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**Variations in the Upper Paleolithic Adaptations of North China:
A Review of the Evidence and Implications for the Onset of Food
Production**

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<a>Abstract<a>

The Upper Paleolithic (UP) of North China has the richest archaeological data and longest history of research in the Paleolithic archaeology of China, but there is a relative lack of systematic studies addressing human adaptations. This paper explores the spatial and temporal variability of human adaptations in terms of mobility, the key variable in the adaptive systems of hunter-gatherers. We find that before the UP, little adaptive differentiation is shown in the archaeological record of North China. The early Upper Paleolithic (EUP) is distinguished by four distinctive modes of mobility and subsistence organized roughly along lines of habitat variation. These modes persisted in the Late Upper Paleolithic (LUP), underlying the widespread prevalence of microblade technology throughout North China. This pattern significantly influenced adaptive changes during the transition from the terminal Pleistocene to early Holocene. Earliest food production emerged in hilly flank habitats where EUP

mobility decreased quickly and social organization was more complex. This retrospective view of UP adaptations highlights the important role that prior conditions played at the evolutionary crossroads of prehistoric North China.

<a>Keywords<a>

Upper Paleolithic; North China; Adaptation; Lithic Technology; Mobility

<a>Introduction<a>

The Upper Paleolithic (UP) was a watershed in human evolution, a time when genetically modern humans colonized all continents except the Antarctic and adapted to diverse habitats from plateaus to coasts. At the same time, the UP also foreshadows the end of the era of foraging-dominated lifeways, and the cultural trajectory of the Holocene was certainly influenced by the prior state of UP cultural processes. The expansion of archaeological research in North China in recent decades, including new chronological sequences, paleo-environmental data, and especially lithic artifacts and modes of their analysis, offers a new opportunity to examine the Upper Paleolithic in fresh perspective.

Research design and results for Upper Paleolithic in China have been influenced by contingencies of discovery as well as changing research objectives that have influenced the state of our knowledge today. For many years, UP studies in North China were dominated by a paradigm of lithic techno-typology that was used to reconstruct a cultural-historical framework at a regional scale (Qiu et al. 2013). More recently, studies have begun to pay attention to topics such as "behavioral modernity" (Gao et al. 2010; Gao 2014; Li et al. 2014; Norton and Jin 2009) and cultural exchanges between the west and the east sides of Eurasian continent (Hou 2005; Huang et al. 2009). The theme of adaptation has been only marginally addressed in several studies (e.g., Gao and Pei 2006; Madsen et al. 2007),

thus not much is known about adaptive strategies and tactics of UP foragers of North China. In addition to constraints imposed by paradigms, our knowledge is also limited by variable preservation and the conditions of the archaeological record. The social turmoil of the past century in China has also profoundly influenced the quality of fieldwork, methods used, and ability to report and publish archaeological research. Consequently, it is largely impractical to make detailed quantitative comparisons of individual artifact assemblages. Yet it is still within our power to provide a large-scale, holistic view of available materials for the benefit of researchers interested in this archaeological record, and attempt to frame research questions regarding its significance. In this review, we will discuss the current state of our knowledge about the UP in North China, including a summary of major UP archaeological discoveries and materials. We will also briefly examine the prior evidence from the pre-Upper Paleolithic and emerging information about the Early Upper Paleolithic. This information will be synthesized to identify patterning indicative of adaptive changes of the UP to evaluate the major, yet variable, adaptive transformations that announce the onset of Early Holocene food production.

<a>Upper Paleolithic foraging: an adaptive perspective<a>

Adaptation for modern humans involves problem-solving using physical and

cultural strategies. The mechanism of culture, an extrasomatic means of adaptation (Binford 1962), has predominated since the late Pleistocene. Human cultures are characterized by time-transgressive accumulation and inter-generational transmission (Tomasello 1999), thus human adaptation is the outcome of past processes that condition for a repertory of alternative responses, and the ways that repertory is deployed to meet emerging challenges. For our topic, we need to consider both aspects: the long-term process in human adaptation that forms the backdrop of conditions for events we wish to study, and dynamic problem-solving tactics that are used to meet present challenges. The former involves cultural sequences derived from the archaeological record of past human adaptation. The latter is related to hunter-gatherer ethnographies, which provide crucial reference information for hypothesis creation.

With the exception of foraging societies adjacent to exceptionally resource-rich environments (for example the densely populated and sedentized foraging cultures of the Pacific Northwest Coast in North America), hunter-gatherers like those of Pleistocene North China faced with changing ratios of consumers to resources (from increasing local population densities, climate or environmental change, and so forth), can offset resource stress with adaptive strategies like increasing mobility, broadening diet spectrum, storage, exchange, sharing, and intensifying key resources (e.g., Bettinger 1991; Kelly 1995, Binford

2001). Among these strategies, mobility plays a critical role. Mobility offers not only the resources needed for food and technology, but is also critical to vital information about local conditions generally (e.g., climate, environment, potential mates, allies, trading relationships, etc. [Binford 1983; Yu 2015]). As hunter-gatherer mobility is diminished, so is the feasibility of making a living exclusively from wild resources. The significance of mobile foraging to hunter-gatherers is analogous to food production among traditional farmers and market economy to modern societies: it is a key causal variable that influences settlement patterns, social organization, and even ideology. Further, mobility can be assessed using archaeological indicators (e.g., lithic materials and site structure and distribution), as compared to paleo-demographics or even climate change.

Of the materials that are used to study UP adaptations, human remains are no doubt the most direct in that they can reveal diet, health condition, strength, life expectancy and other proxies that are relevant to human adaptation. However, human remains from this period are still very rare, especially in North China. Sometimes other biological materials such as faunal and floral remains can reflect ecological conditions and food sources. Nevertheless, these species must be firmly associated with human activities, which is rare at the archaeological sites of North China. For example, 77 faunal species found in the Gulongshan site were all

attributed to human hunting, although only several somewhat ambiguous stone tools have been uncovered (Zhou et al. 1990). It is likely that humans were only one of several formational agents for these large deposits of animal bones.

Fortunately, there is a large body of lithic material accessible to Paleolithic archaeologists, not only durable but highly variable. These lithics preserve different orders of temporality in their acquisition, manufacture and discard (Gamble 1999: 125). They are not only typological, but simultaneously conceptual, technical and economic (Perlès 1992: 224). Experts on lithic analysis have developed conceptual frameworks (e.g., Bleed 1987; Hayden et al. 1996) and many exemplary studies on large-scale phenomena like global microlithization (Elston and Kuhn 2002). These works help to incorporate lithic technologies with mobility. In addition, organic residues on stone tools may also provide extra information about the resources which these tools were used to process. Related work has begun with UP materials from North China (Guan et al. 2012). Sometimes lithic materials are found *in situ* with other artifacts such as organic tools, ornaments, and hearths. These objects constitute spatial patterns in site organization, which may indicate the organization of mobility. Binford's model (1980) for foragers versus collectors presents a useful framework for explaining the spatial patterns of North China's UP materials, and more significantly, could partly explain post-Pleistocene

adaptive frameworks along a continuum of persistence of hunting and gathering to the initiation of food production.

Using an evolutionary perspective, Clark (1969) devised a rough five-mode summarization of lithic technologies over the world. Shea's updated lithic categories (2013) presents a new nine-mode scheme, more logically rigorous albeit at the expense of simplicity and the evolutionary perspective. He notes that the appearance of a new technology does not necessarily replace the prior one, but rather may add more technological resiliency in solving problems. With these considerations in mind, we will see a prominent feature in the evolution of lithic technology: that is, the growing prevalence of UP blade and microblade technologies (in the paper it means pressure-flaked microblade) trends toward increased portability and maintainability of stone tools. Composite tools with stone insets are evidently useful in increasing mobility of foragers (Goebel 2002). Global microlithization in the later Paleolithic could also represent this trend (Elston and Kuhn 2002). Interestingly, lithic technologies of the Neolithic period are precisely reversed from UP lithics, in that durability of tools in sedentary situations becomes more important than portability. This was coincident with the transition from hunting-gathering to food production, to be discussed in detail later in this paper.

To date, certain patterns in UP adaptations are commonly held among

archaeologists although they also acknowledge wide variations in different regions. One noteworthy consensus is the emphasis on big-game (e.g., herbivore) hunting. In an evolutionary sense, this represents a long-term tendency toward energy maximizing; that is, obtaining as much energy as possible in the shortest time duration through use of technology and other means. Big-game hunting not only brings large packages of highly ranked foods, but also can help able individuals acquire mates or prestige through the mechanism of costly signalling (Grimstead 2010). The ability to hunt large-body-sized game through the use of sophisticated technology and logistically organized groups is more relevant to fully modern humans (Binford 1988). Globally, this behavior appears to ebb and flow in the UP; the archaeological record of Italy, for instance, suggests that human hunters intensified hunting returns by preying on slow growing animals (e.g., turtle) and agile small animals (e.g., hare), probably as a density-dependent response of intensification (Stiner et al. 1999, 2000). With the wide-spread extinctions of big game species at the end of the Pleistocene, human hunters had to change their food preferences, with attendant changes in the hunting toolkit.

In sum, we assert that lithic variability is closely related to mobility of human foragers. Both the weight and functional effectiveness of stone tools are variables that cannot be overlooked in the process of mobile foraging, which in turn influences lithic form and function.

Lithics therefore can reflect adaptive characteristics, and help to identify patterning indicative of adaptive change. By examining lithics, site organization, and faunal remains at a regional scale as in North China, we can explore the UP adaptations of hunter-gatherers from a mobility perspective.

<a>Setting the stage: Adaptations before the UP<a>

An ambiguous Middle Paleolithic

As a foundation to North China's UP adaptations we first address the basic characteristics of their antecedents -- although these can be hard to pin down due to uncertain dates and geological contexts. The validity of the 'Middle Paleolithic' in North China has been repeatedly questioned (Gao 1999; Gao and Norton 2002; Norton et al. 2009), with increasing justification, in our view. One example of this ambiguity is the Middle Paleolithic site of Xujiayao (Jia et al. 1979), whose distinctive lithic assemblage includes thumbnail-shaped scrapers, end scrapers, notched scrapers, proto-prismatic cores, and a large number of spheroids. The Xujiayao toolkit may also include antler tools, as cut and saw marks were found on some antler stems. These characteristics are also common to the UP, e.g., Ulan Moron (Wang Z. et al. 2012). Xujiayao dates vary, with associated faunal remains used to derive an estimate between 60kya and 30 kya but subsequent U-series dating to as early as 120 - 100 kya (Chen 1988; Chen et al. 1982, 1984). Finally, a subsequent date indicates an

age of only 50 kya (Norton and Gao 2008). Interestingly, associated hominid fossils exhibit primitive anatomical traits comparable to Archaic Homo (*H. erectus*) (Wu 1980).

A recent Middle Paleolithic discovery in Lingjing (Li 2007, 2010; Li and Dong 2007) revealed a rich assemblage of lithic artifacts and faunal bone specimens as well as plausible bone tools exhibiting use microwear (Li and Shen 2010), but the only date at Lingjing comes from the faunal assemblage (which resembles that of the Xiujiayao site). A better-documented site at Zhijidong cave has two cultural components: earlier layers (8, 9) characterized by a chopper and chopping tool industry; and upper layers (1 to 7) radiocarbon dated between 50 and 40 kya that are dominated by a small flake tool industry manufactured from quartz and flint (Zhang and Liu 2003; Wang 2008).

Similarly, recent excavations at Ulan Moron in Inner Mongolia uncovered a lithic assemblage of small flake tools dated from 70 kya to 30 kya using OSL and radiocarbon methods (Wang Z. et al. 2012). The researchers regard this site as a new manifestation of the Middle Paleolithic in North China, but some of the lithic artifacts show intentional basal retouch similar to that used for hafting. In sum, the so-called Middle Paleolithic sites of Xiujiayao, Lingjing, and Ulan Moron have certain characteristics generally used to define the UP, and the dates are not certain. For this reason we feel that the Middle Paleolithic

is a problematic concept. However, because the term Early Paleolithic (*sensu* Gao and Norton 2002) extends further than the period of this study, we will use the term pre-Upper Paleolithic (pre-UP) to describe the period of interest from about 100,000–30,000 years ago.

Describing and explaining pre-UP lithic variability

Many Paleolithic studies emphasize spatial and temporal techno-typological differences as a means of distinguishing culture areas, then tracing so-called cultural connections between regions. For several decades the pre-UP stone tool industry of China has been divided into two systems: North China and South China (Zhang 1987). The South China system is characterized by the chopper and chopping tools tradition (Wu et al. 1989; Wang Y. 1997), with occasional reference to the large flake cleaver-trihedral point tradition. North China is further divided into another two sub-systems: the Kehe-Dingcun tradition and the Zhoukoudian-Shiyu tradition (Jia and Wei 1976). There is also some reference to the small boat bottom-shaped scraper and burin tradition. In general, variation in sizes of lithic artifacts is ascribed to regional differences in vegetation. That is, larger stone tools would be used in forest environments, whereas smaller ones would be preferred in grasslands (Wang 2012). This argument implies that large stone tools were used to cut trees or manufacture other organic tools (e.g., bamboo tools

[Pope 1989]).

However, the rapid increase in discoveries of archaeological materials in recent decades provide detailed results from across wider expanses. These new discoveries suggest that two so-called industrial traditions existed concurrently in the same area. In the Luonan basin of Shaanxi, the cave site Longyadong is dominated by a flake tool industry consisting of light duty tools and tens of thousands of flakes, but completely lacks heavy duty tools (Wang et al. 2004; Wang 2008). In contrast, several hundred open-air sites in the same area are characterized by an Acheulean-like industry (Wang 2007) consisting of heavy-duty tool types such as handaxe, pick, cleaver, spheroid and chopper. This is reminiscent of the relationship between the Clactonian and the Acheulean in England (Ashton et al. 1994): for years these were regarded as two traditions, but were then discovered in the same level at a single site. The European case suggests that, rather than habitat characteristics like vegetation type, stone tool forms are strongly conditioned by accessibility and quality of raw materials, site function, and immediate circumstances and technological demands. The case of Luonan likely invalidates the dualistic classification of lithic industries in North China.

In rejecting the former scheme we can view extant data in a new light: in the well-known Zhoukoudian site (Loc.1), stone tools produced from

blocky blanks account for 56.8 percent of the tool assemblages at the early stage, and still comprise 26.1 percent in the late stage (Pei and Zhang 1985). Heavy duty tools include varieties of choppers, some of which could also be termed as cleavers, picks or even handaxes. The designations depend on the taxonomy and the extent of rigor in classification criteria. Whether the Paleolithic of North China has handaxes or not has long been subject to debate (Gao 2012; Huang 1987; Lin 1996). About 100,000 years later than Loc.1, the representative "Middle Paleolithic" site of Zhoukoudian Loc. 15 (Jia 1984) has a lithic assemblage that is definitely smaller, but still contains heavy duty tools like spheroids, cleavers and choppers (Gao 2001).

Another site known for small stone tools is Xujiayao. In the site report, Jia and Wei (1976) claim two traditions in North China: the Xujiayao site represents the smaller tool tradition, and Dingcun site the larger. Interestingly, three years after the report's publication, a new excavation at Xujiayao revealed a rich array of heavy duty tools including more than a thousand spheroids (Jia et al. 1979). Meanwhile at Dingcun, the type site for the large tool tradition, smaller light-duty tools in fact account for 32.86 percent of assemblages from twenty "Middle Paleolithic" localities (Wang 2014). Thus evidence from Xujiayao and Dingcun also contradict the argument for the so-called two lithic tool traditions. The lithic products from low-quality quartz are certainly

very small. In contrast, where there are high-quality gravels, as in the Luonan basin, an experimental study suggests that a set of tool blanks, large or small, could be obtained with the simple method of throwing sizeable nodules onto anvils (Chen and Chen 2015). Different tools would be manufactured according to the forms of blanks and immediate technological needs.

Lithic tools are task-oriented products designed to solve actual problems. Raw material, weight, and form directly influence tool portability, flexibility and efficiency in use. Hunter-gatherers of the UP would have resembled ethnographically known hunter-gatherers in that their mobility demands would to some extent condition the features of stone tools. Highly mobile foragers who are faced with a high degree of uncertainty and risk would prefer portable, high-quality, flexible tools rather than weighty heavy-duty tools. Other environmental conditions such as rugged topography and dense vegetation would also influence the mobility of hunter-gatherers. Among these factors, subsistence and resource density are strong conditioners, with hunting-dependent foragers generally more mobile than those dependent upon plants (Binford 2001). North China habitats show a general increase in grassland from south to north, thus the availability of ungulates and the proportion of hunting in subsistence would also increase. This corresponds with the lithic industry of abundant scrapers and burins. But North China is also

geographically a mosaic, especially in the wooded upper valleys which have denser vegetation as well as large gravels. Here, heavy duty tools could therefore be made and used, as shown in Dingcun (Wang et al. 1994; Wang 2014) and Luonan basin (Wang 2007, 2008; Wang et al. 2004). Thus we argue that the very mobility of hunter-gatherers would have permitted movement across ecotones to access a variety of North China habitats, thus lithic tools are not expected to vary strictly according to vegetation zone but rather with functional demands and raw material availability.

Several basic features characterize the pre-UP lithic industries of North China. Few exotic raw materials have been found; most come from riverbeds and floodplains near occupation sites. Secondly, both heavy and light duty stone tools co-exist in the same sites. The relative proportions largely depend on accessibility of raw materials, topography, vegetation as well as subsistence. Thirdly, stone tools show a wide range of variation in form. Many scrapers are found in each assemblage, but they are lack invasive retouch, as seen in Zhoukoudian loc. 15 (Gao 2000, 2001a). The utilization of raw materials is not economical in that there are few finely retouched tools (Gao 2001b). According to Binford's differentiation between curated and expedient technology (Binford 1980), these pre-UP industries seem to resemble the latter. The Acheulean-like industry of Luonan basin consists of a wide variety of tool types with

some seemingly definite forms, but all could be produced quickly in a very simple manner (Chen and Chen 2015). In a word, pre-UP lithic industries reflect short-term technological responses to immediate circumstances. The adaptations represented by these materials are not indicative of specialization and the organization of residential mobility is also simple, unlike the complex features seen in the Chinese UP.

<a>The Upper Paleolithic of North China: Discoveries, Dates and Stages<a>

It is important to remember that the concept of the UP of North China was established using the European model as a frame of reference, with a beginning date presumed at c. 40 kya (Tang and Gai 1986). In *Early Humankind in China*, the classic work on Chinese Paleolithic archaeology and paleoanthropology published in 1989 (Wu et al. 1989), Salawusu is described as the earliest UP site in North China. Salawusu typifies the small tool tradition of North China, inherited from Zhoukoudian Loc.1 and Loc. 15. Salawusu also exhibits new characteristics including pressure retouch technology (Huang 1989; Huang and Hou 2003). However, recent infrared thermoluminescence dating for the Salawusu site has yielded a date of no later than 70 kya (Yin and Huang 2004), younger than a prior thermoluminescence date of 124 - 93 kya (Dong et al. 1998) but older than the radiocarbon date of 35 kya (Li et al. 1984) and the U-series date 50 - 37 kya (Yuan et al. 1983).

At this time, relatively reliable dates for the early UP of North China come from Zhoukoudian Upper Cave (Pei 1940; Chen et al. 1989, 1992), Shiyu (Jia et al. 1972; Yuan et al. 1993), Wangfujing (Li et al. 2000), Shuidonggou (Jia et al. 1964; Li et al. 2013; Madsen et al. 2001; Morgan et al. 2014; Nian et al. 2014a; Ningxia Institute of Archaeology and Cultural Relics 2003; Pei et al. 2012; Peng et al. 2012; Wang et al. 2007), Xiaogushan (Huang and Fu 2009; Zhang et al. 2010), and recently excavated sites such as Laonainaimiao, Zhaozhuang and Huangdikou (Wang J. et al. 2012; Wang and Wang 2014) (Figure 1). Of the above, Upper Cave AMS upper levels date as early as 28 kya, and the date of the lowest component is 34 kya, believed to be more consistent with the faunal assemblage (Chen et al. 1992). Another important UP site, Shiyu, excavated in the 1970s, was dated by AMS to about 32 kya (Yuan 1993), earlier than its conventional radiocarbon date of ca. 28 kya (IA-CASS 1983). Similarly, new dating techniques like OSL (optically stimulated luminescence) used in the Xiaogushan site has changed the earliest date of its UP layer (layer 2), from ca. 43 kya (Huang and Fu 2009), to nearly 50 kya (Zhang et al. 2010).

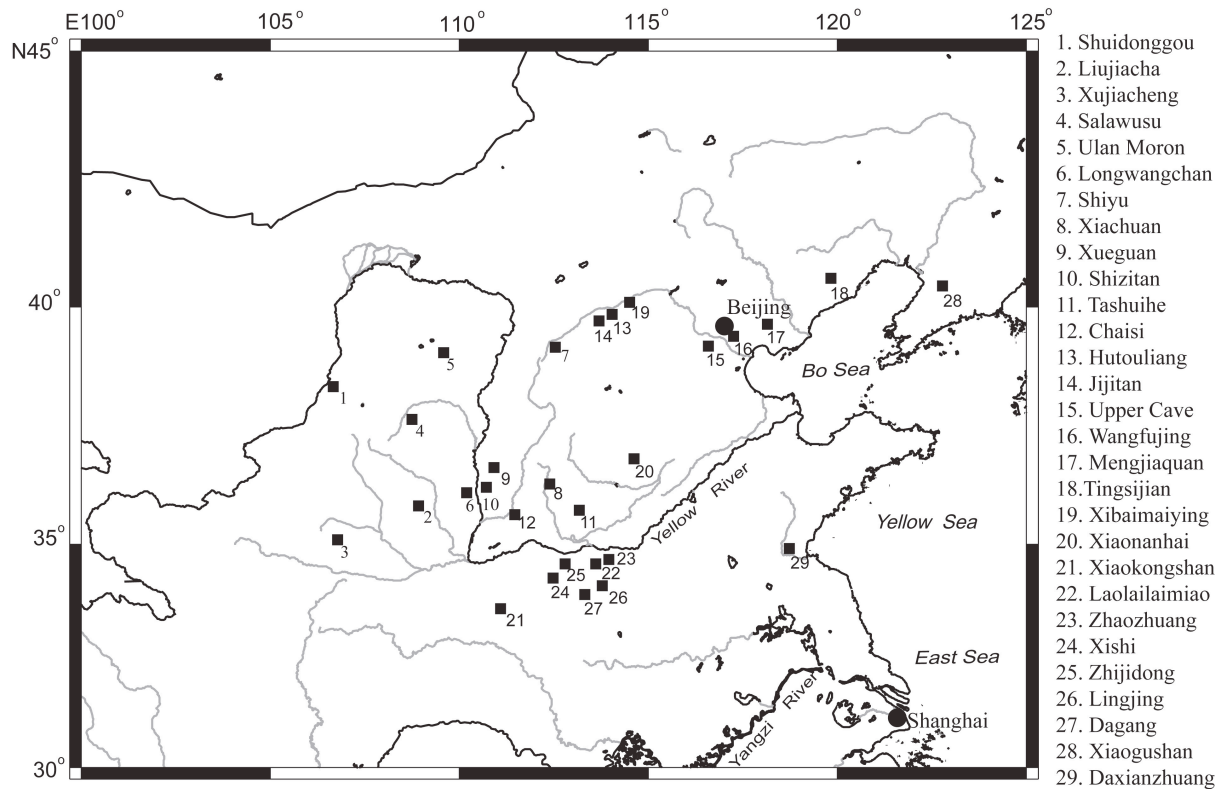


Figure 1. The major UP sites of North China

The Shuidonggou site has a long research history. Its major component is characterized by blade technology dated to between 29 and 24 kya (Madsen et al. 2001). However, new radiocarbon dating on bones found in original contexts suggests that Shuidonggou is probably older, since blade technology shows up in the lowest cultural layer (CL7) of Loc. 2, dated up to 41 kya by AMS and OSL (Chen et al. 2012; Gao et al. 2013; Liu D. et al. 2009), and Locality 1, dated up to 43 kya (Morgan et al. 2014;

Nian et al. 2014a). The blade industry represented at Shuidonggou has long been an unusual case, with similar remains found only in Ningxia basin and the Hetao region (the big bend area of Yellow River). New fieldwork suggests that the Shuidonggou techno-complex, which also includes Levallois technology and some Mousterian artifact types, extends eastward along the Mongolian grassland (Wang et al. 2010) and reaches the Korean Peninsula (Seong 2009). Moreover, in southwest China, the Dahe site has also yielded lithic artifacts characteristic of Levallois technology, thus having Mousterian affinities. The AMS and U-series dates for Dahe are within the range of 36 - 44 kya (Ji 2007).

According to the techno-typological classification system, UP stone tool industries of North China have been grouped into two categories: "small tool tradition" and "small flake tool - blade/microblade tradition" (Zhang 1987). These categories have also been adopted for the UP of Korea (Seong 2009) although the categories vary slightly (e.g., "small tool tradition", "blade technology" [Huang 1989], "microblade technology", and others [Li 1993]). Following Clark's five-mode system of lithic technology (Clark 1969), the North China UP assemblage would include at least three industry types: flake (Mode III), blade (Mode IV), and microblade (the latter corresponding to Clark's microliths or Mode V). According to Shea's classification scheme, North China's UP assemblage includes flake and blade (D) and microblade (D4) categories.

However, temporal-spatial relationships among the industries are not clearly demonstrated by these systems of classification. In general these industries are thought to be regional variants of the UP that were distributed variably in time. Nevertheless, in the case of Shuidonggou, blade technology existed in the same area with small flake tools, interestingly, the latter replaced the former (Chen et al. 2012; Pei et al. 2012; Li et al. 2013).

The small flake tool industry, the most traditional and prevalent lithic technology of early UP North China, was gradually replaced by microblade technology. The latest date for the small flake tool industry comes from the Xibaimaying site at 18 kya (U-series dating), but this date should probably be earlier based on other aspects of the site (Xie and Yu 1989). Other small flake tool industry sites are similar to Zhoukoudian Upper Cave (originally radiocarbon dated to 18 kya, later corrected to 28 kya and 34 kya). One typical site of this industry, Xiaonanhai, has upper strata (layers 2 and 3) dating as early as 11 ± 0.5 kya. However, An (1965) found no difference in lithic materials between the upper and the lower layers (layer 6, dated about 24 - 19 kya), thus he grouped them together typologically -- the younger Xiaonanhai lithic materials may actually have originated in the lower layers. In sum, there are no reliable data to suggest that the small flake tool industry persisted until 18kya.

As far as microblades are concerned, discoveries in Shizitan (Shi and Song 2010; Shi et al. 2002; Song and Shi 2013; Xie et al. 1989; Yuan et al. 1998; Zhang 1990), Longwangchan (Yin and Wang 2007; Zhang J. et al. 2011) and Xishi (Wang and Zhang 2011) show that the earliest microblade technology appeared in the southern part of North China as theoretically predicted by co-author Chen (Chen 2008). Three radiocarbon dates at Xishi cluster around 22 kya, fairly close to the OSL dates (Wang and Zhang 2011). One exception is a single earlier radiocarbon date for microblade technology that comes from Chaisi 77:01 site in Shanxi Province, at 26.4 ± 0.8 kya or earlier than 40kya (Wang et al 1994), but the geological context is still in debate. The newest fieldwork at Xishahe (Guan, personal communication), Xiachuan (Du, personal communication) and Youfang (Nian et al. 2014b) extend the earliest microblade technology to ca. 27 kya, with some even earlier dates. Nevertheless, most of sites with microblade technology date later than 22 kya, around the Last Glacier Maximum (LGM). In other words, the major components of this technology existed in rudimentary form before the LGM, but became dominant only afterward. Ultimately the microblade industry overwhelmingly replaced all variants of early UP industries of North China (Table 1).

Table 1. Late Pleistocene archaeological sequences and major sites of North China

Time (kya)	Stage	Major Sites
ca. 25 - 10	Upper Paleolithic Late Upper Paleolithic (LUP)	<i>Microblade Technology</i> : Chaisi; Dagang; Daxianzhuang; Hutouliang; Jijitan; Lingjing Longwangcan; Shizitan; Tingsijian; Xiachuan; Xishi; Xueguan
ca. 45/50 - 25	Early Upper Paleolithic (EUP)	<i>Blade Industry</i> : Shuidonggou <i>Small Flake Industry</i> : Laonainaimiao; Liujiacha Mengjiaquan; Salawusu; Shiyu; Shuidonggou; Tashuihe; Ulan Moron; Upper Cave; Wangfujing; Xiaogushan; Xiaonanhai; Xiaokongshan; Xibaimaying; Xujiacheng; Xujiayao; Zhaozhuang; Zhijidong
ca. 120 - 45/50	Middle Paleolithic	Longyadong; Gezidong; Lingjing; Zhoukoudian loc.15

References not mentioned in the text

Dagang (Zhang and Li 1996); Jijitan (Xie 1993); Lingjing (microblade technology, see Zhou 1974); Xueguan (Wang et al. 1983); Mengjiaquan (Xie et al. 1991); Taishuihe (Chen 1989); Xiaokongshan (Wang et al. 1988); Gezidong (Gezidong Field Team 1975)

<a>The Process of UP Adaptations<a>

The Emergence of UP in North China

From the ambiguous Middle Paleolithic record to the distinctive Upper Paleolithic, North China underwent a revolutionary change - not only in lithic technologies and forms but in the face of culture itself. A suite of new characteristics emerged that are comparable to the western regions of the Eurasian continent (e.g., west Asia and Europe). Together, these cultural and technological innovations constitute a clear picture of revolutionary change at the onset of the UP (Table 2).

Table 2 The Upper Paleolithic innovations of North China against the Western Eurasia (Mellars 2005)

Western Eurasia	North China
Improved (punch-struck) blade and bladelet technology	General size reduction in stone tools; finer raw materials; blade technology;
New end-scraper and burin forms	Finely retouched end scraper, thumb-nail scraper, and burin
Increased “imposed form” in tool manufacture (appearance of new “type-fossil” forms)	As shown in end scraper, backed knife and other formal tools; pressure retouch
Complex, highly shaped bone, antler and ivory tools	Harpoons of Xiaogushan; bone awls of Shuidonggou; bone needles of Upper Cave
Appearance of personal ornaments (perforated teeth, marine shells, shaped stone, and ivory beads)	Ornaments found in nine sites in North China, ochre found in Wangfujing, Upper Cave, Shuidonggou and Lingjing
Appearance of complex and varied art forms (engravings, sculptures, cave paintings)	Antler bars of Upper Cave, possible rock carvings of Shizitan
Appearance of symbolic “notation” systems	Inscribed bones of Wangfujing and possibly Shiyu, Shuidonggou
New musical instruments (bird-bone flutes)	Not found
Long distance distribution and exchange networks (for marine shells, high quality stone, etc.)	Finer flint of Shuidonggou (CL2) probably exotic; seashells of Upper Cave
Improved projectile technology	e.g., “arrowheads” from Shiyu
Rapid changes in technological patterns	Very distinctive from earlier lithic industries
Increased population densities	Larger size of sites; more site complexes
More highly structured occupation sites	more complex site structure, e.g., Shuidonggou, Laonainaimiao
Increased “specialization” in some animal exploitation patterns	e.g., a large number of caprid bones found at Shiyu

Many, if not most, technological innovations are difficult to discern in the archaeological record. For instance, UP hunters most likely employed intensified capture technologies such as traps, nets and poison, but most elements would have been organic. New DNA analyses and archaeological evidences suggest that the UP foragers probably hunted with help of dogs (e.g., Germonpré et al. 2012; Larson et al. 2012) but

the earliest archaeological evidence of domesticated dogs dates only to 10 kya, found in the incipient Neolithic site of Nanzhuangtou in North China (Xu et al. 1992). In any case, it is not possible to know the date of the first use of dogs as hunting partners (versus camp followers).

Another example of UP intensification is the discovery of antler harpoon points at Xiaogushan, indicating the utilization of aquatic resources. Fishing diversifies subsistence -- sometimes spectacularly, as with anadromous fish migrations - and requires sophisticated multi-component toolkits. Formal bone and antler tools that facilitated mobility and dispersal in harsh climates appeared in the UP: the bone awls of Shuidonggou and bone needles of Zhoukoudian Upper Cave were likely used to make fur or leather clothing for cold Late Pleistocene winters (Yi et al. 2013).

Among the many innovations of the UP, the most important aspect of tool technology is hafted composite tools which are shown in the general size reduction in stone tools, as well as more likely in the blade components of Shuidonggou and the finely retouched small tools of Shiyu. Hafted tools are characterized by reduced time needed for repair and replacement, as well as more flexibility in dealing with different tasks such as batch processing of food. Blades and microblades are generally produced to replace cutting edges or tips of hafted tools. Easily replaceable cutting tools would help reduce risk in losing time-sensitive

resources (e.g., meat, fish) that require rapid processing.

Key adaptive features of the UP reflected by lithic technologies of North China show several tendencies.

(1) UP foragers, particularly in the LUP, made use of extensive foraging ranges in that they used the lightest microblades to facilitate tool transport and economical use of high quality raw materials. This may relate to resource reduction and fluctuation in the LGM, or/and reduced access to lithic raw material sources due to population packing in desirable areas of the landscape (Barton et al. 2007).

(2) UP foragers stressed multi-purpose functions of tools to cope with uncertainties of foraging a diverse range of resources across an extensive range of mobility.

(3) They also sought to reduce tool manufacture and repair time by hafting tools to process seasonal or contingent resources quickly or in batches. This in turn reduced total handling time.

(4) Durability was less important than portability and flexibility in the UP toolkit, likely because foragers did not stay long in residential camps.

In the UP of western Eurasia, the archaeological record indicates a broad spectrum of prey, including small terrestrial animals like hare and aquatic resources such as fish and mollusks (Stiner et al. 1999). A roughly similar intensification sequence is seen from the Early to Late

UP of North China, where faunal assemblages show a decrease in the average size of animal prey and increased degree of bone fragmentation. However, contrary to expectations of expanding diet breadth with resource intensification, the number of prey species decreases. Evidence of these tendencies is fairly clear in EUP sites of Shiyu, Zhoukoudian Upper Cave, and Xiaogushan, which contain abundant faunal remains. Comparatively, the faunal remains found in LUP sites of Shizitan (Shi and Song 2010; Shi et al. 2002; Song and Shi 2013; Xie et al. 1989; Yang et al. 1998; Zhang 1990), Hutouliang (Gai and Wei 1977), and Xiachuan (Wang et al. 1978) are poor and mostly fragmentary. However, site function and post-depositional processes can also influence the composition and preservation of faunal assemblages: for instance, animal bones at Shuidonggou are fragmentary and relatively scarce but eight species of large animals are represented (Ningxia Institute of Archaeology and Cultural Relics 2003).

Except for the above comparisons, the UP is generally marked by clear developments in social organization, information transmission, and belief systems. With regard to social organization, the UP evolved into greater maturity in individual identity, self-consciousness and social exchange networks (Gamble 1999), which are reflected archaeologically in personal ornaments, exotic artifacts and raw materials, and regionalized styles of lithic technologies and assemblages. These

features are seen in North China, including the presence of personal ornaments at nine sites. Transmission of language in the UP is indicated by archaeological discoveries of symbolic notation. In this regard North China does not yet have many discoveries, with the only suggestive evidence being marked or inscribed animal bones at the sites of Wangfujing (Li et al. 2000; Feng et al. 2006), Xiaogushan and Shiyu. Inscribed marks have also been detected microscopically on a stone found at Shuidonggou (Peng et al. 2012) although their significance is unclear.

Belief systems are indicated archaeologically by various evidence for art, especially cave painting, rock art, carvings and so on. To date, Western Europe is home to the most spectacular discoveries, which seem to reach their apex prior to the termination of the last ice age. To a large extent, these types of artistic expression seem to be specific to certain environmental and cultural circumstances (Straus 1995). In North China, the polished antler bar unearthed in Zhoukoudian Upper Cave (Pei 1940) and rock art found in Shizhitan (Xie et al. 1989) are tantalizing clues, but the rock art remains undated and we do not know what the antler bar symbolized.

Adaptive specializations of the Early Upper Paleolithic

So far, archaeologists have not found adequate evidence to confirm that modern *H. sapiens* were the sole authors of the Upper Paleolithic "revolution." We do know that humans entered new and unfamiliar habitats

such as the Americas, and regionalization of human adaptations became more apparent. This process is comparable to adaptive radiation among other species, in that expansion into new habitats conditions for increasingly diverse characteristics adapted to local demands and opportunities. In North China, the evolutionary pattern of the Late Pleistocene/Early Holocene is manifested in four phases: (1) diversification of adaptations in the EUP; (2) development and widespread diffusion of microblade technology in the LUP; (3) expansion of human populations into more marginal habitats throughout the UP; and (4) initiation of food production in the terminal LUP.

In the EUP, foragers equipped with new technologies had expanded into unfamiliar habitats that were marginal for humans. For instance, humans colonized Siberia during this period, reaching the extremely cold zone of 55°N (Hoffecker 2005). There is an even more extreme northern site, Yana RHS, at 71°N, dated to 27 kya (Pitulko et al. 2004). In North China, EUP people moved into marginal environments where resources generally were scarce, including the western plateaus, desert margins, grasslands of Inner Mongolia, and boreal coniferous forests of Northeast China. In Shuidonggou, foragers using blade technologies lived in the ecotone between grassland and desert, where ostriches persisted. Similar sites have also been found in the northwestern margin of North China including Liujiacha (Xie 1982), Xujiacheng (Li et al. 2012) in Gansu. Moreover,

EUP foragers appear to have reached the fringe of Tibetan Plateau (Madsen et al. 2006), represented in Xiao Chadam (Huang et al. 1987) and Lenghu Loc. 1 (Brantingham et al. 2007).

In the UP of North China, hunter-gatherer subsistence was not homogeneous: in the EUP alone there were at least four subsistence patterns evidenced at Shuidonggou, Shiyu, Wangfujing and Xiaogushan (Figure 2, Table 3). This division springs from diverse local habitats and associated cultural-ecological adaptations, varying site organization, artifact inventories and faunal assemblages. The first EUP pattern, the Shuidonggou, demonstrates adaptation to the relatively marginal environment between forest-grassland and desert, where primary productivity is low because of aridity (although the paleoenvironment probably was warmer and wetter than at present [Gao et al. 2008]). The site organization of Loc. 2 shows a pattern of open-air distribution with the debris scatters in the northwest (Chen et al. 2012), indicating that the wind blew from southeast. Shuidonggou site could have been used in summer when the southeast summer monsoon prevails. In this cold, dry environment, foragers focused subsistence on terrestrial hunting rather than gathering. The Shuidonggou lithic assemblage is characterized by a blade industry indicative of high mobility, and multiple occupations of this site reveal a pattern of repetitive, ephemeral occupations.

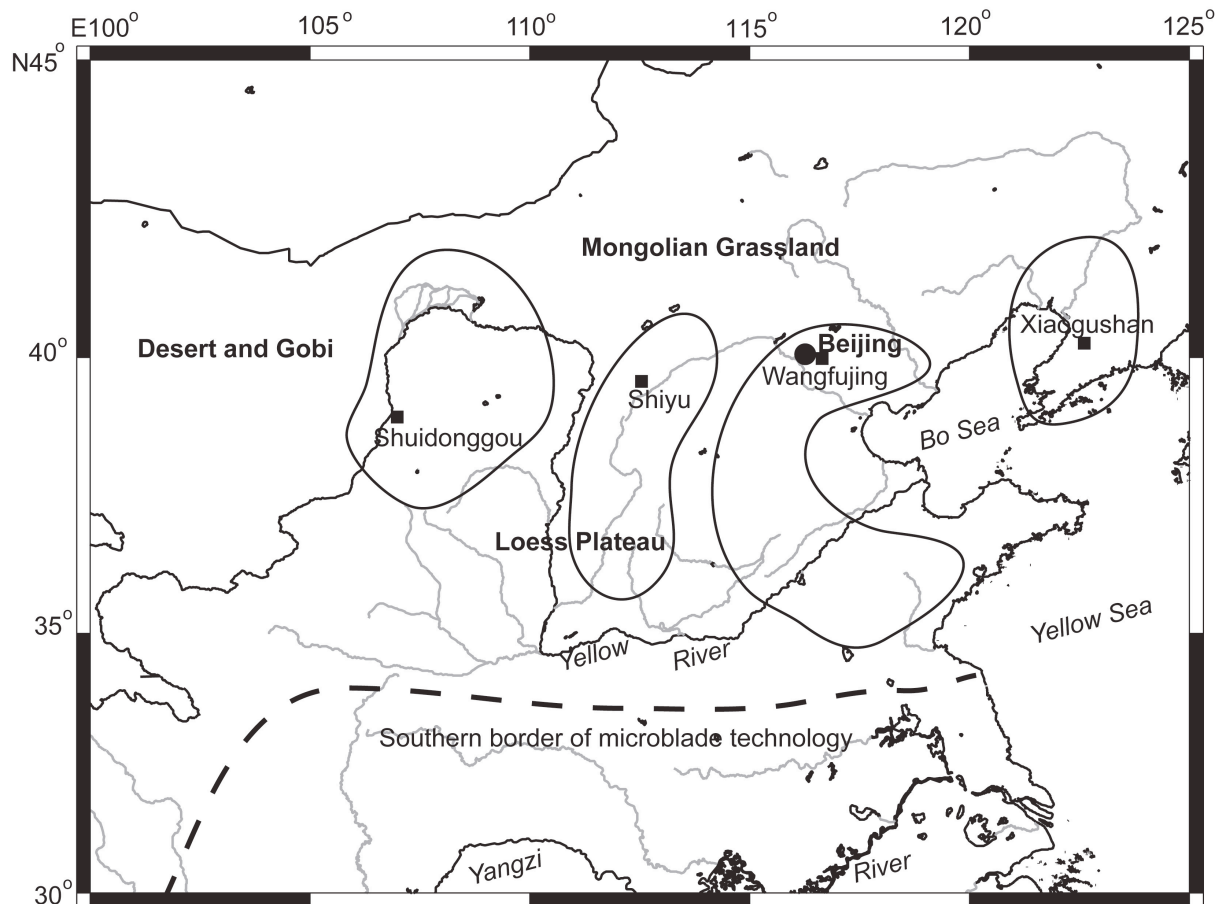


Figure 2 Four adaptive patterns of North China during the EUP

Apparently Shuidonggou was in a desirable location. Site structure in each component is basically the same, and a few similar localities in the vicinity probably represent residential foraging type mobility within a certain territory, *sensu* Binford (Binford 2001). Moreover, recent residue analysis for stone tools from Shuidonggou Loc. 2 is suggestive of a "broad-spectrum revolution", as starch grains of wild wheat (*Triticeae*) have been detected

on some tools. The damage pattern in samples of plant remains is consistent with grinding and heating of seed foods (Guan et al. 2012). Foragers coped with this kind of marginal environment by expanding their range and food spectrum to cope with scarcity and unpredictability of resources.

Table 3 about here

Table 3 Four major sites representing adaptive patterns of North China

	<i>Shuidonggou</i>	<i>Shiyu</i>	<i>Wangfujing</i>	<i>Xiaogushan</i>	
Location	38°21'N; 106°21'E	39°25'N; 112°17'E	39° 55' 26"N; 116°25' 8"E	40°34'53"N; 122°58' 3"E	
Altitude	1200m asl. (above sea level)	1230m asl.	50m asl.	150m asl.	
Geography	Margin of Muus Desert	Loess Plateau	Hilly flank with plain	Low-hilly land of Liaodong Peninsula	
Paleoenvironment	Steppe savanna Warmer and wetter than the present	Steppe with shrubbery Colder than the present	Steppe with conifer forest Colder and drier than the present	Conifer forest Warmer and wetter than the present	
Date (BP)	Loc.1, 36200 ± 140 (layer 3), AMS ¹⁴ C; 22000 ± 2000~46000 ± 3000, OSL Loc.2, 34395 ± 625 cal. (upper CL7); 41445 ± 213 (lower CL7) cal., AMS ¹⁴ C	28945 ± 1370, ¹⁴ C 32220 ± 625, AMS ¹⁴ C	24240 ± 300 (upper layer), ¹⁴ C 24890 ± 350 (lower layer), ¹⁴ C	33360 ± 666 cal. ¹⁴ C; 39982 ± 1623 cal. ¹⁴ C; 40400 ± 3500, TL; 31700 ± 2400~50100 ± 3600, OSL	
Indicators of mobility	Tool assemblage	>10000 lithics; high-quality flint of CL2 probably exotic; blade technology coexistent with flake tools; 1 bone needle	15000 lithics; raw materials including quartz, quartzite, jasper, siliceous limestone, and igneous rocks; fine retouch; microblade-technology-like	1098 lithics; flint dominated, from river bed; small flake tools; a generalized assemblage	12226 lithics; raw materials from local sources; 1 antler harpoon, 3 bone needles; diverse lithic assemblage including both heavy and light tool
	Site organization	Loc.2, 11 hearths (CL1-4), open-air site	Burnt stones and bones, open air site	6 hearths, open-air site	cave site
	Faunal remains	Loc.2, very fragmentary, mostly from a highly mobile fauna including wild horse, wild ass, and gazelle	12 species; >5000 teeth, most from wild horse (MNI=120) and onager (MNI=88, and other 400 milk teeth)	Six species, a forest-steppe fauna including <i>bos</i> , deer, ostrich, hare, fish, peasant;	40 species from two layers; forest species dominated

Notes:

Shuidonggou: loc. 2 site report (Chen et al. 2012); loc.1 AMS date (Peng et al. 2012); OSL date (Nian et al. 2014); loc. 2 dates (Liu et al. 2009); paleoenvironment (Gao et al. 2008). CL:

cultural layer

Shiyu: site report and paleoenvironment (Jia et al. 1972); the upper layer date (IA-CASS 1983); the lower layer date (Yuan 1993).

Wangfujing: site report and dates (Li et al. 2000); Lithic analysis (Feng et al. 2006); paleoenvironment (Mo et al. 2000).

Xiaogushan: site report, paleoenvironment and dates (Huang and Fu 2009; Zhang et al. 2010), all the dates from layer 2. TL: thermal luminescence

The second subsistence pattern, termed the Shiyu, corresponds to a habitat with higher primary productivity: the forest-grassland zone. Terrestrial game and wild plant food resources were more accessible than at Shuidonggou. A more diverse lithic assemblage includes arrowheads and exquisitely retouched scrapers. The rich faunal assemblage consists of nine herbivore mammal species and three others (two carnivores and one rodent), but is dominated by horse (*Equus przewalskii* Poliakov) and Mongolian ass or onager (*Equus hemionus* Pallas), with an MNI of 120 and 88 individuals respectively (Jia et al. 1972). A similar faunal assemblage at Salawusu has more than 300 antelope horns representative of at least 150 individuals (Huang and Hou 2003). Both assemblages indicate that hunting grassland animals was a major subsistence activity. The brief report for Salawusu mentions an ash layer about 2.5 cm of maximum depth along with a large number of stone artifacts and faunal remains, and some burned stones in a cultural layer at 0.9 - 1.5 m depth. These archaeological remains probably resulted from redundant use of the site.

The third pattern, called Wangfujing (Dongfang Plaza), is marked by the most diverse lithic assemblage and probably longest duration of the four patterns. This subsistence adaptation was located in the temperate deciduous forest zone (Mo et al. 2000), where plant food gathering is expected to be more productive than the former two pattern areas.

Generalized foraging was more favored, and is reflected in remains found

at sites such as Wangfujing, Upper Cave, Laonainaimiao and Xiaonanhai. These EUP faunal assemblages are more diverse than those of Shiyu and Salawusu, where one or two species predominate. Furthermore, intense fieldwork in Henan Province in the past decade suggests some differentiation of sites (Wang and Wang 2014). For instance, Laonainaimiao was likely a base camp, where diverse and abundant lithic and faunal remains have been revealed around hearths, up to ten in Layer 3B and six in Layer 3F (Wang 2012). Zhaozhuang was a site specially used for ritual activities. A skull of wild elephant (genus *Palaeoloxodon*) was intentionally surrounded by large purple quartzite rocks that had been transported from a source five kilometers distant. A nearby site, Huangdikou, is a location that could have been used temporarily for butchering or other activities, as only one hundred artifacts were found in excavations (Wang et al. 2009). The mobility of foragers in the Wangfujing adaptive pattern seems to be lower than the Shuidonggou and Shiyu.

The fourth EUP subsistence pattern, Xiaogushan, corresponds with a colder, more humid forest environment (Huang and Fu 2009). Aquatic resources are prominent, unlike other UP sites. Fishing tools including harpoons have been found in Xiaogushan toolkits. All other things being equal, subsistence marked by aquatic resources is more stable, which implicates mobility that is at least seasonally tethered to aquatic

resource areas (e.g., rivers, estuaries, etc.) and probably lower overall (Binford 2001). Although fishing in the EUP is not comparable with central place-based foraging of riparian resources for which the earliest evidence is about 11 kya (e.g., at Angangxi [Chen 2012]), this EUP adaptive pattern does initiate a new and significant lifeway. The utilization of aquatic resources eventually became predominant in Northeast China (*ibid.*). The tool assemblage from the Xiaogushan cave site encompasses both heavy and light-duty tools which were involved with the forest environment, and with lower foraging mobility.

In sum, from west to east, we show that the subsistence and mobility of EUP foragers changed from terrestrial hunting-dominated to mixed hunting and gathering (more hunting in Shiyu), to foraging focused on aquatic resources. These patterns represent an interesting geographic spectrum of foraging intensification, predicated on the different constraints and opportunities offered by the varied habitats of North China.

Microlithization of the Late Upper Paleolithic

Current evidence suggests that microblade technology first emerged in North China not long before the LGM, and then may have diffused into North Asia, the Japanese archipelago, and North America (Elston and Kuhn 2002; Kuzimin et al. 2007). This technology is appropriate for highly mobile foraging subsistence in that it produces high-performance tools using

small quantities of raw material (Goebel 2002). The emergence and diffusion of microblade technology may have facilitated expansion of human habitats across ecotones and into marginal environments (Chen 2008), as well as cold environments (Yi et al. 2013). This is supported by the persistence of microblade technology in the transitional zone between Northeast and Southwest China as late as the historical period. Blade and microblade technologies rank high in the dimensions of portability, effectiveness (e.g., rate of capture in hunting), maintainability, flexibility (multi-purpose uses) and durability when compared with other lithic tool types. Blade and microblade manufacture produces standardized cutting edges that are easily maintained and flexible in many different tasks. However, these benefits come at the expense of durability, as thin sharp cutting edges are relatively fragile.

The tools of the LUP indicate that mobile foragers valued certain tool attributes above durability, a trait arguably more valuable among sedentary groups. Microblade technology began to prevail throughout North China in the LUP, in line with a global pattern of UP microlithization. Technologically, microblade technology is better suited to high-mobility foraging and ideal for the environmental fluctuations of the LGM. We assert that North Chinese microlithization represents the climax of highly mobile, intensified foraging. Microblades likely resulted from combination between bifacial flaking and prismatic core technologies

somewhat before the LGM. The dominance of microblade technology from the LGM verify co-author Chen's theoretical prediction based on cultural-ecological conditions around the period and advantages of microblade technology for mobile foraging (Chen 2008). Other current research (Barton et al. 2007) indicates that foragers of the LUP undergoing the harsh conditions of the LGM may have adapted initially by increasing frequency and distance of mobility, followed by growing focus around desirable resource areas. This pattern of mobility and settlement eventually came to span the entire landmass of North China, with LUP microblade technologies fully replacing more diverse EUP techno-complexes by 18 kya.

Though microblade technology expanded across habitat boundaries, there are some interesting regional variations. Two types have been described, primarily based on core forms (Xie 2000). The first, located on the Loess Plateau and represented by Xiachuan and Hutouliang sites, is characterized by wedge-shaped microblade cores that are relatively large. The other regional variant in the eastern part of North China is marked by boat-shaped microblade cores that typically produce smaller microblades (for instance, at the Tingsijian [Li et al. 1992; Wang E. 1997] and Daxianzhuang [Ge and Lin 1985] sites). As with EUP subsistence patterns, the differentiation in microblade technologies probably reflects adaptation to localized habitat conditions. Hunting was more

important in the grasslands of Loess Plateau, where ungulates were abundant and accessible. Likewise, aquatic resources were more abundant in the well-watered drainages of eastern North China. Nevertheless, this division is not simplistic: for example, a new discovery at Shizitan suggests that the earliest microblade cores were boat-shaped, then replaced by wedge-shaped cores in upper components (Song and Shi 2013). Considering that wedge-shaped cores are usually made on bifacial blanks that were used as multi-purpose tools (Kelly 1988), this versatile microblade technology reflects an adaptation to higher mobility than boat-shaped cores. Thus, we propose that LUP foragers in the western part of North China practiced long-distance, frequent mobility with focus on key resource areas, and those in the eastern regions were mapping onto aquatic resources, reducing mobility at least seasonally.

The clear contrast between microblade technology and the polished stone tools that increase in frequency at the terminal UP indicates that durability became a desirable attribute in certain tools, even at the expense of portability, flexibility of use contexts, and ease of maintenance and repair. Ground or polished stone tools are typically used for pounding and grinding functions that extend the value of animal foods (e.g., bone grease processing) and plants (e.g., pounding of nuts, grinding of fibrous roots and grains): both are indicative of intensification of wild food resources. Given some assurance of returning

to a given location, ground stone tools can be left in camp as site furniture and even handed down through lineages as in ethnographically documented foragers. Polished stone implicates a new pattern of mobility at the Terminal UP, where 'settling in' to key territories leads to long term re-occupation of desirable sites.

<a>Discussion: UP Adaptations and the Emergence of Food Production<a>

With regard to the regional variation of North China, we now can see that there is a difference in the UP foraging mobility in which western groups depended more on hunting and eastern groups began to utilize aquatic resources. Although North China was almost entirely microlithized in the LUP, regional differentiation developed continuously. Interestingly, in the intermediate regions of the Loess Plateau and the hilly flanks with extended plains, a significant differentiation occurred that resulted in emergence of food production in the latter zone. In the zone of the Loess Plateau, foragers maintained high mobility which is reflected in the dominance of microblade technology, as we see at the sites of Shizitan and Xiachuan. In contrast, the hilly flank zone is characterized by the decline of microblade technology and new patterns of site organization, artifact inventories, and faunal assemblages. These features are fundamentally different from highly mobile foraging of the LUP, as shown in the sites such as Lijiagou (Wang et al. 2011; Zhang S. et al. 2011), Donghulin (Zhao 2006), Zhuannian (Li et al. 1998), Ma'anshan (Xie et al.

2006) and Nanzhuangtou (Li et al. 2010). These discoveries suggest that foragers in the hilly flank/extended plain zone preferred a collector strategy. Consequently, they would need durable tools and facilities, which were worth the investment only when people lived long enough in base camps and/or returned often. Thus, foragers would become more familiar with, and dependent upon, resources around their base camps. This series of responses built the foundations of the origin of food production.

We here propose that foragers living on North China's hilly flanks and river basins first experimented with food production, with the earliest plant crops mostly centered on millets (*Setaria italica* and *Panicum miliaceum*). Food production quickly spread in this region, growing in sophistication and utility. Microblade technology practically disappeared in eastern North China during the early Holocene: only a few microblades have been found in early Neolithic sites such as Cishan (Sun et al. 1981) and Jiahu (Zhang 1999). Once established, the early Neolithic food-producing economies became adopted throughout most of western North China (Bettinger et al. 2007; IA-CASS 2010) and the Yanshan-Great Wall transitional zone (Chen 2011), both of which are marginal environments for food production. Several early Neolithic cultures such as Cishan, Peiligang, Houli, and Laoguantai flourished in the hilly flank and plain region (Liu X. et al. 2009), which was also the nuclear region of Chinese

civilization.

However, not all habitats are equally conducive to food production. Mobile foraging persisted in cold, arid grassland habitats like the Loess Plateau in western North China as late as the middle Holocene. In fact, microblade technology was still used until the historical period in northeast and southwest China and Tibetan Plateau, where nomadic pastoralism evolved. Variation in the pace of the food production in North China is subject to increasing efforts at explanation; for instance, a recent analysis of the Dadiwan area (Bettinger et al. 2007) asserts that the apparent variation in adoption of agriculture is due to a) the overall adaptive advantage of agriculture for feeding large, sedentized populations; b) the lack of local archaeological evidence for foraging predecessors; and c) stipulated social conventions of foraging groups against the establishment of territories, the holding of private plots and the hoarding of food (*ibid.*). Social conventions are cited to explain why areas already populated by foragers would be slower to develop intensive wild plant use (and later, domesticated crops). In landscapes presumed to be vacant (due to the lack of pre-Neolithic evidence) there would have been few barriers to colonization by intensified plant users already pre-disposed to agriculture.

This argument, while provocative, is not conclusive. Absence of archaeological evidence for highly mobile foragers in the harsh

environments of Late Pleistocene North China does not equal evidence for absence. Further, the ethnographic literature is full of information about foraging groups who establish and maintain territories, hold exclusive rights of use to resource and resource areas, and store food for private and family use. This is more common in areas where resources are seasonally abundant, can be procured and processed in bulk, and environmental conditions favor storage (Binford 2001). In addition, the 'social convention' scenario does not address the probability that dis-incentives to food production (clearly described by foragers themselves [Binford 1983; Kelly 1995; Yu 1997]) might vary the pace and process of agricultural spread. Opportunity costs to foragers include, among other things, the loss of mobility. As mentioned above, this reduces or eliminates access to highly ranked wild resources (Yu 2015) and more importantly, *information* about local resources and social conditions (Binford 2001).

Recently, the costs and benefits of food production to foraging peoples, and predictive models for variability in agricultural spread (such as vegiculture or proto-domestication) have been productively explored using human behavioral ecology approaches (e.g., Winterhalder and Golan 1997, Winterhalder and Kennett 2006). The onset of the Neolithic in North China was certainly multi-factorial, but we argue that much of the variability can be explained by pre-existing adaptive patterns of the

UP. For example, the higher mobility of foragers in the western part of North China did not condition for the same adaptive changes (e.g., plant based intensification) as in the hilly flank region. Decreasing mobility and variation in the organization of mobility are reflected in lithic technologies, site structures, and settlement patterns. Unlike prehistoric social conventions, these data have the advantage of being recoverable archaeologically for use in hypothesis testing.

<a>Summary and Conclusion<a>

The domination of North China's Paleolithic archaeology by a techno-typological paradigm has delayed our ability to explore adaptations of ancient foragers. Yet despite the limited resolution of current archaeological records (which remain largely centered on lithic forms and technologies), a holistic perspective that assesses data over long time scales can be used to explore adaptive patterns of the UP. Starting from the crucial variable in the adaptive strategy of hunter-gatherers - e.g, mobility - we then re-examined major archaeological materials including new discoveries. The dualistic division of pre-UP lithic industries appears to lack sufficient warranting evidence; rather, pre-UP technology represents a generalized adaptive pattern that used a variety of tool forms and materials to meet short-term demands. We agree with Gao and Norton (2002) that the Middle

Paleolithic is not a valid culture stage. Presently, the UP archaeology of North China can be separated into two stages, the EUP and LUP. In the EUP apparent diversification in adaptations resulted in four recognizable patterns. These diversified responses can be explained by differences in UP hunter-gatherer mobility: those who lived in the hilly flank region of North China were able to intensify on plant foods and practiced lower, collector-style mobility compared to the western region. Thus foragers of the hilly flank region initiated food production earlier - a system-level transformation of subsistence with ramifications that would eventually extend across the continent. At large scales of analysis, patterns of UP adaptations and changes permit us to understand the important roles that regionally conditioned cultural evolution would play at a prehistoric crossroads: the onset of the Neolithic.

<a>References<a>

- An 安志敏, Z., 1965. 河南安阳小南海旧石器时代洞穴堆积的试掘 (The test excavation of the Paleolithic Xiaonanhai cave site, Anyang, Henan Province). 考古学报 (Kaogu Xuebao) 1965(1), 1-27.
- Ashton, N.M., Bowen, D.Q., Homan, J.A., Hunt, C.O., Irving, B.G., Kemp, R.A., Lewis, S.G., McNabb, J., Parfitt, S.A., and Seddon, M.B., 1994. Excavation at the Lower Palaeolithic site at East Farm Barnham, Suffolk: 1989-1992. Journal of the Geological Society 151, 599-605.

- Barton, L.; Brantingham, P.J., and Ji, D., 2007. Late Pleistocene climate change and Paleolithic cultural evolution in Northern China: Implications from the Last Glacial Maximum. *Developments in Quaternary Sciences* 9, 105-128.
- Bettinger, R.L., 1991. *Hunter-Gatherers: Archaeological and Evolutionary Theory*. Plenum Press, New York and London.
- Bettinger, R.L., Barton, L., Richerson, P.J., Boyd, R., Wang, H., and Choi, W., 2007. The Transition to agriculture in northwestern China. *Developments in Quaternary Sciences* 9, 83-101.
- Binford, L.R., 1962. Archaeology as anthropology. *American Antiquity* 28, 217-225.
- Binford, L.R., 1980. Willow smokes and dog's tails: hunter-gatherer settlement systems and archaeological site formation. *American Antiquity* 45, 4-20.
- Binford, L.R., 1983. In *Pursuit of the Past*. Thames and Hudson, New York.
- Binford, L.R., 1988. The hunting hypothesis, archaeological methods, and the past. *Yearbook of Physical Anthropology* 30, 1-9.
- Binford, L.R., 2001. *Constructing Frames of Reference: an Analytical Method for Archaeological Theory Building Using Hunter-Gatherer and Environmental Data Sets*. University of California Press, Berkeley.
- Bleed, P., 1987. The optimal design of hunting weapons: maintainability or reliability. *American Antiquity* 51, 737-747.

- Brantingham, P.J., Gao, X., Olsen, J.W., Ma, H., Rhode, D., Zhang, H., and Madsen, D.B., 2007. A short chronology for the peopling of the Tibetan Plateau. In: Madsen, D.B., Chen, F., Gao, X. (Eds.), *Late Quaternary climate change and human adaptation in arid China*. Elsevier, Amsterdam, pp. 129-50.
- Chen 陈福友, F., Li, F., Wang, H., Pei, S., Feng, X., Zhang, S., Zhang, Y., Liu, D., Zhang, X., Guan, Y., and Gao, X., 2012. 宁夏水洞沟遗址第2地点发掘报告 (A preliminary report on excavations at Shuidonggou Locality 2 in Ningxia Hui Autonomous Region, North China). *Acta Anthropologica Sinica* 31, 317-333.
- Chen 陈胜前, S., 2008. 细石叶工艺的起源——一个理论与生态学的视角 (The origin of microblade technology—a theoretical and ecological perspective). In: Wang, Y., He, J., Huang, Y. (Eds.), *考古学研究 (Archaeological Research)*, vol.7. 科学出版社 Kexue Chubanshe, pp. 244-264.
- Chen 陈胜前, S., 2011. The adaptive changes of the prehistoric cultures in the zones along the Yanshan Mountains and the Great Wall. *考古学报 (Kaogu Xuebao)* 2011(1), 1-22.
- Chen 陈胜前, S., 2012. The Pleistocene to Holocene adaptive changes of foragers in Northeast China. *Asian Archaeology* 1, 26-43.
- Chen, S., and Chen, W., 2015. A chain of tools: An experimental study on picks of the Qinling region. *Quaternary International* (2015), <http://dx.doi.org/10.1016/j.quaint.2015.06.049>

- Chen 陈铁梅, T., 1988. 我国旧石器考古年代学的进展与述评 (The progress and review of Paleolithic chronology in China). 考古学报 (Kaogu Xuebao) 1988 (3), 357-367.
- Chen 陈铁梅, T., Yuan, S., Gao, S., 1984. 铀子系法测定骨化石年龄的可靠性研究及华北地区主要旧石器地点的铀子系年代序列 (The study on Uranium-series dating of fossil bones and an absolute age sequence for the main Paleolithic sites of North China). Acta Anthropologica Sinica 3, 259-269.
- Chen 陈铁梅, T., Yuan, S., Gao, S., Wang, L., and Zhao, G., 1982. 许家窑遗址哺乳动物化石的铀子系法年代测定 (Uranium series dating of Xujiayao site). Acta Anthropologica Sinica 2, 91-95.
- Chen 陈铁梅, T., Hedges, R.E.M, and Yuan, Z., 1989. 周口店山顶洞遗址年代的加速器质谱法再测定与讨论 (Accelerator radiocarbon dating for Upper Cave of Zhoukoudian). Acta Anthropologica Sinica 8, 216-221.
- Chen 陈铁梅, T., Hedges, R.E.M, and Yuan, Z., 1992. 山顶洞遗址的第二批加速器质谱 ^{14}C 年代数据与讨论 (The second batch of accelerator radiocarbon dates for Upper Cave Site of Zhoukoudian). 考古学报 (Kaogu Xuebao) 1992 (11), 112-116.
- Chen 陈哲英, Z., 1989. 陵川塔水河的旧石器 (Paleolithic artifacts from Tashuihe, Lingchuan County). 文物季刊 (Wenwu Jikan) 1989(2), 1-12.
- Clark, G., 1969. World Prehistory in New Perspective. Cambridge University Press, Cambridge.

- Dong 董光荣, G., Su, Z., and Jin, H., 1998. 晚更新世萨拉乌苏组时代的新认识 (New study on the date of Late Pleistocene Sjava-ooso-gol Group). *Chinese Science Bulletin* 43, 1869-1872.
- Elston, R.G., and Kuhn, S.L. (Eds.), 2002. *Thinking Small: Global Perspectives on Microlithization*. *Archaeological Papers of the American Anthropological Association* Number 12.
- Feng 冯兴无, X., Li, C., and Yu, J., 2006. 王府井东方广场遗址石制品研究 (A study of the stone artifacts from the Orient Plaza site of Beijing). *Acta Anthropologica Sinica* 25, 285-297.
- Gai 盖培, P., Wei, Q., 1977. 虎头梁旧石器时代晚期的发现 (The discovery of Upper Paleolithic Hutouliang Site). *Vertebrata Palasiatica* 15, 280-300.
- Gamble, C., 1999. *The Paleolithic Societies of Europe*. Cambridge University Press, Cambridge.
- Gao X., 1999. 关于“中国旧石器时代中期”的探讨 (A discussion on “Chinese Middle Paleolithic”). *Acta Anthropologica Sinica* 18, 1-16.
- Gao 高星 X., 2000. 周口店第 15 地点剥片技术研究 (A study of flaking technology at Zhoukoudian locality 15). *Acta Anthropologica Sinica* 19, 199-215.
- Gao 高星 X., 2001a. 关于周口店第 15 地点石器类型和加工技术的研究 (A study of stone tool typology and retouch technology at Zhoukoudian locality 15). *Acta Anthropologica Sinica* 20, 1-18.
- Gao 高星 X., 2001b., 周口店第 15 地点石器原料开发方略与经济形态研究 (A study of

- raw material exploration and economy at Zhoukoudian locality 15).
Acta Anthropologica Sinica 20, 186-200.
- Gao 高星 X., 2012. 中国旧石器时代手斧的特点与意义 (Characteristics and significance of Paleolithic handaxes from China). *Acta Anthropologica Sinica* 31, 97-112.
- Gao 高星 X., 2014. 更新世东亚人群连续演化的考古证据及相关问题论述 (Archaeological evidence for evolutionary continuity of Pleistocene humans in China and East Asia and related discussions). *Acta Anthropologica Sinica* 33, 237-253.
- Gao 高星 X, Norton, C.J., 2002. Critique of the Chinese "Middle Paleolithic." *Antiquity* 76, 397-412.
- Gao 高星 X., and Pei, S. 2006. 中国古人类石器技术与生存模式的考古学阐释 (Lithic technologies of ancient humans and archaeological explanations of subsistence pattern). *第四纪研究 (Disiji Yanjiu)* 26, 506-513.
- Gao 高星, X., Yuan, B., Pei, S., Wang, H., Chen, F., and Feng, X., 2008. 水洞沟遗址沉积-地貌演化与古人类生存环境 (The sedimentary-geomorphic evolution and living environment of humans in Shuidonggou site). *Chinese Science Bulletin* 53, 1200-1206.
- Gao 高星, X., Wang, H., and Guan, Y., 2013. 水洞沟旧石器考古研究的新进展与新认识 (Research at Shuidonggou: new advance and new perceptions). *Acta Anthropologica Sinica* 32, 121-132.
- Gao 高星 X., Zhang, X., Yang, D., Shen, C., and Wu, X., 2010. Revisiting

- the origin of modern humans in China and its implications for global human evolution. *Sci China Earth Sci*, 2010, doi: 10.1007/s11430-010-4099-4
- Ge 葛治功, Z., and Lin, Y., 1985. 大贤庄的中石器时代细石器 (Mesolithic microliths of Daxianzhuang). *东南文化 (Dongnan Wenhua)* 1985(1), 2-17.
- Germonpré, M., Láznicková-Galetová, M., and Sablin, M.V., 2012. Paleolithic dog skulls at the Gravettian Předmostí site, the Czech Republic. *Journal of Archaeological Science* 39, 184-202.
- Gezidong Field Team 鸽子洞发掘队, 1975. 辽宁鸽子洞旧石器遗址发掘报告 (Report on the excavation of Paleolithic Gezidong Site, Liaoning Province). *Vertebrata Palasiatica* 13, 122-136.
- Grimstead, D.N., 2010. Ethnographic and modeled costs of long-distance, big-game hunting. *American Antiquity* 75, 61-80.
- Goebel, T., 2002. The "microblade adaptation" and recolonization of Siberia during the Late Upper Pleistocene. In: Elston, R.G., Kuhn, S.L. (Eds.), *Thinking Small: Global Perspectives on Microlithization*. *Archaeological Papers of the American Anthropological Association* Number 12, pp. 117-132.
- Guan, Y., Gao, X., Li, F., Pei, S., Chen, F., and Zhou, Z., 2012. Modern human behaviors during the late stage of the MIS 3 and the Broad Spectrum Revolution: Evidence from a Shuidonggou Late Paleolithic site. *Chinese Science Bulletin* 57, 379-386, doi:

10.1007/s11434-011-4828-x

- Hayden, B., Franco, N., and Spafford, J., 1996. Evaluating lithic strategies and design criteria. In: Odell, G.H. (Ed.), *Stone Tools: Theoretical Insights into Human Prehistory*. Plenum Press, New York, pp. 9-45.
- Hoffecker, J.F., 2005. *A Prehistory of the North: Human Settlement of the Higher Latitudes*. Rutgers University Press, New Brunswick.
- Hou 侯亚梅, Y., 2005. 水洞沟: 东西方文化交流的风向标? (Shuidonggou: a vane of intercommunication between the east and the west?). *第四纪研究* (Disiji Yanjiu) 25, 749-760.
- Huang 黄慰文, W., 1987. 中国的手斧 (Bifaces in China). *Acta Anthropologica Sinica* 6, 61-68.
- Huang 黄慰文, W., 1989. 中国旧石器时代早期 (The Late Paleolithic of China). In: Wu, R., Wu, X., Zhang, S. (Eds.), *中国远古人类* (Early Man of China). 科学出版社 Kexue Chubanshe, Beijing, pp. 220-244.
- Huang 黄慰文, W., Dong, G., and Hou, Y., 2004. 鄂尔多斯化石智人的地层、年代和生态环境 (Stratigraphic, chronological and ecological contexts of Pleistocene Homo Sapiens of Sjava-osso-gol Site, Ordos Plateau of North China). *Acta Anthropologica Sinica* 23, S258-S271.
- Huang 黄慰文, W., and Fu, R. (Eds.), 2009. 小孤山—辽宁海城史前洞穴遗址 (Xiaogushan - Prehistoric Cave Site of Haicheng, Liaoning). 科学出版社 Kexue Chubanshe, Beijing.

Huang 黄慰文, W., and Hou, Y., 2003. 萨拉乌苏遗址的新材料: 范家沟湾 1980 出土的旧石器 (New materials from Salawusu sites of North China: Paleoliths of 1980 excavation at Fanjiagouwan). *Acta Anthropologica Sinica* 22, 209-318.

Huang 黄慰文, W., Chen, K., and Yuan, B., 1987. 青海小柴达木湖的旧石器 (Paleolithic artifacts from Xiao Chadam, Qinghai Province). In: Sino-Australian Quaternary Cooperative Research Team and Chinese Academy of Sciences (Ed.), *Papers of Sino-Australian Quaternary Conference*. 科学出版社 Kexue Chubanshe, Beijing, pp. 68-175.

Huang 黄慰文, W., Hou, Y., and Gao, L., 2009. 中国旧石器文化的“西方因素”与早期人类文化进化格局 (“Western elements” in the Chinese Paleolithic as viewed in a framework of early human cultural evolution). *Acta Anthropologica Sinica* 28, 16-25.

IA-CASS (Institute of Archaeology, Chinese Academy of Social Sciences), 1983. 中国考古学中碳十四年代数据集 1965-1981 (Radiocarbon dates in Chinese archaeology, 1965-1981). 文物出版社 Wenwu Chubanshe, Beijing.

IA-CASS (Ed.), 2010. 中国考古学: 新石器时代卷 (Chinese Archaeology: the Neolithic). 中国社会科学出版社 Zhongguo Shehui Kexue Chubanshe, Beijing.

Kelly, R. L., 1988. The three sides a biface. *American Antiquity* 53: 717-734.

Kelly, R. L., 1995. *The Foraging Spectrum*. Smithsonian Institution Press,

Washington and London.

Ji 吉学平, X., 2007. 云南富源大河旧石器遗址入选 2006 年度全国十大考古新发现 (The Dahe site of Fuyuan, Yunnan Province was named in the list of The Most Important Archaeological Discoveries of China in 2006). *Acta Anthropologica Sinica* 26, 221.

Jia 贾兰坡, L., 1984(1936). 周口店第 15 地点开掘简单报告 (Preliminary report on the excavation of Locality 15 of Zhoukoudian). In: 贾兰坡旧石器考古论文选 (The Paleolithic of China: selected works of Jia Lanpo). 文物出版社 Wenwu Chubanshe, Beijing, pp. 107-111.

Jia 贾兰坡, L., and Wei, Q., 1976. 阳高许家窑旧石器时代文化遗址 (The Paleolithic Site, Xiujiayao, Yanggao County). *考古学报 (Kaogu Xuebao)* 1976(2), 97-114.

Jia 贾兰坡, L., Gai, P., and Li, Y., 1964. 水洞沟旧石器时代遗址的新材料 (New materials from Paleolithic Shuidonggou site). *Vertebrata Palasiatica* 8, 75-80.

Jia 贾兰坡, L., Gai, P., and You, Y., 1972. 山西峙峪旧石器时代遗址发掘报告 (The excavated report of the Paleolithic Shiyu site, Shanxi Province). *考古学报 (Kaogu Xuebao)* 1972(1), 39-58.

Jia 贾兰坡, L., Wei, Q. and Li, C., 1979. 许家窑旧石器时代文化遗址 1976 年发掘报告 (The fieldwork of 1976 in the Paleolithic site, Xujiayao). *Vertebrata Palasiatica* 17, 277-293.

Kuzimin, Y., Keates, S.G., and Shen, C. (Eds.), 2007. Origin and Spread

- of Microblade Technology in Northern Asia and North America.
Archaeology Press, Simon Fraser Univeristy, Burnaby.
- Larson, G., Karlsson, E.K., Perri, A., Webster, M.T., Ho, S.Y.W., Peters, J., Stahl, P.W., Piper, P.J., Lingaas, F., Fredholm, M., Comstock, K.E., Modiano, J.F., Schelling, C., Agoulnik, A.I., Leegwater, P.A., Dobney, K., Vigne, J-D., Vilà, C., Andersson, L., and Lindblad-Toh K., 2012. Rethinking dog domestication by integrating Genetics, archaeology, and biogeography. *Proceedings of the National Academy of Sciences USA* 109, 8878-8883.
- Li 李超荣, C., Yu, J., and Feng, Y., 1998. 北京地区旧石器考古新进展 (Latest achievements of Paleolithic archaeology in Beijing area). *Acta Anthropologica Sinica* 17, 137-146.
- Li 李超荣, C., Yu, J., and Feng, X., 2000. 北京市王府井东方广场旧石器时代遗址发掘简报 (A preliminary report on the excavation of Wangfujing Oriental Square Paleolithic site, Beijing). *考古 (Kaogu)* 2000(9), 1-8.
- Li 李锋, F., Chen, F., and Gao, X., 2014. 水洞沟遗址第2地点古人类“行为现代性”及演化意义 (Behavioral modernity of ancient populations at Shuidonggou locality 2 and its implications). *Acta Anthropologica Sinica* 33, 510-521.
- Li, F., Kuhn, S.L., Gao, X., and Chen, F., 2013. Re-examination of the dates of large blade technology in China: A comparison of Shuidonggou

- Locality 1 and Locality 2. *Journal of Human Evolution* 64, 161-168.
- Li 李锋, F., Chen, F., Wang, H., Liu, D., Wang, S., Zhang, D., Li, G., Zhang, X., and Gao, X., 2012. 甘肃省徐家城旧石器遗址发掘简报 (A preliminary report on the 2009 excavation of the Xujiacheng Paleolithic site in Gansu Province, North China). *Acta Anthropologica Sinica* 31, 209-227.
- Li 李珺 J, Wang, E., and Yan, L., 1992. 河北昌黎淳泗涧细石器地点 (Microlithic Tingsijian locality, Changli County, Hebei Province). *文物春秋 (Wenwu Chunqiu)*, 1992 Supplement, 121-127.
- Li 李珺, J, Qiao, J., and Ren, X., 2010. 1997年河北徐水南庄头遗址发掘报告 (The 1997 excavation report of Nanzhuangtou site in Xushui, Hebei). *考古学报 (Kaogu Xuebao)* 2010 (3), 361-392.
- Li 黎兴国, X., Liu, G., Xu, G., Wang, F., and Liu, K., 1984. 鄂尔多斯人与萨拉乌苏文化的年代 (Dates of Ordos Man and Sajara-osso-gol Culture). In: *The First National ¹⁴C Conference Committee (Ed.), Papers of the First ¹⁴C Conference*. 文物出版社 Wenwu Chubanshe, Beijing, pp.141-143.
- Li 李炎贤, Y., 1993. 中国旧石器时代晚期的划分 (On the division of the Upper Palaeolithic industries of China). *Acta Anthropologica Sinica* 12, 214-223.
- Li 李占扬, Z., 2007. 许昌灵井遗址 2005 年出土石制品的初步研究 (A primary study on the stone artifacts of Lingjing site excavated in 2005). *Acta Anthropologica Sinica* 26, 138-154.

- Li 李占扬, Z., 2010. 许昌灵井旧石器时代遗址 2006 年发掘报告 (2006 excavation on the Paleolithic Lingjing site in Xuchang). 考古学报 (Kaogu Xuebao) 2010(1), 73-100.
- Li 李占扬, Z., and Dong, W., 2007. 河南许昌灵井旧石器时代遗址哺乳动物群的性质及时代探讨 (Mammalian fauna from the Lingjing Paleolithic site in Xuchang, Henan Province). *Acta Anthropologica Sinica* 26, 345-360.
- Li, Z., and Shen, C., 2010. Use-wear analysis confirms the use of Paleolithic bone tools by the Lingjing Xuchang Early Human. *Chinese Science Bulletin*, 55, doi:10.1007/s11434-010-0089-3.
- Lin 林圣龙, S., 1996. 中西方旧石器文化中的技术模式的比较 (Comparison of technological mode of Paleolithic culture between China and the west). *Acta Anthropologica Sinica* 15, 1-20.
- Liu, D., Wang, X., Gao, X., Xia, Z., Pei, S., Chen, F., and Wang, H., 2009. Progress on the stratigraphy and geochronology of the Shuidonggou site, Ningxia, North China. *Chinese Science Bulletin* 54, 3880-3886, doi: 10.1007/s11434-009-0652-y
- Liu, X., Hunt, H.V., and Jones, M. K., 2009. River valleys and foothills: changing archaeological perceptions of North China's earliest farms. *Antiquity* 83, 82-95.
- Madsen, D.B., Li, J., Brantingham, P.J., Gao, X., Elston, R.G., and Bettinger, R.L., 2001. Dating Shuidonggou and the Upper Paleolithic blade industry in North China. *Antiquity* 75, 706-716.

- Madsen, D.B., Ma, H., Brantingham P.J., Gao, X., Rhode, D., Zhang, H., and Olsen, J.W., 2006. The late Upper Paleolithic occupation of the northern Tibetan Plateau margin. *Journal Archaeological Science* 33, 1433-1444.
- Madsen, D.B., Chen, F., and Gao, X. (Eds.), 2007. *Late Quaternary Climate Change and Human Adaptation in Arid China*. Elsevier, Amsterdam.
- Mellars, P., 2005. The impossible coincidence. A single-species model for the origins of modern human behavior in Europe. *Evolutionary Anthropology* 14, 12-27.
- Mo 莫多闻, Xu, H., Yang, X., and Zhu, Z., 2000. 北京王府井东方广场旧石器晚期文化遗址的古环境背景 (Paleoenvironment settings of the Dongfang Plaza Late Paleolithic site, Wangfujing, Beijing. *Acta Scientiarum Naturalium Universitat Pekinensis* 36, 231-239.
- Morgan, C., Barton, L., Yi, M., Bettinger, R.L., Gao, X., and Peng., F., 2014. Re-dating Shuidonggou Locality 1 and implications for the Initial Upper Paleolithic in East Asia. *Radiocarbon* 56, 165-179.
- Nian, X., Gao, X., and Zhou, L., 2014a. Chronological studies of Shuidonggou (SDG) Locality 1 and their significance for archaeology. *Quaternary International* 347, 5-11.
- Nian, X., Gao, X., Xie, F., Mei, H., and Zhou, L., 2014b. Chronology of the Youfang site and its implications for the emergence of microblade technology in China. *Quaternary International* 347, 112-121.

- Ningxia Institute of Archaeology and Cultural Relics (Ed.), 2003. 水洞沟—1980年发掘报告 (Shuidonggou – the Report of Excavation in 1980). 科学出版社 Kexue Chubanshe, Beijing.
- Norton, C.J., and Jin, J., 2009. The evolution of modern human behavior in East Asia: current perspectives. *Evolutionary Anthropology* 18, 247-260.
- Norton, C.J., and Gao, X., 2008. Hominin-carnivore interactions during the Chinese Early Paleolithic: taphonomic perspectives from Xujiayao. *Journal of Human Evolution* 55, 164-178.
- Norton, C.J., Gao, X., and Feng, X., 2009. The East Asian Middle Paleolithic reexamined. In: Camps M, Chauhan, P. (Ed.), *Sourcebook of Paleolithic Transitions*. Springer, New York, pp. 245-254.
- Pei, S., Gao, X., Wang, H., Kuman, K., Bae, C.J., Chen, F., Guan, Y., Zhang, Y., Zhang, X., Peng, F., and Li, X., 2012. The Shuidonggou site complex: new excavations and implications for the earliest Late Paleolithic in North China. *Journal of Archaeological Science* 39, 3610-3626.
- Pei, W., 1940. The Upper Cave Fauna of Choukoutien. *Pal. Sin. New Series* C (10), 1-100.
- Pei 裴文中, and W., Zhang, S., 1985. 中国猿人石器研究 (A Study on the Lithic Artifacts of Sinanthropus). 科学出版社 Kexue Chubanshe, Beijing.
- Perlès, C., 1992. In search of lithic strategies: a cognitive approach

- to prehistoric chipper stone assemblages. In: Gardin, J., Peebles, C. (Eds.), *Representations in Archaeology*. Indiana University Press, Bloomington and Indianapolis, pp. 223-247.
- Peng, F., Gao, X., Wang, H., Chen, F., Liu, D., and Pei, S., 2012. An engraved artifact from Shuidonggou, an early Late Paleolithic site in Northwest China. *Chinese Science Bulletin*, doi: 10.1007/s11434-012-5317-6.
- Pitulko, V.V., Nikolsky, P.A., Girya, E.Y., Basilyan, A.E., Tumskey, V.E., Koulakov, S.A., Astakhov, S.N., Pavlova, E.Y., and Anisimov M.A., 2004. The Yana RHS site: humans in the arctic before the Last Glacial Maximum. *Science* 303, 52-56.
- Pope, G.G., 1989. Bamboo and human evolution. *Natural History* 1989(10), 48-57.
- Qiu, T., Bar-Yosef, O., Wang, Y., and Wu, X., 2013. The Chinese Upper Paleolithic: geography, chronology, and techno-typology. *Journal of Archaeological Research* 21, 1-73.
- Seong, C., 2009. Emergence of a blade industry and evolution of Late Paleolithic technology in the Republic of Korea. *Journal of Anthropological Research* 65, 417-451.
- Shea, J.J., 2013. Lithic modes A-I: A new framework for describing global-scale variation in stone tool technology illustrated with evidence from the East Mediterranean Levant. *Journal of*

- Archaeological Method and Theory 20, 151-186.
- Shi 石金鸣, and J. Song, Y., 2010. 山西吉县柿子滩遗址第九地点发掘简报 (A brief report of Locality No. 9, Shizitan Site, Ji County, Shanxi Province). 考古 (Kaogu) 2010(10), 7-17.
- Shi 石金鸣, J., Song, Y., and Yan, Y., 2002. 山西吉县柿子滩旧石器时代遗址 S14 地点 (Locality No. 14 of Paleolithic Shizitan Site, Ji County, Shanxi Province). 考古 (Kaogu) 2002(4), 15-28.
- Song 宋艳花, Y., and Shi, J., 2013. 山西吉县柿子滩遗址 S12G 地点发掘简报 (A preliminary report of loc. S12G, Shizitan site, Ji County, Shanxi Province). 考古与文物 (Kaogu yu Wenwu) 2013(3), 3-8.
- Stiner, M.C., Munro, N.D., Surovell, T.A., Tchernov, E., and Bar-Yosef, O., 1999. Paleolithic population growth pulses evidenced by small animal exploitation. *Science* 283, 190-194.
- Stiner, M.C., Munro, N.D., and Surovell, T.A., 2000. The tortoise and the hare: small-game use, the broad-spectrum revolution, and Paleolithic demography. *Current Anthropology* 41, 39-73.
- Straus, L.G., 1995. The Upper Paleolithic of Europe: an overview. *Evolutionary Anthropology* 4, 4-16.
- Sun 孙德海, D., Liu, Y., and Chen, G., 1981. The site of Cishan at Wu'an, Hebei Province. 考古学报 (Kaogu Xuebao) 1981(3), 303-338.
- Tang, C., and Gai, P., 1986. Upper Paleolithic cultural traditions in North China. In: Wendorf, F., Close, A.D. (Eds.), *Advances in World*

- Archaeology, vol.5. Academic Press, New York, pp. 339-364.
- Tomasello, M., 1999. *The Cultural Origins of Human Cognition*. Harvard University Press, Cambridge.
- Wang 王恩霖, E., 1997. 河北昌黎淳泗涧细石器遗址的新材料 (New materials of microliths from Tingsijian site of Changli County, Hebei Province). *Acta Anthropologica Sinica* 16, 1-10.
- Wang 王惠民, H., Pei, S., Ma, X., and Feng, X., 2007. 水洞沟遗址第3, 4, 5地点发掘简报 (A preliminary report on the excavation of Shuidonggou localities 3, 4, 5 in Ningxia). *Acta Anthropologica Sinica* 26, 206-220.
- Wang 王建, J., Tao, F., and Wang, Y., 1994. 丁村旧石器时代遗址群调查发掘简报 (Report on the survey and excavation of Dingcun Paleolithic Site Group). *文物季刊 (Wenwu Jikan)* 1994(3), 1-26.
- Wang 王佳音, J., Zhang, S., Wang, S., Xin, Y., Liu, Q., Gao, X., Zhao, J., and Wang, Y., 2012. 河南新郑黄帝口遗址2009年发掘简报 (A preliminary report on the 2009 excavation of the Huangdikou Paleolithic site, Xinzheng, Henan). *Acta Anthropologica Sinica* 31, 127-136.
- Wang 王建, J., Wang, X., and Chen, Z., 1978. 下川文化 (Xiachuan Culture). *考古学报 (Kaogu Xuebao)* 1978(3), 259-288.
- Wang 王社江, S., 2007. 花石浪(I)—洛南盆地旷野类型旧石器地点群研究 (Huashilang I: The Paleolithic Open-air Sites in the Luonan Basin). 科学出版社 Kexue Chubanshe, Beijing.

- Wang 王社江, S., 2008. 花石浪(II)—洛南花石浪龙牙洞遗址发掘报告 (Huashilang II: Longyadong Paleolithic Cave Site in the Luonan Basin). 科学出版社 Kexue Chubanshe, Beijing.
- Wang 王社江, S., Zhang, X., Shen, C., Hu, S., and Zhang, X., 2004. 洛南花石浪龙牙洞 1995 年出土石制品研究 (A study of lithic assemblages from 1995 excavation at Longyadong Cave, Luonan Basin, China). *Acta Anthropologica Sinica* 23, 93-110.
- Wang 王益人, Y., 2014. 丁村旧石器时代遗址群: 丁村遗址群 1976-1980 年发掘报告 (Dingcun Paleolithic Group Sites: an Excavation Report of 1976-1980). 科学出版社 Kexue Chubanshe, Beijing.
- Wang 王幼平, Y., 1997. 更新世环境与中国南方旧石器文化发展 (Pleistocene environment and development of Paleolithic culture in South China). 北京大学出版社 Beijing Daxue Chubanshe, Beijing.
- Wang 王幼平, Y., 2008. Pleistocene human activity in the Zhijidong site, China, and its chronological and environmental context. In: Matsufuji, K. (Ed.), *Loess-paleosol and Paleolithic chronology in East Asia*. Yuzakaku, Tokyo, pp. 173-182.
- Wang 王幼平, Y., 2012. 嵩山东南麓 MIS3 阶段古人类的栖居形态及相关问题 (The settlement pattern of ancient humans during the MIS3 in the southeastern flank of Songshan Mount and the related questions). In: 考古学研究 (A collection of studies on archaeology), vol.10. 科学出版社 Kexue Chubanshe, pp. 287-296.

- Wang 王幼平, and Wang, S., 2014. MIS3 阶段嵩山东麓旧石器发现与问题 (New achievements and perspectives on Paleolithic archaeology during the MIS3 along the eastern foot of Songshan Mountain, Henan Province). *Acta Anthropologica Sinica* 33, 304-314.
- Wang 王幼平, and Y., Zhang S., 2011. 河南登封西施旧石器遗址 (The Paleolithic Xishi site of Dengfeng, Henan). *中国文化遗产* (Zhongguo Wenhua Yichan) 2011 supplement, 280-283.
- Wang 王幼平, Y., Zhou, J., and Yang, Z., 1988. 1987 年河南南召小空山旧石器时代遗址发掘报告 (1987 Report on the excavation of Paleolithic Xiaokongshan Site, Nanzhao County, Henan Province). *华夏考古* (Huaxia Kaogu) 1988(4), 1-15.
- Wang 王幼平, Y., Zhang, S., He, J., Wang, S., Zhao, J., Qu, T., Wang, J., and Gao, X., 2011. 河南新密市李家沟遗址发掘简报 (A preliminary report of Lijiagou site in Xinmi city, Henan). *考古* (Kaogu) 2011(4), 3-9.
- Wang 王向前, X., Ding, J., and Tao, F., 1983. 山西蒲县薛关细石器 (Microliths from Xueguan Puxian County, Shanxi). *Acta Anthropologica Sinica* 2, 162-171.
- Wang 王晓琨, X., Wei, J., Chen, Q., Tang, Z., and Wang, C., 2010. 内蒙古金斯太洞穴遗址发掘简报 (A preliminary study on the excavation of Jinsitai cave site). *Acta Anthropologica Sinica* 29, 15-32.
- Wang 王志浩, Z., Hou, Y., Yang, Z., Zeng, Z., Liu, Y., Bao, L., Yang, J., Bai, L., and Zhang, L., 2012. 内蒙古鄂尔多斯市乌兰木伦旧石器时代中期遗址

- (The Ulan Moron site of Middle Paleolithic age in Ordos City, Inner Mongolia). *考古 (Kaogu)* 2012(7), 3-13.
- Winterhalder, B., and C. Goland, 1997. An evolutionary ecology perspective on diet choice, risk, and plant domestication. In K. J. Gremillian, ed., *Peoples, Plants, and Landscapes: Studies in Paleoethnobotany*, pp. 123-160. U. of Alabama Press, Tuscaloosa, AL.
- Winterhalder, B., and D. Kennett, 2006. Behavioral ecology and the transition from hunting and gathering to agriculture. In *Behavioral Ecology and the Transition to Agriculture*, ed. D. Kennett and B. Winterhalder, pp. 1-21. U. of California Press, Berkeley.
- Wu 吴茂霖 M. 1980. 许家窑遗址 1977 年出土的人类化石 (Human fossils unearthed from Xujiayao site in 1977). *Vertebrata Palasiatica* 18, 229-238.
- Wu 吴汝康, RK., Wu, X., and Zhang, S. (Eds.), *中国远古人类 (Early Humankind in China)*. 科学出版社 Kexue Chubanshe, Beijing.
- Xie 谢飞, F., 1993. 籍箕滩旧石器时代晚期细石器遗址 (Jijitan: an Upper Paleolithic microlithic site). *文物春秋 (Wenwu Chuanqiu)* 1993(2), 1-22, 70.
- Xie 谢飞, F., 2000. 环渤海地域新旧石器时代文化过渡问题研究纲要 (The research outline on the Paleolithic-Neolithic cultural transition in circum-Bo Sea region). In: Zhang, Z., Xu, Z. (Eds.), *Retrospect and Prospect of Chinese Archaeology at the Millennium*. 科学出版社 Kexue Chubanshe, Beijing, pp. 181-189.

- Xie 谢飞, F., and Yu, S., 1989. 河北阳原西白马营晚期旧石器研究 (The study on Upper Paleolithic Xibaimaying, Yangyuan County, Heibei Province). 文物春秋 (Wenwu Chunqiu) 1989(3), 13-26, 40.
- Xie 谢飞, F., Meng, Z., and Wang, Z., 1991. 河北玉田县孟家泉旧石器遗址发掘简报 (A preliminary report on the excavation of Paleolithic Mengjiaquan Site, Yutian County, Hebei Province). 文物春秋 (Wenwu Chunqiu) 1991(1), 1-13.
- Xie 谢飞, F., Li, J., and Liu, L., 2006. 泥河湾旧石器文化 (The Paleolithic of the Nihewan Basin). 花山文艺出版社 Huashan Wenyi Chubanshe, Shijiazhuang.
- Xie 谢骏义, J., 1982. 甘肃环县刘家岔旧石器时代遗址 (Liujiacha: a Paleolithic site in Huan County, Gansu). 考古学报 (Kaogu Xuebao) 1982(1), 35-48.
- Xie 解希恭, X., Yan, J., and Tao, F., 1989. 山西吉县柿子滩中石器文化遗址 (The Mesolithic site at Shizitan, Jixian County, Shanxi Province). 考古学报 (Kaogu Xuebao) 1989(3), 305-323.
- Xu 徐浩生, H., Jin, J., and Yang, Y., 1992. 河北徐水县南庄头遗址发掘简报 (The test excavations at the Nanzhuangtou site in Xushui County, Hebei). 考古 (Kaogu) 1992 (11), 961-970.
- Yi, M., Barton, L., Morgan, C., Liu, D., Chen, F., Zhang, Y., Pei, S., Guan, Y., Wang, H., Gao, X., and Bettinger, R.L., 2013. Microblade technology and the rise of serial specialists in north-central China. *Journal of Anthropological Archaeology* 32, 212-223.

- Yin 尹功明, and G., Huang, W., 2004. 萨拉乌苏遗址范家沟湾地点的光释光年代 (IRSL dating for the Sjara-osso-gol, a Paleolithic site of North China). *Acta Anthropologica Sinica* 23, S272-S276.
- Yin 尹申平, S., and Wang, X., 2007. 陕西宜川县龙王辿旧石器遗址 (The Paleolithic Longwangchan site of Yichuan County, Shannxi). *考古* (Kaogu) 2007(7), 3-8.
- Yu, P., 2015. Ethnoarchaeology of foraging and the case of the vanishing agriculturalists in the Amazon Basin. *Journal of Anthropological Archaeology* 38, 59-66.
- Yu, P., 1997. *Hungry Lightning: Notes of a Woman Anthropologist*. University of New Mexico Press, Albuquerque.
- Yuan 原思训, S., 1993. 加速器质谱法测定兴隆纹饰鹿角与峙峪等样品的 ^{14}C 年代. (AMS radiocarbon dating of Xinglong carved antler, Shiyu and Ximiao sites). *考古学报* (Kaogu Xuebao) 1993(12), 92-95.
- Yuan 原思训, S., Chen T., and Gao, S., 1983. 用铀子系法测定河套人和萨拉乌苏文化的年代 (Uranium series dating of "Ordos Man" and "Sjara-osso-gol Culture"). *Acta Anthropologica Sinica* 2, 90-94.
- Yuan 原思训, S., Zhou, C., Zhu, X., Yan, J., and Yan, Y., 1998. 山西吉县柿子滩遗址的年代与文化研究 (The study on the date and culture of Shizitan Site, Ji County, Shanxi Province). *考古* (Kaogu) 1998(6), 57-62.
- Zhang, J., Wang, W., Qiu, W., Shelach, G., Hu, G., Fu, X., Zhang, M., and Zhou, L., 2011. The Paleolithic site of Longwangchan in the middle Yellow River, China: chronology, paleoenvironment and implications.

- Journal of Archaeological Science 38, 1537-1550.
- Zhang, J., 1999. 舞阳贾湖 (Wuyang Jiahu). 科学出版社 Kexue Chubanshe, Beijing.
- Zhang 张居中, J., and Li, Z., 1996. 河南舞阳大岗细石器地点发掘报告 (Preliminary report on the excavation of Dagang microlithic site in Wuyang County, Henan Province). Acta Anthropologica Sinica 15, 105-113.
- Zhang, J., Huang, W., Yuan, B., Fu, R., and Zhou, L., 2010. Optically stimulated luminescence dating of cave deposits at the Xiaogushan prehistoric site, northeastern China. Journal of Human Evolution 59, 514-524.
- Zhang 张森水, S., 1987. 中国旧石器文化 (Paleolithic Cultures of China). 天津科学技术出版社 Tianjin Kexue Jishu Chubanshe, Tianjin.
- Zhang 张松林, and Liu, Y., 2003. 织机洞旧石器时代遗址发掘报告 (Report on the excavation of Zhijidong cave site). Acta Anthropologica Sinica 22, 1-17.
- Zhang 张松林, S., Wang, S., and Wang, Y., 2011. 新密李家沟遗址的主要收获 (The major discoveries in the excavation of Lijiagou site, Xinmi). 中原文物 (Zhongyuan Wenwu) 2011(1), 4-6, 39.
- Zhang 张文君, W., 1990. 山西吉县柿子滩旧石器遗址试掘记 (The test excavation of Paleolithic Shizitan Site, Ji County, Shanxi Province). 考古与文物 (Kaogu yu Wenwu) 1990(1), 1-5.

Zhang 张镇洪, Z., Fu, R., Chen, B., Liu, J., Zhu, M., Wu, and H., Huang, W., 1985. A preliminary report on the excavation of Paleolithic site at Xiaogushan of Haicheng, Liaoning Province. *Acta Anthropologica Sinica* 4, 70-79.

Zhao 赵朝洪, C., 2006. 北京市门头沟区东胡林史前遗址 (The prehistoric Donghulin site of Mentougou District, Beijing City). *考古 (Kaogu)* 2006(7), 3-8.

Zhou 周国兴, G., 1974. 河南许昌灵井的石器时代遗存 (Stone age remains from Lingjing, Xuchang, Henan Province). *考古 (Kaogu)* 1974(2), 91-98, 108.

Zhou 周信学, X., Sun, Y., Wang, Z., and Wang, H., 1990. 大连古龙山遗址 (Gulongshan Site, Daliang). 北京科学技术出版社 Beijing Kexue Chubanshe, Beijing.