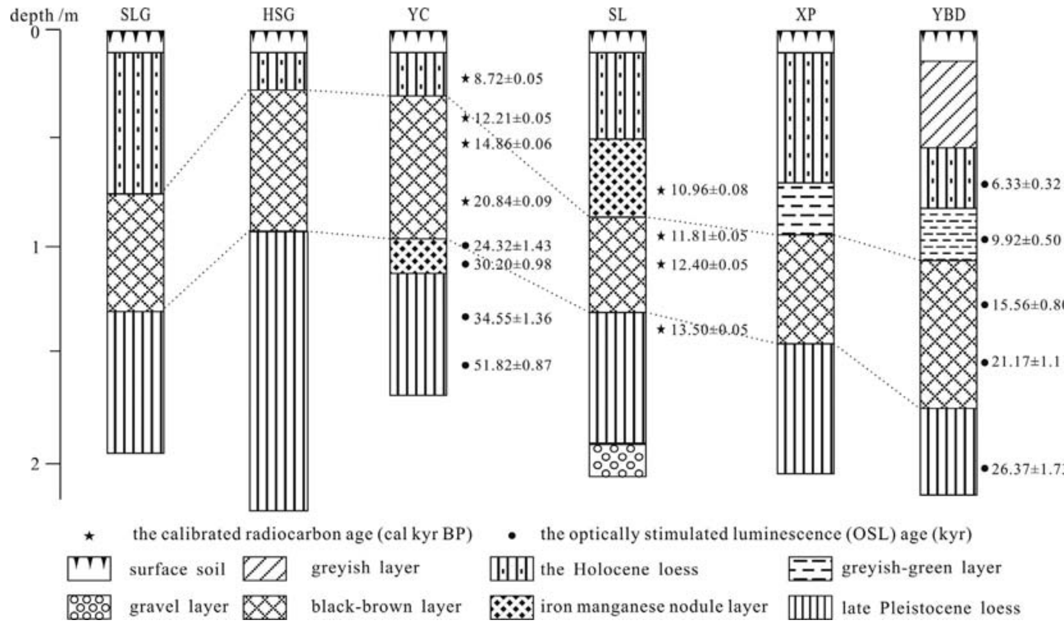


**Fig. 4.** Stratigraphic correlation of typical profiles in Liyang Plain.

rice were discovered within less than 100 $m^2$ in river mud from the Bashidang site (Pei et al., 1998). These early and large amounts of rice remains demonstrated the initial development of rice agriculture, which was closely related to natural and cultural conditions of the Liyang Plain.

The climate improved markedly in the early Holocene. Pollen analysis conducted at the Pengtoushan site confirmed that the temperature was only 0.5–1 C° lower than the present during 9–8 ka (Gu, 1990). With increasing monsoon precipitation, water supply condition improved significantly in Liyang Plain. The landscape of the Liyang Plain in the early Holocene was characterized by vast flat plain, crisscrossed by water networks, dotted lakes and scattered hillocks or mounds. Mounds inside the plain were preferable locations for settlements because of the relatively high elevation and safety from floods, while surrounding lowlands were relatively flat and covered with loose and fertile soils which could be farmed as paddy fields. Therefore, the Liyang Plain satisfied the environmental requirements (including adequate moisture and temperature, suitable landforms and soil) for rice production at this time.

With respect to the long-term, regional cultural history, human activities were sustained successively and without interruption in the Liyang Plain throughout the late Paleolithic. Rice phytoliths, including dumbbell- and fan- shaped ones, were discovered in sediments of the transitional layer at the Shiligang site (Pei, 2008), which demonstrated the existence of rice, although it is hard to say whether this was cultivated rice. The long tradition of intensive exploitation of certain types of flora helped Paleolithic people accumulate understanding of these plants. Wild rice was one, eventually domesticated and cultivated for food. This process lasted for a long time, and rice cultivation became an important activity during the Pengtoushan cultural period. Therefore, in the early Holocene, the Liyang Plain was well situated with the environmental and cultural foundations for rice production, and became an important center of rice agriculture.

### 5.2.3. The middle and late Neolithic

In the middle Holocene, the climate was warm and humid and the sea level was relatively high, resulting in water level rise of rivers and expansion of Dongting Lake (Zhang et al., 1994). During this period, the Liyang Plain was a wide plain drained by river channels, and the area of marshes and small lakes increased. Suitable environmental conditions promoted the progress of rice agriculture. Paddy fields and associated supporting irrigation facilities were discovered at the Chengtoushan site (He and Yasuda, 2007). Rice cultivation was widely practiced in the low-lying plain area. However, during 6.5–6.0 ka, thick pure loess deposits in the YBD and the BSD profiles indicated the significant rise of water table and expansion of water-covered area in the lower reaches of the Cen River. Therefore, human activities of the early Daxi culture were mostly concentrated in the central and western plain at relatively high elevations.

After 6 ka, monsoon precipitation started to decrease. As the Liyang Plain was relatively low in elevation and vulnerable to floods, the decreasing rainfall together with the prolonged siltation actually facilitated the expansion of human habitation in eastern low-lying plain areas. The eastern plain was more open and wide, and water supply was more sufficient, which raised the development of rice agriculture to a new level. After 5 ka, climatic cooling became more prominent, but it was still warm before 4 ka. The development of prehistoric culture of the Liyang Plain accelerated and flourished during the Shijiahe cultural stage. The distribution of Shijiahe culture sites was no longer restricted to hillocks or mounds but also appeared in low-lying flat areas. This phenomenon was displayed throughout the whole middle Yangtze River region. The number of sites in the low-lying Jianghan plain increased significantly during this period (Li et al., 2011a). The lowest habitable base fell to the minimum (24.8 m) in the Dongting Lake area at this stage (Liu et al., 2012). Overall, the level of productivity and the degree of social complexity developed at an unprecedented pace, and perhaps established an early civilization in the late Neolithic.

Prehistoric society of the entire middle Yangtze River region declined abruptly around 4 ka (Mo et al., 2010). Climate deteriorated significantly around 4 ka. This cooling event, known as 'the 4000 BP Event', is displayed in many regions throughout the world, and might have been the coldest period since the YD cold period (Bar-Matthews et al., 1999; Perry and Hsu, 2000). Rice agriculture might be affected by climatic cooling because of its strict hydrothermal requirements. The reduced agricultural production resulted in food shortage which further led to social decline. Secondly, increasing flooding disasters were also an important reason for cultural decline. Of main importance, the middle Yangtze River region was low in elevation and vulnerable to floods. In the middle Holocene, sea level reached the height close to the modern level, which caused rising water of rivers and siltation in riverbeds. Study of the ZK01 core indicated that the water level of Dongting Lake rose continually during 6–4 ka (Li et al., 2011b). Pollen analysis of sediments from M1 core found that the aquatic plants including *Typha*, *Ceratopteris* and *Myriophyllum* showed up frequently and the Yun-meng lakes expanded after 4.1 cal. ka BP (Yang et al., 1998). The continued rising water level and siltation of rivers and lakes resulted in significant increases in frequency and intensity of floods. Of additional importance was population growth: after 6 ka, Neolithic cultures developed continually and population expanded rapidly. Human exploration of the low-lying plains increased to the largest scale during the Shijiahe culture period. The conflicts between hydrological changes and cultural evolution contributed to large-scale flood disasters and further led to social collapse. Previous studies found that the density of archaeological sites of the Shang period was lower than that of the Shijiahe culture period in the Yangtze River region, especially on the north shore of the Yangtze River, and many sites of the Shijiahe culture were buried beneath thick flood deposits (Shan and Deng, 1984; Ren, 1993; Wu and Wu, 1998; Deng et al., 2009).

#### 5.2.4. The Bronze Age

For a long time after the Shijiahe cultural stage, human activities were very rare in Liyang Plain. Human occupation gradually intensified during the Shang–Zhou period. The gradually stabilizing climate facilitated human inhabitation. The political situation of a broader region might also affect the Bronze culture (Zhang, 2006). The Shang culture from the middle Yellow River valley expanded into the middle Yangtze River valley pursuing resources such as copper and indirectly promoted regional culture into a revival phase (Xu, 2003; Dou, 2012). During the Zhou Dynasty, the regional Chu state consolidated its power in the middle Yangtze River and eventually became a powerful kingdom (Yuan, 1991). The Liyang Plain was also occupied by the Chu culture and social development flourished unprecedentedly.

## 6. Conclusions

Human activities in the Liyang Plain can be traced to the Paleolithic Age. The early and middle Paleolithic sites were mostly located in the surrounding mountainous and hilly areas and human activities migrated towards plain areas during the late Paleolithic Age. Climate deterioration during the LGM did not cause severe damages to the regional ecosystem, which allowed the continued development of culture in Liyang Plain. The improvement of environmental conditions in early Holocene and the continued human activities contributed to origin and development of rice cultivation in Liyang Plain. Rice agriculture as an important food resource provided a material foundation for human inhabitation and promoted the expansion of Neolithic sites towards low-lying plain. After developing over several thousand years, prehistoric culture flourished unprecedentedly in the late Neolithic, but declined abruptly in the late Shijiahe culture. The hydrological and geomorphological changes as well as climatic cooling resulted in the recession of society and the interruption of civilization in Liyang Plain. Social development recovered during the Shang–Zhou period. Besides the stabilized environment, political situations of a broader region also affected the distribution of archaeological sites in the Bronze Age.

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