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Environmental and cultural change in the Yiluo basin, east-central China

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New archaeological discoveries in Henan Province south of the Huanghe (Yellow) River are revealing the beginnings of Chinese civilization. The Institute's recently appointed geoarchaeologist here describes her involvement in this major interdisciplinary research project.

Some 4000 years ago, on the broad plains traversed by the Yiluo River and its tributaries in east-central China, the first state societies of China may have come into being.[1] There the earliest known site that appears to have functioned as the centre of a state society is Erlitou in the Luo valley east of the present-day city of Luoyang (Fig. 1). It is in a region that was neither as well watered as the valleys in which the cities of the early Mesopotamian and Egyptian civilizations developed, nor as forested as the lands of the ancient Maya civilization of Central America. Unlike these other early civilizations, in the Yiluo region there were no networks of irrigation or drainage canals to help feed the large populations that would have supported the emerging state, but there are many Neolithic and Bronze Age sites that probably contain clues that will help to explain how and why economically, socially and politically complex societies developed very early here.

The geographical setting of the region is also significant because the Yiluo River and its tributaries occupy a vast fertile basin surrounded by the Huanghe River to the north and by mountain ranges on the other three sides (Fig. 1). The advantages of this combination of protective isolation and access along the valleys to other regions are reflected in the role the basin has played in Chinese history, no less than nine dynasties having established their capitals there.

The Yiluo basin project and the environment

In 1998 a project known as the Yiluo Regional Survey was initiated with the aims of locating and recording the distribution of Neolithic and Bronze Age archaeological sites in the region and of attempting to understand the relationships between economic and political networks, increasing social complexity and environmental change.[2] The focus of the project is on an interdisciplinary effort to study the environment, land use and other forms of resource exploitation that supported the emerging state society. My research role is to explore the relationships between environmental change and human exploitation of the landscape in the relatively arid region that hosted this developing society. Were the climate and landscape in the past much the same as they are today or did significant changes take place during the past four millennia? Could rice agriculture, the foundation of Chinese complex society, have been undertaken in this seemingly unlikely setting?

Today the region is primarily a wheat and maize producing area. It has a temperate, subhumid monsoon climate, with annual average precipitation of about 635 mm and the heaviest rainfall in July. The summers are warm (July average 27.8°C) and the winters cool (January average –0.3°C). Topographically the area is characterized by high plateaux of loess (wind-blown silt), most of which was deposited during cold dry climatic episodes that occurred in the Pleistocene period (approximately the past two million years). These plateaux are scored by many deeply entrenched river valleys filled with re-deposited silt (Fig. 2). Over the course of the past 11,500 years (the Holocene period), the valleys have fluctuated between a regime of floodplain building and episodes of downcutting and erosion. During the phases of sediment build-up (alluvial episodes), the valley bottoms were continually renewed with freshly deposited silts and they could therefore be very fertile localities for high-yield grain production. However, during phases when stream-channel incision was dominant, the former floodplains were left high and dry without the benefit of natural irrigation or renewal of silt deposits.

The river valleys critically determined how agriculture was conducted and how people responded to variations in the quality and quantity of crop yields. We need to understand these variations in potential yield when studying the resource base that supported complex societies in the region, and also to compare the evidence of landscape change with the record of crops and cultivation methods derived from archaeological deposits. Therefore, my own research within the project concentrates on two goals:

- to reconstruct landscape changes within the river valleys and to work out their implications for agricultural exploitation
- to investigate the history of agriculture by analyzing micro-botanical remains recovered from archaeological sites identified in the survey.

The two goals require two very different research techniques. The first entails a survey of exposed sediment sections within the valleys, recording their properties in the field, and collecting samples for laboratory analyses and radiocarbon dating. The second requires the collection of small samples of ashy deposits from ancient storage pits that have been exposed in sections cut by roads or streams.

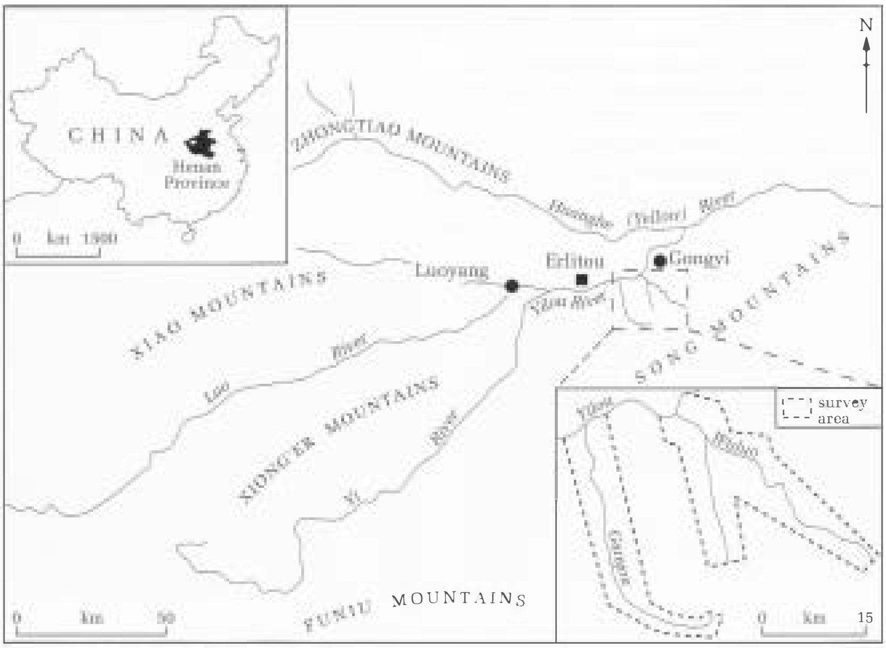

Figure 1 *The Yiluo basin in Henan Province, showing (inset) the area of detailed archaeological survey.*

Ancient settlement in the Yiluo region

As a result of several years of archaeological survey, it is now possible to outline

Figure 2 *Loess plateau dissected by entrenched stream courses in the research area near Gongyi. Henan Province.*

the settlement history of the Yiluo basin from the Neolithic period into the Bronze Age.[3] The survey has focused on two southern tributaries of the Yiluo River, the Wuluo and the Gangou (Fig. 1). The earliest *in* situ evidence of settlement we have located comes from the early Neolithic in what is known as the Peiligong period (*c.* 6100 to *c.* 5700 cal BC).[4] The sites we have found from this period are located in the upper reaches of the Wuluo and the middle region of the Gangou drainages. They suggest a scatter of possibly seasonal camps and at least one household complex, and the finds from them imply a mixed economy of agriculture, hunting and the gathering of wild fruits.

There is evidence of a sizeable increase in population in the succeeding Neolithic Yangshao period (*c.* 4800 to *c.* 2800 cal BC). Foxtail millet (*Setaria italica*) was the major staple cereal, but rice appears at a Yangshao site, Huizui, in the Yiluo basin survey area.[5] This find prompts us to ask whether environmental changes took place that allowed the cultivation of rice to increase during the Yangshao period; whether new groups of people brought different forms of agriculture from the south; or whether other social and economic factors led to the changing agricultural strategies at this time?

In the late Neolithic Longshan period (*c.* 2800 to *c.* 2000 cal BC), our survey data indicate a reduction in the number of sites in the earliest part of the period, followed by a relatively large increase in both the number and size of sites in the later part. Population density appears to increase further in the early Bronze Age Erlitou period (*c.* 1900 to *c.* 1500 cal BC), and there is evidence that settlements were organized more hierarchically. It appears that, by then, a much more complex form of social and political organization, approximating to a state society, had developed.[6]

Botanical evidence for agricultural change

Evidence for the types of crops cultivated at the Neolithic and early Bronze Age sites comes from two different sources: macrobotanical data gained from the study of charred remains of seeds recovered from ash pits and refuse heaps (middens), which, however, are not always well preserved and often provide only an incomplete record; and the micro-botanical remains of fossilized plant materials known as phytoliths.[7]

Phytoliths are silt-size silicified particles of plant epidermal (outermost) tissue, which are often preserved in sediments (Fig. 3). They retain the shape of the individual plant cells and are identifiable at different taxonomic levels of classification, such as family, genus and species.[8] Some of the preliminary results of our phytolith analyses indicate that, although millet agriculture was prevalent in most periods, the cultivation of rice began in the Yiluo region as early as the Late Yangshao period (*c.* 3300 to *c.* 2800 cal BC). This discovery constitutes the earliest known occurrence of rice cultivation this far north, and it suggests either that climatic conditions were then more conducive to rice cultivation than in later periods or that irrigation technologies were adapted to this drier and cooler environment, which was well north of the natural habitat for rice. A similar problem exists for the Longshan-period sites, where there is also evidence that rice was commonly consumed. The occurrence of rice in midden deposits and pit infillings from the later more politically advanced Erlitou period might be indicative not of its local cultivation but of the existence of extensive trade networks initiated by the preference of the elite for rice over the more common millet. Was rice an imported luxury product or was it environmentally possible to cultivate it in this primarily millet region throughout the Neolithic and the Bronze Age?

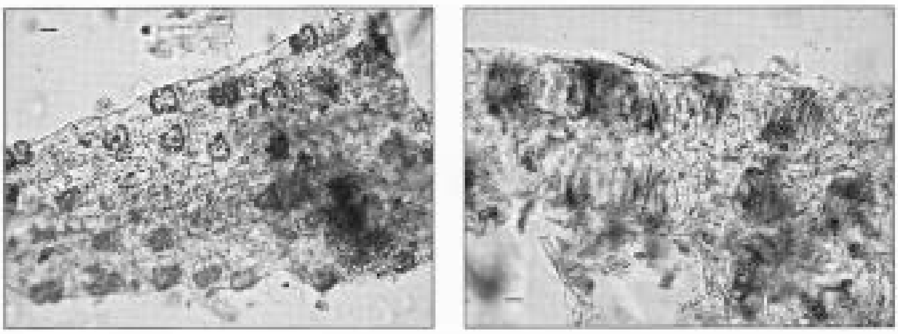

Figure 3 *Phytoliths from Neolithic sites in the Yiluo basin: (a) silicified leaf tissue similar to that of millet (*Panicum miliaceum*) from the Longshan period site of Sigou South (b) silicified husk of a rice grain (*Oryza sativa*) from the Yangshao period site of Huizui (scale bars 10 micrometers).*

Landscape change and agriculture

Geoarchaeological reconnaissance in both the Wuluo and the Gangou river drainages has revealed major landscape changes in the area that may have had a significant impact on subsistence economies in the Yilou region throughout the history of settlement there. Today these two drainages are dry along most of their courses through much of the year. This is partly because reservoirs have been built upstream and capture runoff from the Song Mountains, partly because of the use of water for irrigation, and partly because of lower water tables under the present dry climatic conditions. It is difficult to imagine these valleys as having contained major rivers, but the remains of high gravel terraces lining the banks in the upper reaches are witness to major streamflows in the past.

The basic pattern of drainage was formed during the Late Pleistocene period by the erosive force of runoff over the easily eroded loess plains. Once these valleys appeared, they were alternately filled and incised, leaving behind a record of climate and landscape changes that provides us with valuable data for reconstructing past environments. One of the earliest deposits of stream sediment is a terrace about 15 m high, composed of fine-grain silts that have been dated, from associated Late Palaeolithic artefacts, approximately to the end of the Pleistocene, when small bands of hunter–gatherers roamed the loess plains in search of wild resources. These deposits represent an actively building floodplain associated with a quiet perennial stream and well-vegetated steppe grasslands.

An episode of severe downcutting followed, which left the stream systems deeply entrenched. This may have been the result of the greatly lowered water tables that accompanied the *c.* 1500 year-long episode of cool dry climate that occurred across much of the northern hemisphere and is known as the Younger Dryas stadial. It lasted from *c.* 13,000 to *c.* 11,500 cal BP and was followed by the much milder Holocene period. In the Yiluo region a phase of landscape stability ensued that was characterized by well-watered valleys, gentle perennial streams and marshy bottom lands. This phase probably corresponds with the earlier part of the mid-Holocene episode of warmer and wetter conditions known as the Climatic Optimum. It was this more hospitable landscape that was first colonized by the mixed millet-farming and hunting populations of the Neolithic Peiligang period.

In the Neolithic Yangshao period the landscape underwent further dramatic changes. The streams deposited silts at a faster rate than previously and again began to fill the valleys with fine-grained flood deposits. The presence of occasional archaeological remains buried in situ suggest that this renewed deposition was seasonal and allowed human activity to take place on the floodplains in the drier parts of the year. Perhaps it is not coincidental that our first good evidence for rice cultivation appears in the phytolith record of this period. Whatever the cause of these hydrological events, whether they are attributable to climatic change or to the human impact on the landscape that caused erosion in the uplands and deposition on the floodplains, the valleys were now naturally irrigated and probably more suitable for rice cultivation than they had been in the past. This environmental change coincided with the demands of an increasingly complex society for higher-status foods such as rice.

At some time during or at the end of the Yangshao period, the streams ceased to build up their floodplains and began a phase of renewed downcutting, which left the former floodplains high and dry. This corresponded with a drier and cooler climatic episode that followed the mid-Holocene Climatic Optimum. At present we can only speculate on the impact this would have had on the irrigation farming of rice. Preliminary phytolith studies at selected Longshan-period sites in the region still indicate the presence of rice at the sites, but we do not know if the rice was cultivated at these locations, or if trade networks were well enough established to make the importation of rice an economically sound option. Another possibility is that more advanced techniques were developed to irrigate ricefields, involving methods of raising water to the level of the floodplains. However, we have not found any archaeological evidence for such irrigation farming. The reduction in the number of sites in the early Longshan period may be related to this deterioration of the environment, and the recovery evident in the later Longshan may reflect new adaptations to the less hospitable environmental conditions. Longshan people may have introduced more advanced irrigation technologies that are no longer visible because of later erosion in the river valleys. Cultural complexity continued to develop throughout the Erlitou period, but there is no evidence that it was accompanied by an environmental change to more hospitable conditions.

Conclusions

The interdisciplinary research undertaken by the Yiluo project is an attempt to examine the role of environmental change in the process of increasing economic, social and political complexity in the region during the Neolithic and the early Bronze Age. Rather than being a forcing mechanism, environmental changes presented both opportunities and challenges to the societies inhabiting the region. Groups at different levels of social, economic and technological development responded in their own ways to these changes. In the Yangshao period there were opportunities for rice cultivation that may not have existed previously. However, the benefits of the hospitable environment of that time did not extend into the later periods when social complexity increased. The early Bronze Age civilization, as witnessed at the site of Erlitou, faced new challenges in feeding large settled populations, which may have been met with both social and technological innovations.

Notes

1. Archaeologists recognize archaic state societies by the existence of centralized government and of social stratification into two or more classes (e.g. commoners and a ruling elite). Evidence ofthe former comes from the remains of administrative buildings and of the latter from differentiated burials with and without grave goods.
2. The project is led by Liu Li (La Trobe University, Melbourne), Chen Xingcan (Chinese Academy of Social Sciences) and Lee Yun Kuen (Harvard University); L. Liu, X. Chen. Y. K. Lee, H. Wright, A. Rosen, "Development of social complexity in the heartland of Chinese civilization: Yiluo region settlement patterns", submitted for publication.
3. Liu et al. (cited in *n.* 2 above).
4. All the radiocarbon dates cited in this article are calibrated: see *p.* 2 of *Archaeology International 1997/98* for an explanation of calibrated and uncalibrated dates.
5. A. Rosen, report in preparation.
6. See L. Liu, "Settlement systems, chiefdom variability and the development of early states in north China", *Journal of Anthropological Archaeology* **15**, 237–88, 1996.
7. Work on phytoliths from sites in the Yiluo basin is being conducted by Zhao Zhijun (Chinese Academy of Sciences) and myself.
8. See A. Rosen, "Phytolith analysis in Near Eastern archaeology", in *The practical impact of science on Aegean and Near Eastern archaeology*, S. Pike & S. Gitin (eds), 86–92 (London: Archetype Press, 1999) and A. M. Rosen, "Preliminary identification of silica skeletons from Near Eastern archaeological sites: an anatomical approach", in *Phytolith systematics: emerging issues*, G. J. Rapp & S. C, Mulholland (eds), 129–47 (New York: Plenum, 1992).