THE ROLE OF ENVIRONMENTAL CHANGE IN THE DEVELOPMENT OF COMPLEX SOCIETIES IN CHINA: A STUDY FROM THE HUIZUI SITE

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ABSTRACT

Holocene environmental change on the Loess Plateau of China presented both opportunities and challenges for populations inhabiting the region. A study of sediment sections within the catchment of the Yiluo River, Henan Province, indicates a sequence beginning with a stable landscape and high water tables in the early Mid-Holocene corresponding to the Peiligang occupation, shifting to a period of valley alluviation in the later Mid-Holocene at the time of the Yangshao occupation. Alluvial sediments dating from 5300/5010 cal. BC through 2130/1870 cal. BC are waterlogged deposits that contain sediment and phytolith evidence for the first rice paddy farming in this region. This coincides with the first migration of rice farmers to the area in the Yangshao Period ca. 5500 cal. BC. After ca. 2000 cal. BC stream incision in this catchment led to narrowing floodplains, the disappearance of the marsh deposits, and a reduction in land available for paddy farming. Ironically, this period coincided with the first Chinese state society and large population increases, necessitating new agricultural and economic strategies on the part of the Early Bronze Age inhabitants of the Loess Plateau. This study illustrates how human responses to environmental change depend on social as well as environmental considerations.

A NON-DETERMINISTIC PERSPECTIVE ON ENVIRONMENT AND SOCIETY

The relationships between ancient societies and their environments is neither simple nor direct. Fluctuating patterns of rainfall and temperature clearly effect water resources and the quality of the land for agriculture which directly impacts a society's ability to produce consistent and predictable grain yields. This is an essential requirement for provisioning large stable or growing populations. It is also apparently the limiting factor for how a complex society can develop in a given region. However, there is no simple correlation between beneficial climatic conditions and the development of social complexity, or conversely adverse climatic trends and social collapse. There are numerous cases where complex societies developed in localities in which land and climatic factors appear to be less than optimal. Such is the case with the first Chinese state in the Early Bronze Age Erlitou Period in Henan Province, north central China. Such cases are a challenge to a simple climatic determinist perspective which dictates that adverse environmental conditions are not conducive to origins of complex societies, and are widely believed to cause the collapse of states and empires worldwide (Issar 2003; Weiss and Bradley 2001).

Some authors have attempted to draw simple correlations between environmental degradation and the failure of social systems in a particular region (*c.f.* Weiss et al. 1993). Only a handful of researchers have pointed to situations whereby societies might have thrived under adverse conditions, as in the Egyptian Middle Kingdom after a short period of political chaos at a time of low Nile floods (Hassan 1997). This approach requires a more sophisticated investigation of how societies operate, a perspective that can only be achieved by taking into account the fact that societies are complex units which do not behave in a monolithic fashion, and their responses to outside stimuli such as environmental change are dictated by the interaction of a number of spheres of influence on the social, technological, economic and conceptual levels (Rosen 2007). Therefore, in order to explain how a particular society reacted to environmental degradation or amelioration, it is necessary to examine each situation as a unique and particular case.

Likewise, it is important to view climate and environmental change as a multi-faceted entity. It too cannot be reduced to a simple equation whose principle variables are wet/dry or warm/cold. Changes in temperature and precipitation impact different regions in different ways as seen by shifts in hydrological patterns, vegetation, landforms and soil-forming processes among other factors. In the same way that human responses to environmental change are unique to specific cultural entities, the impacts of climate changes are different depending upon the environmental setting. Here too it is necessary to take a close look at the particular landscape situation associated with the human social group under investigation.

One way to approach this is through the contributions of geoarchaeology. The study of landform changes within the immediate vicinity of archaeological sites provides a critical link between climate and environmental change, and their immediate impact on populations who live in a particular region of study. Human responses to these changes can be directly recorded in the form of agricultural decision-making and the impact of human economic activities on the landscape. The role of human/environmental relations and their effect on the rise of social complexity is illustrated by the case of the origins of complex society on the Loess Plateau of north central China. Our research at the Huizui site in Henan Province provides a model of this process based on a case study at the site-vicinity level of investigation. Before considering the specific case of Huizui, it is necessary to provide a background to the overall environmental sequences for the Holocene in this region.

HOLOCENE ENVIRONMENTAL CHANGE ON THE LOESS PLATEAU

In recent years there have been a growing number of studies on climate and environmental change across various regions of China. These have given us an ever finer resolution on shifts in precipitation and temperature and their effect on landscape and vegetation. Much of this work has taken place in northeastern China, Inner Mongolia, the Loess Plateau or north central China as well as southern China. These have outlined both local environmental sequences as well as their relationships to larger-scale global climatic events.

Pleistocene and Holocene climatic patterns of China have been controlled by the uplifting of the Tibetan Plateau beginning from ca. 7.2 million years ago. This massive geographic feature contributes to the regionalization of rainfall and temperature, dividing the climatic zones from north to south by splitting the jet stream into northern and southern branches. It also creates a precipitation gradient with decreasing amounts of rainfall as one moves from the southeast to the northwest. The summer warming of the continent of Asia heats the air masses over China which leads to the formation of summer monsoons when the air mass comes into contact with the temperature differential of the Pacific Ocean in the east, creating the southeasterly monsoon, and the Indian Ocean in the west, creating the southwesterly or Indian monsoons.

Northwestern China is influenced by the mid-latitude Westerlies (the Jet Stream), which bring small amounts of rain to that region in the winter. Low atmospheric pressure on the Tibetan Plateau during the summer augments these western monsoons. High pressure cells that build up on the Tibetan Plateau during the winter generate the "winter monsoons" and bring cold dry air to most parts of China (Y. He *et al*. 2004). The climate of the arid and semi-arid localities of northern China is controlled by these winter monsoons. The northeast to sSouthwest boundary of the semi-arid regions of China define the modern border between the zones dominated by the effects of the winter and summer monsoons (C.B. An *et al*. 2006). However, these boundaries have shifted throughout the Holocene, depending upon the strength of the summer monsoons. It is therefore important to understand these shifts and how they might have impacted the development of landscapes and societies in the semi-arid zone of the Loess Plateau where the first Chinese states came into being.

The major phases of Holocene paleoclimates in north/central China are related to global climatic events. A general outline is as follows. At the beginning of the Holocene, there was a general warming and increase in precipitation. This culminated in the 'Mid-Holocene Climatic Optimum' which represents the warmest and in many areas the wettest period of the Holocene. Due to shifting orbital cycles the Early and Middle Holocene climatic events world-wide were a function of increased solar radiation at around 9-8000 years BP (Kutzbach and Gallimore 1988). It is likely that the significantly warmer Asian continent and warming of the low latitude Pacific Ocean temperatures led to a much stronger East Asian monsoon at that time. At the end of this episode, northern China turned to cooler and drier conditions which characterized much of the Late Holocene period (Feng and An *et al*. 2006).

Although most researchers agree to this general outline of climatic events in China, there is some disagreement as to the timing of the Mid-Holocene warming from region to region, as well as the intensity or even existence of the moist phase that accompanied it. The debate as to the synchronicity of the Climatic Optimum centers around zones which are today in the arid and semi-arid regions of northern and northeastern China including Xinjiang, Inner Mongolia and the Loess Plateau. C.B. An et al. (2004) examined the degree to which the Climatic Optimum influenced the humidity of the desertic northern regions. Although the semi-arid areas such as the Loess Plateau enjoyed a significantly wetter Mid-Holocene, the desert regions of the north remained dry for much of the time due to the proportionate increase in evaporation rates with increasing temperatures. They also were significantly beyond the influence of the East Asian monsoonal regime.

Z. An *et al*. (2000) reviewed existing data from lake and bog cores as well as sediment sections in stratified loess sequences. They maintained that the pollen sequences from these cores show that the moist phases of rising arboreal pollen vary in their timing. They claim that the earliest evidence for moister conditions are in the Early Holocene on the Tibetan Plateau, and Middle Holocene in the Xinjiang region, the Loess Plateau and Inner Mongolia. Z. An *et al*. (2000) believe that this is a function of differences in the paleoclimatic patterns of these regions. However, Feng and An *et al*. (2006:126) convincingly critique this interpretation by pointing out that the dates of these cores all fall within the statistically equivalent range. They re-examine the dates in the form of ranges rather than points in time, and maintain that the Holocene Climatic Optimum took place relatively simultaneously in all these localities.

This climatic optimum of warm wet conditions influenced vegetation patterns and soil development all across the Loess Plateau and semi-arid zones of northern China. Two important studies were conducted at Daihai Lake in the semi-arid zone just north of the Loess Plateau in Inner

Mongolia. In one, Xiao *et al*. (2004) report on pollen from a core taken at the western shore of the lake, and in the other Li *et al.* (2004) examine pollen from a core taken in the center of the lake. Both of these sequences yielded strong evidence for vegetation changes with the warmer wetter conditions of the Middle Holocene optimum. Xiao *et al.* (2004) provide a Holocene sequence beginning with their Pollen Stage 4 (ca. 10,250-7900 cal. yr BP) which is dominated by arid herbs and shrubs. Throughout this stage there is a trend of increasing tree pollen which indicates conditions were becoming warmer and wetter with the transition to the Middle Holocene. In their Pollen Stage 3 (ca. 7900-4450 cal. yr BP), a very pronounced increase in arboreal pollen culminated in an arboreal maximum at around 6050-5100 cal. yr BP. This lush vegetation complex declined in Pollen Stage 2 (ca. 4450-2900 cal. yr BP) when the woody plants rapidly declined. The vegetation complex at this time period reflected generally cooler and drier conditions with increases in *Artemisia* and Chenopodiaceae. Li *et al*. (2004) present a sequence that is similar with dry steppic vegetation in the Late Pleistocene giving way to a more mesic arboreal vegetation in the Holocene, however their dates are somewhat out of phase with those of Xiao *et al*. and the sequence presented by Li *et al*. indicates warm moister conditions beginning in the Early Holocene with dry conditions returning in the Late Holocene.

Li *et al*. (2003) also examined a Holocene pollen sequence from a 23 m loess/paleosol section at the southern margin of the Loess Plateau near Yaoxian. The upper ca. 4 m contained sediment of Holocene age. The pollen sequence is in line with other proxy evidence for general Holocene climatic changes, but it is also highly relevant to reconstructing the vegetation for the southern Loess Plateau and therefore important for environmental reconstruction that might have directly impacted the inhabitants of the site of Huizui. The Early Holocene portion of their sediment section (Pollen Zone 1, ca. 12,000-8800 yr BP) is dominated by the dryland steppe vegetation of *Artemisa* and Compositae with very small quantities of conifers and broadleaf trees. The trees were probably restricted to the stream valleys and mountains. In Pollen Zone 2 (8800-5300 yr BP) the dryland plants are much fewer and there is a significant increase in deciduous trees such as *Quercus* (oak), *Betula* (birch) and *Corylus* (hazel). Although the counts of tree pollen are high for this locality, they are too low to indicate that the landscape was covered with parkland or forest, so the authors interpret this as representing a phase of humid steppic vegetation. The last pollen phase that is relevant to the period of settlement at Huizui is their Pollen Zone 3 (5300 – 2000 yr BP). It shows a return to much drier vegetation types with a peak of Chenopodiaceae and *Ephedra*. The steppic rather than forest character of the vegetation in the southern Loess Plateau is reinforced by other pollen studies in the region (Sun 1995, cited by Li *et al*. 2003).

These studies provide a good picture of the vegetation in the region as it would have appeared to the Peiligang and later Yangshao populations who moved into this locality. However, the overall vegetation picture is only one part of the story of reconstructing the environmental opportunities for agriculturalists who settled in this region. The other portion would be the landscape and soil associations which would have contributed to a viable agricultural economic strategy.

Feng and An *et al*. (2004, and 2006) compile data from loess sequences and lake cores providing significant evidence for a strong Mid-Holocene moist episode in the northwest Loess Plateau. At the Dingxi site and Sujiawan section, in Gansu Province, they report on an increase in tree and shrub pollen concentrations, an indicator of moister conditions from 8885±55 ^{14}C BP (ca. 8190-7710 cal. BC) until about 3805±45 ^{14}C BP (2400-2010 cal. BC). They compare the Landa and Jiuzhoutai sections from Lanzhou (Zhou *et al*. 1991) and the Sandaogou section from Yulin (Gao and Chen 1993, Gao *et al*. 1996, cited by Feng and An *et al*. 2006) and point to several distinct phases of soil development. Since soils form on stable land surfaces during warm and moist climatic phases, these are used as proxies for the Mid-Holocene Climatic Optimum. The most pronounced soil-forming phase was dated from about 7500-5000 ^{14}C years BP (ca. 6350-3800 cal. BC).

More detailed investigations were undertaken by Feng and An *et al*. (2004) at the Sujiawan section in Dingxi, Gansu Province. Here they looked at the pollen, organic matter content magnetic susceptibility and grain-size distribution from an important sediment section. They identified a widespread occurrence of Middle Holocene swampy sediment deposits in a number of sediment sections from that area. They dated the swamp deposits to a range from ca. 10,000 cal. BP to ca. 4200 cal. BP corresponding to the increase in pollen concentration from the same section. They characterized this Mid-Holocene landscape as one in which there was significantly denser vegetation than that of the Late Holocene, and actively alluviating floodplains, a situation markedly in contrast to that of the last 4000 years in which very little water reaches the modern streams. Today these streams are incised and maintain little or no floodplain activity. These findings have much significance for human / environmental relations in the Middle Holocene and are directly comparable to the landscape setting of the Huizui area of Henan Province.

HOLOCENE LANDSCAPE CHANGES AT HUIZUI

In the vicinity of the site of Huizui, there are a number of sediment sections which provide significant evidence of landscape changes throughout the middle and late Holocene. These geoarchaeological features are very much in line with the climate, vegetation and landscape as outlined above for the general region of the southern Loess Plateau, but in the case of the Huizui sections they can be tied in directly to the archaeological sequences for a direct reconstruction of human/environmental relations through time. The landscape alterations as indicated in these sediment sections would have had a direct effect on the agricultural economy of populations living in this area from the Peiligang though the Erlitou Periods. Three of these sections record a Middle Holocene sequence of major floodplain activity in the Liujian River valley which runs adjacent to the archaeological site. The site itself contains substantial remains of a Late Yangshao Period village (ca. 5000-3000 BC), a Late Longshan Period village (ca. 3000-2000 BC), and an Erlitou Period Town (ca. 1900-1500 BC) (Liu et al. 2004). These settlements are superimposed on an ancient Late Pleistocene terrace of alluvial silts situated about 20 m above the modern level of the Liujian River (Figures. 1 and 2).

The landscape sequence begins with an Early/Middle Holocene soil which appears on the slopes around the site of Huizui as a buried paleosol (see Figures. 3 and 4). This soil sometimes contains the remains of Peiligang archaeological materials and thus is most likely dated to the most widespread period of soil formation which appears in many localities on the loess plateau. This is dated by Feng and An *et al*. (2006) to ca. 7500-5000 C14 years BP (ca 6300-3800 cal. BC). It has a deep clay-rich organic A-horizon and a moderately well-developed B-horizon. It represents a period of at least 3 thousand years of stable landscape conditions with an undisturbed vegetation cover. According to pollen diagrams from other localities on the loess plateau, it is likely that this vegetation cover consisted of moist steppe vegetation on the interfluves with oak, hazel and birch in the stream valleys (Z. An, 2000; Feng *et al.* 2004, Feng and Tang *et al*. 2006; X. He *et al*. 2004).

Geological Sections GS-02-1, GS-02-2, and GS-04-3 at Huizui represent the period of time dating from the Late Yangshao through the Late Longshan periods. They tell a story of landscape disturbance that is quite different from the situation during the Peiligang period. The Peiligang period was characterized by stable stream valleys with steady perennial stream flow. Contrary to this, the streams at the beginning of the Late Yangshao period had a much stronger and more erosive flow. This is illustrated by the massive gravel deposits at the base of the stratigraphic sequence in GS-04-3 which rest unconformably on a truncated floodplain soil from an earlier episode of stability in the stream valley. In contrast, the Late Yangshao period basal gravels are well-sorted and well-rounded indicating strong stream flows through the valley. This situation is mirrored by sections in the nearby Gangou River valley by the site of Zhaocheng where the gravel deposits are several meters thick in places. At Huizui, these gravels consist almost exclusively of large (5 cm) reworked and rounded carbonate nodules indicating that the source material was the eroded Pleistocene paleosols from higher up in the stream catchment. At Zhaocheng, the gravels consist of limestone and dolomite indicating that the source of the stream originated in the Song Mountains. These gravels all sit on an eroded older floodplain deposit which may represent the old Pleistocene or Early Holocene valley bottom.

The stream flows became less powerful shortly afterwards since the upper portions of these alluvial deposits are characterized by finer sediments and occasional thin units of smaller gravels. The fine sediments extend upwards to a thickness of about 15 meters from the base of the valley until just below the present-day surface. They are for the most part clay-rich silts ranging from about 20-28% clay content, and usually contain less than 10% sand. The most significant feature of these fine deposits is their gray color and abundant signs of gleying indicating water-logged swampy conditions. The water-logged and anaerobic depositional environment is further emphasized by their low magnetic susceptibility readings of around 15. This can be contrasted with the nearby Pleistocene loess sections which have a reading of over 100. These low readings show that the ferruginous material in the sediments is reduced rather than oxidized, a condition that also indicates waterlogging in an oxygen-poor depositional environment. These deposits also contain numerous fragments of charcoal, aquatic snail shells, and occasional Yangshao period sherds.

Interspersed throughout these fine-grained sediments are thin gravel units indicating that small streams transected the floodplain. The unique aspect of these gravel deposits is that they contain a very high proportion of cultural material, primarily well-rounded Yangshao period sherds, charcoal, bone and some shell in addition to the stone gravels. Some of these sub-units contain up to 30% gravels and 20-30% sand-sized particles. They generally have much higher magnetic susceptibility readings, up to ca. 60, most likely a function of the sherd material included in the sand-sized fractions of the deposits.

These deposits are bracketed by radiocarbon dates ranging from 5300-5010 cal. BC (^{14}C 6190±45 BP, RTT 5132.4) at the base of the section to 2300-2030 cal. BC (3760±40 ^{14}C BP RTT 5129) and 1530-1320 cal. BC (^{14}C 3170±40 BP, RTT 5131) in the upper portion of the section. This puts most of the dates in the range of the Late Yangshao through Late Longshan Periods with one later date which might have been intrusive. It also means that they are directly analogous to the deposits described by Feng *et al.* (2004) at the Sujiawan Section in Dingxi and therefore represent the changes in hydrology brought about by the increased precipitation and warmth during the Mid-Holocene Climatic Optimum. This alluvial sediment deposition, representing aggrading floodplains and marshy microenvironments in the Mid-Holocene valleys of the Loess Plateau, came to an abrupt end after about 4000 BP, a date which is also reflected in other climatic proxies indicating cooler and drier climatic conditions throughout much of China, but particularly in the north (Feng *et al*. 2006; Li *et al.* 2003, 2004; Lin *et al*. 2006). These landscape and climatic changes had profound effects on societies in the north of China (C.B. An *et al.* 2004, 2005; Huang *et al.* 2002; Liu 2000). However, each society responded to these external stresses in very different ways.

The sediment deposits near Huizui show that the changes in stream hydrology also documented in Gansu Province by Feng *et al*. (2004) were very widespread throughout the Loess Plateau. In addition to this, there is a much more important significance to these sediment

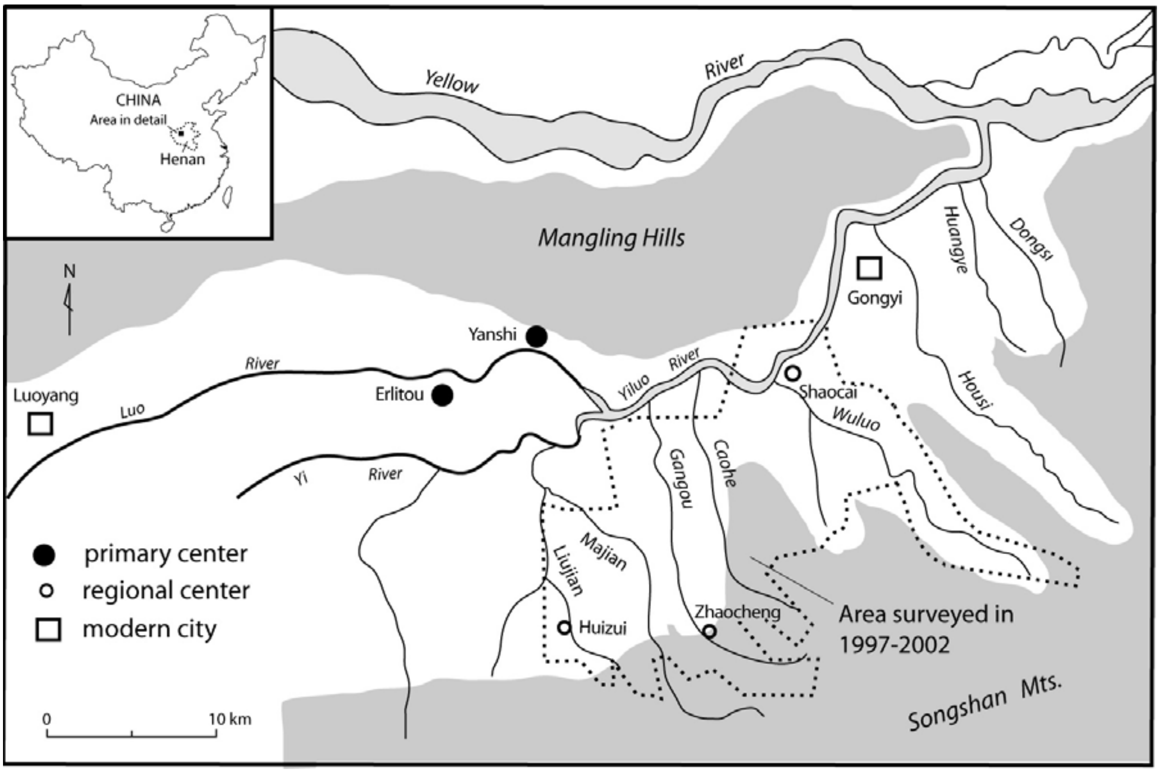

Figure 1. Map showing the location of the Huizui site in the study region (after Liu et al. 2004). Illustration prepared by Wei Ming.

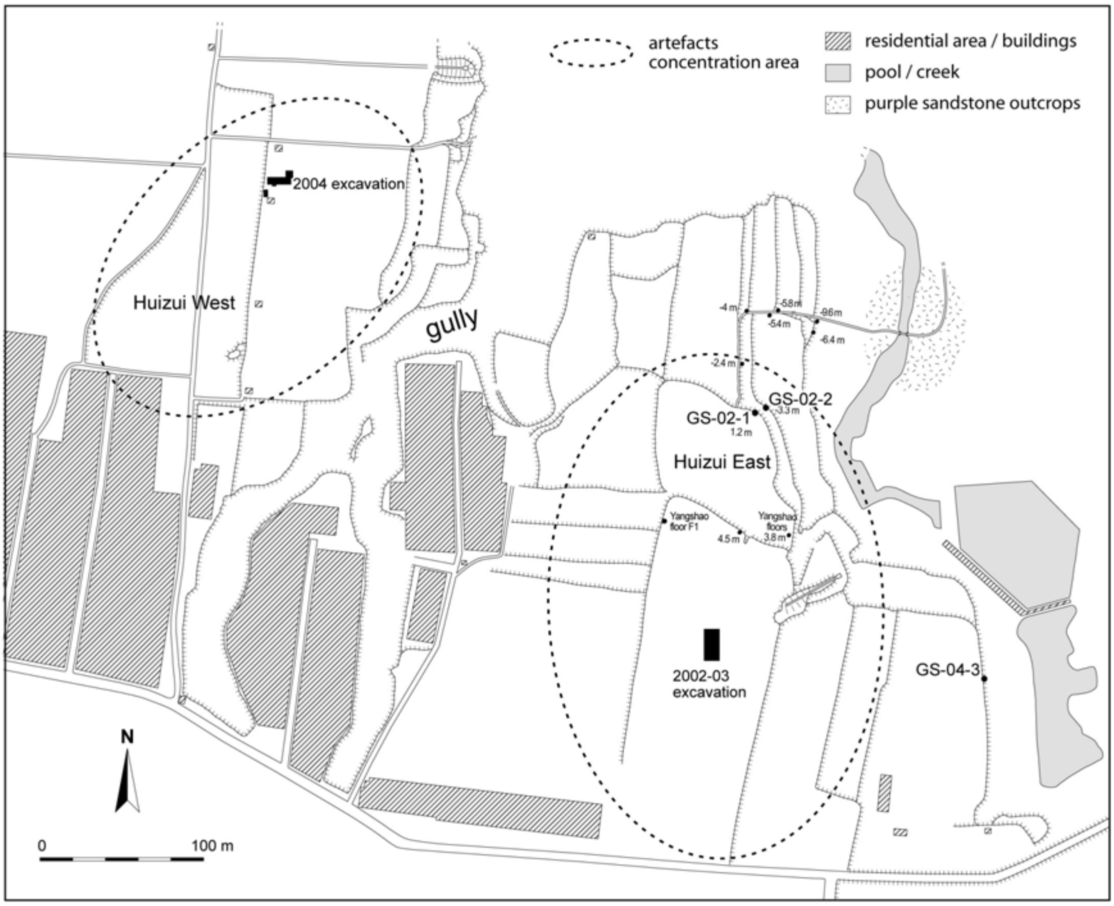

Figure 2. The Huizui site and the location of the Huizui geological sections (Illustration prepared by Anne Ford).

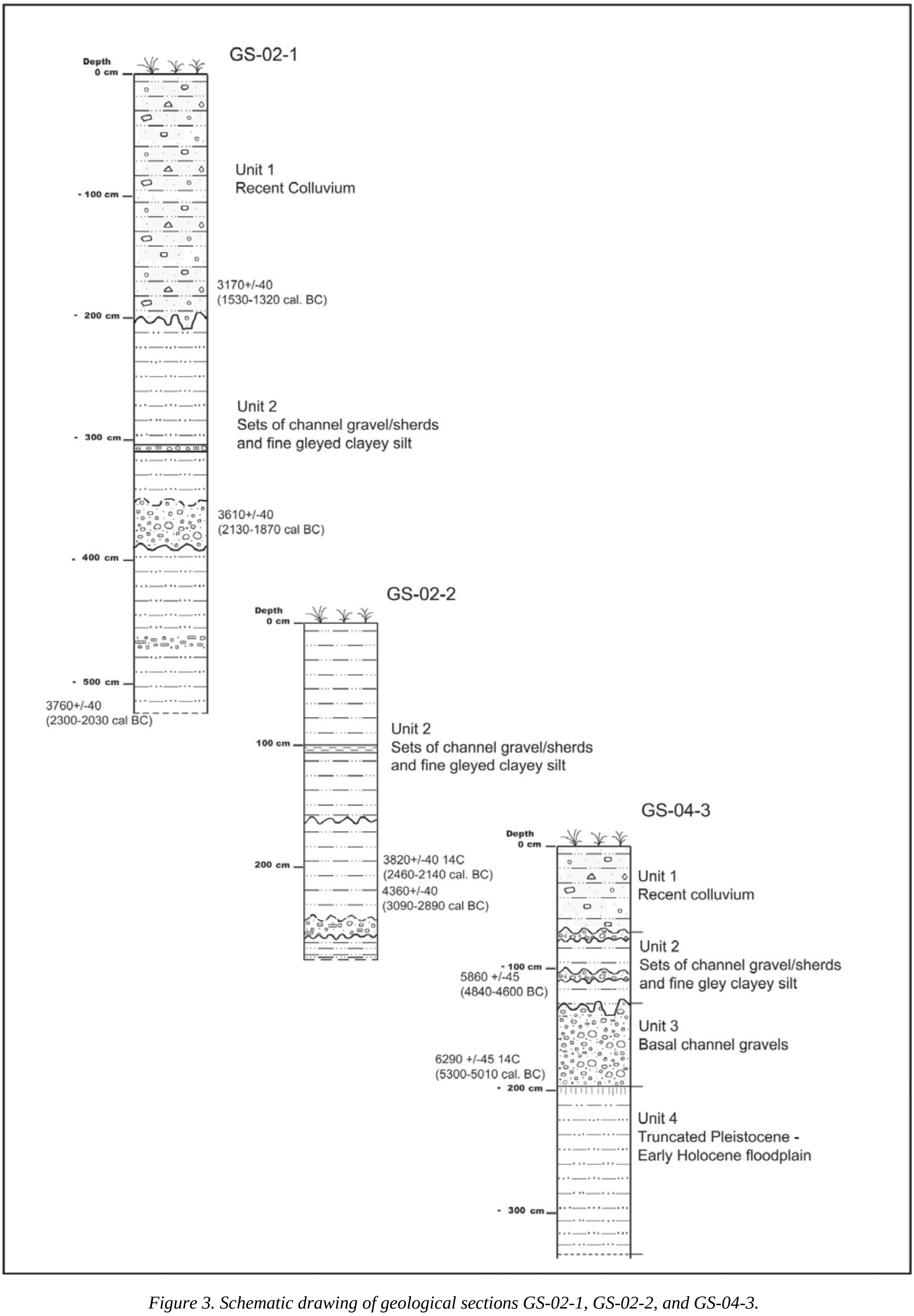

Figure 3. Schematic drawing of geological sections GS-02-1, GS-02-2, and GS-04-3.

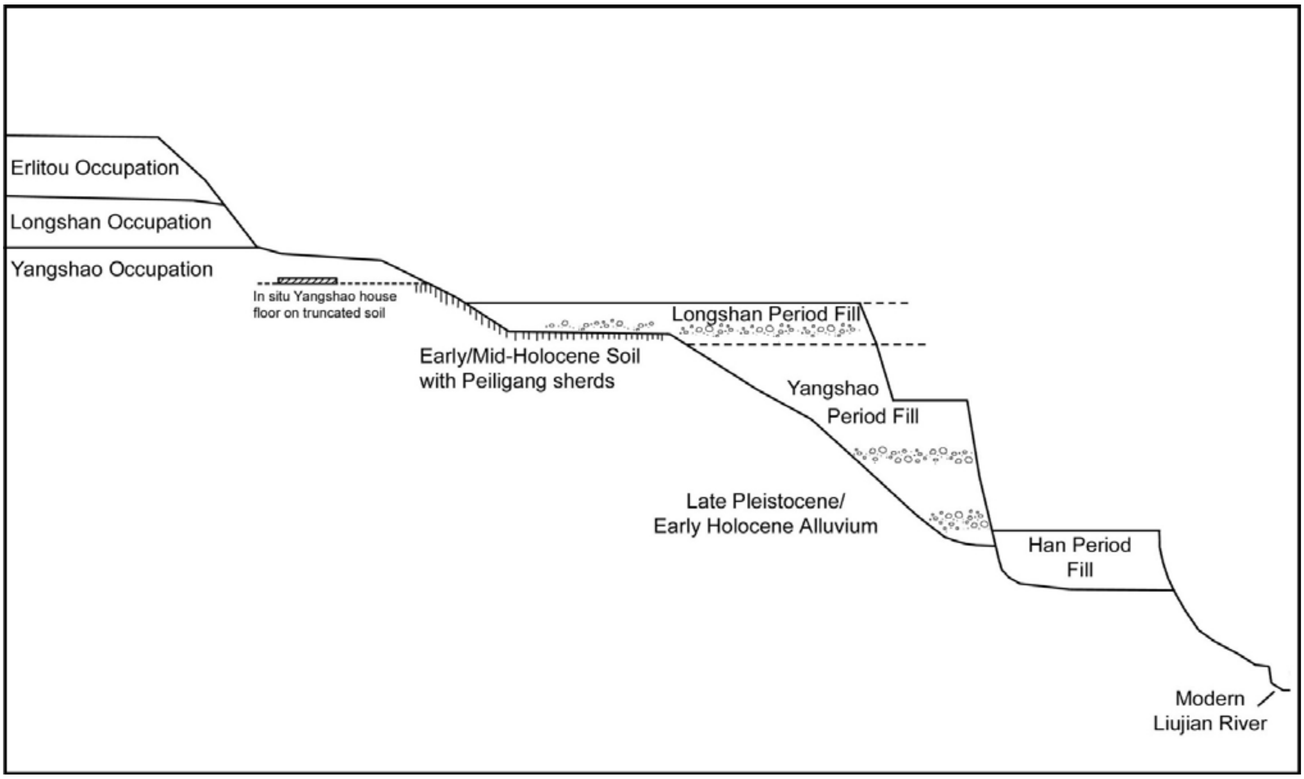

Figure 4. Schematic composite profile of the Luijian River valley by Huizui, outlining the model of Holocene landscape change.

sequences for understanding the human cultural developments of this region. The fact that these deposits contain archaeological materials and are situated in direct association with Late Yangshao and Late Longshan villages is especially noteworthy because it brings the large-scale climatic indicators of the Middle Holocene down to the level of their immediate impact on human settlements.

LANDSCAPE AND SETTLEMENT IN THE YILUO RIVER CATCHMENT

When investigating the mechanisms for the spread of agricultural communities from a core development area, it is worthwhile examining both the push and the pull factors which made this spread worthwhile in terms of social, economic, and technological investment. In the case of China, intensive agriculture in the form of rice paddy farming spread from the southern natural habitat of wild rice, where the date of its earliest appearance is still debated, towards the north at some time within the Yangshao period (Zhang and Wang 1998; Zhao 1998; Fuller *et al*. In press). The profound landscape changes that took place in the stream valleys of the loess plateau during the Middle Holocene would have provided a clear advantage for the spread of paddy farming in particular, and intensive farming in general into the more northern regions. First, the swampy environment would have been a natural draw to wet-rice farmers, providing naturally available land suitable for paddies. Second, the annual flooding of these floodplains from increased stream activity would have provided renewed silts and clays which would have enhanced the fertility of the land. Third, the small perennial streams that crossed the floodplain could have been channeled to feed a network of adjacent paddy plots at a continuous rate, and finally as the V-shaped valleys filled with sediment to the upper levels, there would have been an increasingly broader floodplain, and therefore more flooded land for cultivation. This translates to higher yields and more security and stability in agricultural economic systems of the Late Yangshao populations.

This landscape change provided an attractive “pull factor” for the spread of intensive paddy farming into more northern areas of the Loess Plateau. Since farming is a high-risk enterprise, we should expect it to spread to new regions only when conditions were most advantageous for agriculture. However, there is clearly more to the explanation of the spread of farming into the Loess Plateau than the presence of suitable environmental conditions. If we look at the early dates of the swampy deposits from Gansu, it is clear that the conditions attractive for paddy farming existed from early in the Holocene. However, the widescale spread of rice-farming communities only took place in this area in the Late Yangshao period. This strongly argues for social mechanisms that provide a critical element to the understanding of how agriculture spread from southern regions well within the East Asian monsoonal area in the Middle Holocene, to more northerly areas that would have been on the margins of the summer monsoons. This could have had much to do with the growing population sizes, and the level of social development in Late Yangshao village societies.

The exploitation of these Middle Holocene swampy sediments for their paddy farming potential continued until well into the Late Longshan period as indicated by Longshan period sherds in the upper levels of the section, a radiocarbon date of 2300-2030 cal. BC, and macrobotanical evidence for rice in the Longshan period at the site itself (Lee *et al*. 2007). However, the natural conditions conducive to extensive paddy farming in the stream valleys of the southern Loess Plateau in general and the Liujiang stream valley in particular appear to have ended with the Erlitou period occupation. The final phase of continuous alluvial floodplain build up can be dated at Huizui to sometime after 2000 BC which parallels the evidence from other localities in this region. Feng *et al*. (2004) show the end of swampy floodplain deposits at 2400-2000 cal. BC. At Huizui, the stream then began to incise its former floodplain, cutting through the Middle Holocene (Late Yangshao through Late Longshan Period) sediments, thus leaving the former wet floodplain high and dry, and seriously reducing the amount of farmland that could be brought under irrigation for paddy farming. This does not preclude the possibility of rice cultivation during the Erlitou period at Huizui, but indicates that local production would have decreased.

This hydrological change is related to broad-scale regional evidence for significantly cooler and drier climatic conditions after ca. 2000 BC (cal). This evidence comes from numerous sources including deep-sea cores in the China Sea (Chang *et al*. in press), and many isotope, pollen and sediment profiles from throughout southern and northern China (see for example calibrated versions of dates reported by Dykoski 2005; Peng *et al*. 2005; Zhai *et al*. 2006; W. Zhou *et al*. 2004). The result for the landscape of the southern Loess Plateau was clearly detrimental to the farming potential for the region due to reduction in amount of land that could be irrigated and a decline in field productivity. However, the effect on the communities living there was not necessarily detrimental. Although some authors take a climatic determinist stance and suggest that agricultural societies collapsed due to the economic impact of this widespread drying in the Late Holocene (Yancheva *et al*. 2007:76), others take a more considered look at the situation. C.B. An *et al*. (2004, 2005) for example claim that this drier climatic episode was actually beneficial to the farmers of the northern region, allowing them to expand their cultivation of the traditional dryland crops such as millet.

In the Huizui area, it is worthwhile taking a closer look at the social factors which might have come into play as the agricultural economy was impacted by the effects of reduced rainfall, and the reduction of options for floodplain irrigation of paddy fields, just at a time when populations were growing, settlement numbers were expanding, and there were increasingly more complex settlement hierarchies throughout this region (Liu *et al*. 2004). This seems to be a direct contradiction to a simple climatic determinist model of detrimental climatic conditions leading to collapse. It is also a direct challenge to archaeologists to explain this situation which appears to go against an intuitive approach to human/environmental relationships.

In the case of the Erlitou period expansion in this region, it is worthwhile looking at the broader economic and social factors that contributed to this phenomenon. Liu and Chen (2003) and Liu *et al*. (2004) have pointed to the importance of trade relations at this time for forming a monetary and power base for the emerging elite controllers of this early state society. It is quite possible that the environmental degradation which coincided with the development of this first state in China played a critical role in reducing the economic importance of a subsistence agriculture based economic system, to one necessitating ever increasing trade relations. It is important to note that despite evidence for the reduction of irrigable land after ca. 2000 BC, recent archaeobotanical results indicate an increase rather than a decrease in the amount of rice remains from the Erlitou period at Huizui (G.-A. Lee and L. Liu, pers. comm.). Possible explanations for this could be related to this expansion of trade networks and the enhanced demand for rice on the part of the elite segments of society who were gaining more power, prestige and wealth. Rice could have been imported during this time period, in addition to the employment of more intensive agricultural techniques applied to a smaller land area.

The development of a trade-based economy in response to declining agricultural productivity is only one of many possible options a society might select as a reaction to worsening climatic conditions. Another, could be the use of new crops and changing subsistence patterns. In this sense it may be significant that archaeobotanical remains from the Yiluo survey area show that the first wheat (a high yield dry-farmed crop) appears in this region during the Erlitou Period (G.-A. Lee and L. Liu, pers. comm.). In following these options, the end result led to increasing social complexity and a highly successful society, rather than a possible depopulation and collapse were they to have followed a different strategy of dealing with adverse climatic conditions.

Thus, although climate change and human/environmental relations play an important and even critical role in the development and collapse of human societies, they are not absolute determiners of the direction these societies will take in responding to adverse or beneficial climatic conditions. It is far more productive for our understanding of these essential relationships to take a more nuanced view of human/environmental relationships.

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