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Settlement Patterns Reflected in Assemblages from the Pleistocene/Holocene Transition of North Central China

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Survey along the margins of the Helan Mountains in the Ningxia Hui and Nei Mongol Autonomous Regions discloses variability in the distribution and assemblage composition among 47 archaeological localities, and suggests a reduction in hunter–gatherer residential mobility through time. Late Palaeolithic tool assemblages are less frequent, smaller, and relatively uniform from site to site. They tend to be found near canyon mouths on the mountain front, or around springs in the middle to upper reaches of fans, suggesting limited variation in both length of stay and subsistence strategies. In contrast, early Neolithic sites, more abundant and variable in size and complexity, are located near fan toes or lower fan springs where water could be more easily diverted. Larger more diverse assemblages suggest long-term residential bases, while smaller specialized assemblages, devoid of microliths, indicate short-term camps and resource processing locations. This helps confirm a similar pattern identified in materials collected by the Sino-Swedish expedition, in the northern Alashan. Together they suggest that the trend towards decreased residential mobility is associated with increasingly intensive and specialized use of seed resources that may be related to the early development of plant husbandry.

Keywords: LATE PALAEOLITHIC, NEOLITHIC, NORTH CHINA, AGRICULTURAL ORIGINS, SETTLEMENT VARIABILITY, HUNTER–GATHERERS, MICROLITHIC.

Introduction and Background

In 1989 we began to address the question of environmental constraints in human adaptation by comparing settlement patterns and food procurement strategies in two environmentally similar but historically independent arid regions: central northern China, and the Great Basin of western North America (Bettinger *et al.*, 1990). We hope to obtain insights into the adaptive behaviour of hunter–gatherers during the Pleistocene–Holocene transition in both regions. Beyond the basic question of history versus environment, we also seek to address commonalities and variations in human settlement and subsistence strategies for survival in arid lands and in the face of profound environmental change. Northern China is one of the few places in the world comparable to the Great Basin in terms of latitude, seasonality, climate,

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drainage and vegetation types. Important differences between the two regions include the differential length of the archaeological records, the timing of agricultural innovation in each area, the development of pastoralism in China but not in the Basin, and the lack of state systems in the Great Basin until the 19th century. Nevertheless, environmentally and culturally there are many points of comparison between the two regions during the terminal Pleistocene and the establishment of the modern climatic regime.

Unfortunately, the Pleistocene/Holocene boundary in northern China is poorly understood. Indeed, so few data are currently available regarding the spatial extent and organization of north China hunter–gatherer adaptive systems, it is difficult to design the kind of regional research programme needed to address basic research questions. To meet our larger goals we must first address local cultural–historical questions and refine our knowledge of climatic change and its environmental consequences. The broad culture–evolutionary parallels that unite north China with other parts of the Old World are not much help, since known Chinese lithic sequences are so unlike those of Europe, Africa and the Near East (Gai, 1985; Tang & Gai, 1986). Even within China, as Chen & Olsen (1990: 276) note, the Late Palaeolithic ‘‘. . . cultures of Pleistocene hunter–gatherers in China indicate diverse traditions, uneven in their technological development and differential geographic distribution . . .’’ This diversity is evident in earlier periods (Zhang, 1990) and appears to hold true through the Mesolithic and into the early Neolithic (Chen, 1984; Tong, 1986; Olsen, 1987; Pearson & Underhill, 1987; An, 1988). Given the current state of research, it is difficult to determine whether this environmental and cultural diversity is real or simply represents sketchiness in available records.

Our purpose here is to examine our very preliminary survey results in a descriptive fashion to help identify a research approach which may be useful in examining these larger problems. In a previous paper (Bettinger, Madsen & Elston, 1994), we examined data from the Alashan Desert of Inner Mongolia recovered by the Sino-Swedish Expeditions of 1927–1935 (Bergman, 1945; Maringer, 1950; Hedin, 1968), and speculated on the nature of the hunter–gatherer systems they represented. The hypotheses we consider here complement and clarify those we derived from the data of the Sino-Swedish expeditions. This refined set of hypotheses should allow us to define a realistic research programme to address what is now an intractable entanglement of environment and history in Late Pleistocene–Early Holocene human systems in north China.

Study Area

Our research area (Figure 1) centres on the Helan Shan, an isolated mountain range west of the Huang He (Yellow River) where it makes its great northern loop between the Inner Mongolia Plateau in Ningxia Hui Autonomous Region and Inner Mongolia, and the Ordos Plateau in southern Inner Mongolia, northern Shanxi and northeastern Ningxia. Within the big bend of the Huang He lies the Ordos Plateau, dominated in the north by the sand dunes of Hobq Shamo (sand desert), and in the south by the Mu Us Shamo north of the Great Wall. The Ulan Buh Shamo, north of the Helan Shan, lies between the Lang Shan and the valley of the Huang He. The Yellow River valley north and east of the Helan Shan is the broad and extensively irrigated Hetao Plain, the major farming area of Inner Mongolia.

The Alashan Plain, on the Inner Mongolia Plateau, is an area of internal drainage west of the Helan Shan. To the south in the Tengger Shamo and the vicinity of our study area, the region is a broken expanse of sand dunes, some smaller gobis (gravel/rock deserts) and scattered oases, with elevations of 1400–1500 m. The Alashan Plain contains numerous playas, lake basins and marshes, the largest of which is Jilantai at the northern edge of our study area. This quite shallow and salty lake encompasses about 55 km^2 and is similar to the Humboldt Sink, Nevada, in the western Great Basin.

The Helan Shan (mountains), approximately 150 km long and 30 km wide, oriented slightly northeast-southwest and rising abruptly to 3556 m, is comparable to several of the larger isolated mountain ranges in the central Great Basin, with similar vegetation zones sorted by elevation. The Helan Shan are tectonically active (Geng & Chan, 1992), and on the eastern side numerous Holocene faults cut across the heads of alluvial fans suggesting rapid uplift of canyon mouths during the Late Pleistocene/Holocene. Recent materials are rapidly deposited at fan heads and there are no incised stream channels. On the western side the situation is reversed. Deeply incised, Middle-to-Late Pleistocene alluvial fans stretch from small, narrow canyon mouths to the extensive dune fields of the Tengger Shamo. Deposition is principally at fan toes and surface deposits at the fan heads are of considerable antiquity.

Away from the Helan Shan, vegetation is sparse (Wang, 1961). The sand dune association is particularly prominent and is dominated by various shrubs (e.g. *Calligonum mongolicum*), grasses (e.g. *Timoria villosa*) and dwarf trees (e.g. *Haloxylon ammodendron*), a principal contemporary source of camel fodder. Two prolific seed-producing plants found along the dune margins, a chenopod (*Agriophyllum squarrosum*) and a sagebush (*Artemisia sphaerocephala*), were widely collected historically (Chen Y., Alashan League Forestry Institute, pers. comm.; Geng & Chan, 1992). The saline lake margins are characterized by *Saliconia*, *Kalidium*, *Halogeton* and *Bassia*. Elm (*Ulmus*) and poplar (*Populus*) are locally abundant along stream courses and springs at the foot of the Helan Shan. In the Helan

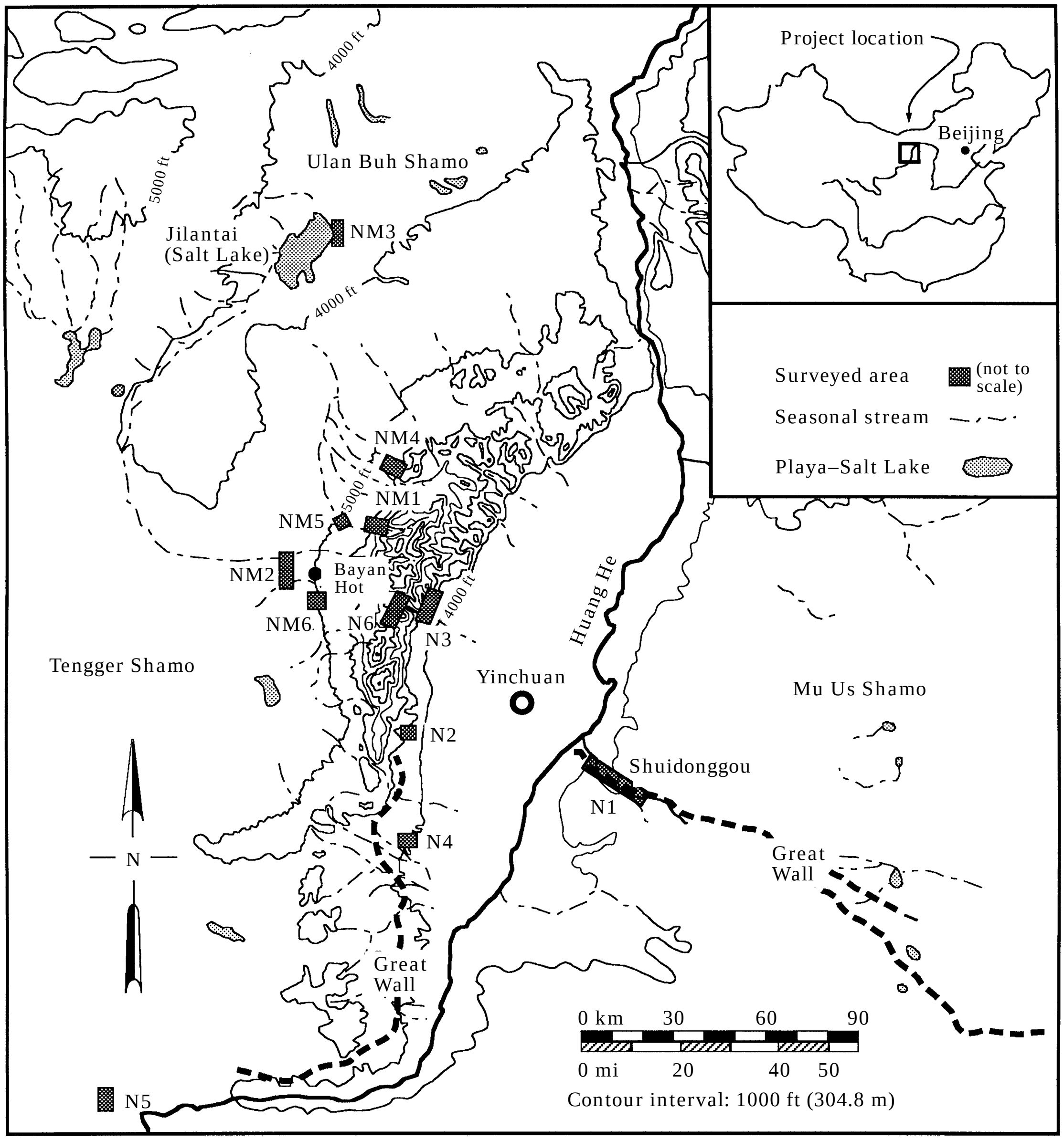

Figure 1. Project location and survey areas in north central China.

Shan a moderate mountain brush zone gives way rapidly on the steep slopes to a woodland community dominated by juniper (*Juniperus* sp.) on the lower/southern exposures and pine (*Pinus* sp.) on the higher/northern exposures. Spruce (*Picea*) is found at the higher elevations, and a small alpine zone is present on the crest of the range.

A continental high pressure system forming in the winter over northern China ensures that winters are cold and dry. Most annual precipitation falls during the summer when the high weakens and the monsoon brings warm, moist air from the southeast. Presently, the summer monsoon penetrates northwesterly to just beyond the crest of the Helan Shan. The Helan Shan now marks the 200 mm isohyet, forming the boundary between the temperate deserts of northwestern China and the semi-arid, temperate grasslands of eastern Inner Mongolia (Zhao, 1986: 169, 1990: 257). In Alashan, annual precipitation ranges from 75 to 150 mm per year, most of it falling in the summer months (Domrös & Peng, 1988). Temperatures average close to 6·8°C, with the mean maximum occurring in July (30·3°C) and the mean minimum in January (– 17·9°C). On the Ningxia Plain at Yinchuan, annual precipitation ranges between 186 and 231 mm, with 59% falling in the summer. The growing season is quite long, with between 145 and 160 frost-free days (Geng & Chan, 1992: 156, 176).

Paleoenvironmental Change

Modern environmental conditions are not directly applicable to the Late Pleistocene–Early Holocene period which is the focus of our research. The two-season monsoonal patterns of cold, dry winters and warm, wet summers have varied in dominance at different periods in prehistory, and sequences are particularly complex for the period spanning the Late Palaeolithic transition. A number of recent studies have generated a wealth of data regarding Late Pleistocene/Holocene paleoclimates of China, not all of which are easily correlated across the continent (Winkler & Wang, 1993). Perhaps the most comprehensive picture comes from the loess-paleosol sequence on the Chinese Loess Plateau, a long-term proxy record of Asian monsoon variability that correlates with global glacial/interglacial cycles observed in marine sediments (Kukla *et al.*, 1988; An *et al.*, 1991*a*,*b*, 1993). In the study area, as in most of north central China, the Mid-Pleistocene Lishi loess is overlain by the Late Pleistocene Malan loess, although in specific areas the loess sequence is considerably more complex (e.g. Yuan, 1978; Derbyshire, 1983; You, 1984; Zhou & Hu, 1985). The surface of the Lishi loess is heavily weathered and, particularly in the Ordos, forms an extensive peneplane on which mixed deposits of Mid-to-Late Palaeolithic materials occur through deflation. Generally, the last glacial period was extremely dry and cold, but during the terminal Pleistocene and lasting into the Holocene conditions were warmer and wetter (Guo & Shao, 1991; Tong & Shao, 1991; An *et al.*, 1991*b*; Chen, Zhou & Lin, 1991; Dai & Zhang, 1991; Li, 1991; Huang *et al.*, 1991; Liu & Li, 1991; Lu *et al.*, 1991).

Proxy evidence (pollen, lake levels, magnetic susceptibility of loess) from several northern China sites have been synthesized in recent models of paleomonsoon variation (An *et al.*, 1991*a*,*b*; Winkler & Wang, 1993) (Figure 2(a)). During the Pleistocene, these constructions suggest strong global circulation drove the monsoon far to the south, giving northern China a cold, dry, continental climate in which loess accumulated, lakes were low and vegetation was dominated by xeric shrubs (An *et al.*, 1991*b*: 237–243). Toward the end of the Pleistocene, around 15,000 BP, the continental high pressure system began to weaken, and the climate of northern China grew warmer and moister. The warming trend was seemingly interrupted by a sharply defined cold–dry interval between 11,000 and 10,000 BP, possibly corresponding to the Younger Dryas, during which magnetic susceptibility was reduced in the Baxie profile, spruce and fir pollen increased at Jinchuan, and Lake Daihai regressed. Between 9000 and 5000 BP moist conditions prevailed, and a complex of paleosols developed. For the last 5000 years, the climate has been cooler and dryer, punctuated by several small episodes of neoglaciation in higher mountain ranges (An *et al.*, 1991*a*: 229).

Recently An and his colleagues (An *et al.*, 1993) have refined this sequence using a loess profile from south of the Tengger Desert. In the Baxie section, Malan Loess began to accumulate about 17,000 TL years ago. The Baxie paleosol then developed, to be subsequently buried by the Taohe Loess, and, in turn, by a Mid-Holocene paleosol complex, interbedded steppe-type paleosols and weak paleosols developed on loess. An's original paleomonsoon model (An *et al.*, 1991*b*) would tend to interpret the Baxie soil, with its greater magnetic susceptibility, as a product of the Late Pleistocene warming trend, and the Taohe Loess as an indicator of the brief cold pulse previously thought to correlate with the Younger Dryas. However, calibrated ^{14}C dates indicate that the Baxie soil is the same age as the Younger Dryas interval dated at 13,029–12,799 to 11,346–11,006 calibrated years BP, while the Taohe Loess is younger. If the Baxie dates are correct, expression of the Younger Dryas in north and central China may not have been uniformly cold and dry, but spatially variable, characterized by a winter monsoon in some places and a strong summer monsoon with increased precipitation in others (An *et al.*, 1993: 50). We observe, nevertheless, that this new interpretation does not account for the very rapid accumulation of Taohe Loess between 10,750 and 10,000 calibrated years BP (An *et al.*, 1993: 48), or the sharp drop in Daihai Lake (Figure 2(a)), both of which indicate a short xeric interval in which perhaps the winter monsoon dominated.

The paleoenvironmental picture of central China is further clouded by the record from Jilantai Salt Lake (Geng & Chen, 1990) in the internally drained Ulan Buh Desert basin northwest of the Helan Shan (Figure 2(c)). Although only two radiocarbon dates are available, stratigraphy and geomorphology suggest a continuing decrease in depth and area since the Early Holocene (Geng & Chen, 1990). However, if the mid-Holocene climate under a dominant summer monsoon was warm and moist (An *et al.*, 1991*b*, 1993), why did Jilantai decline? The Helan Shan itself may explain the apparent disparity. Geng & Chan (1992) suggest that under full glacial conditions the Helan Shan accumulated enough snow pack, and evapotranspiration rates were sufficiently low in the Ulan Buh basin, that run-off from the Helan Shan into Jilantai maintained a brackish lake at high levels. Currently, however, the Helan Mountains are at the limit of effective summer monsoon moisture and the Ulan Buh Desert basin lies in their rain shadow; monsoon rains seldom reach Jilantai, and they contribute little or no snow to the Helan Shan. In the warmer, summer monsoon dominated, Mid-Holocene, run-off from the Helan Shan may have been reduced, while evapotranspiration rates in the Ulan Buh were too high to sustain even a salt lake.

In any case, it seems that not only was the Pleistocene–Holocene transition a time of considerable climatic and environmental flux in central China, but

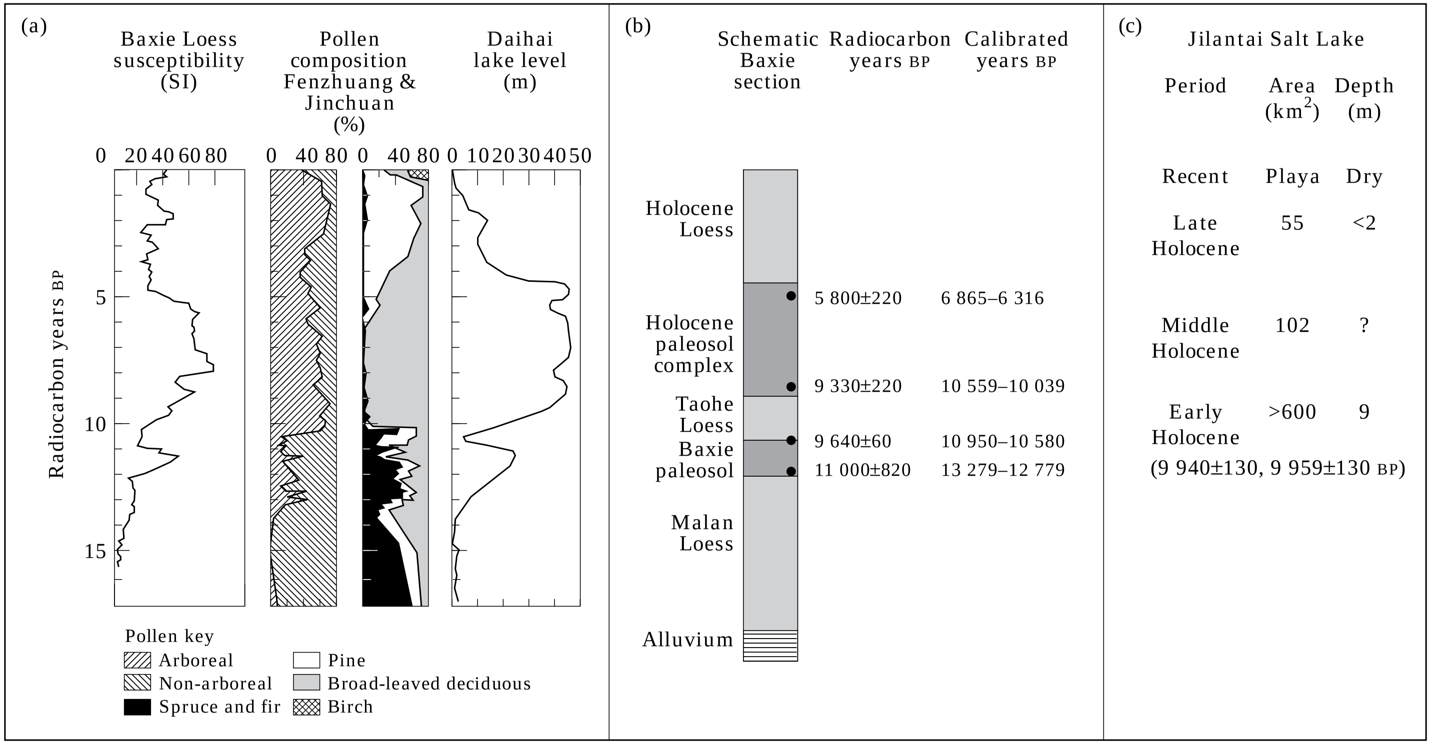

Figure 2. Paleoenvironmental models for the Late Pleistocene/Holocene of north central China. (a) After An *et al*. (1991*b*), (b) after An *et al*. (1992), (c) after Geng & Chen (1990).

Table 1. Survey areas and locality types

	N No. 1	N No. 2	N No. 3	N No. 4	N No. 5	N No. 6	NM No. 1	NM No. 2	NM No. 3	NM No. 4	NM No. 5	NM No. 6
Palaeolithic												
Foraging localities	4			6			1	2		1	1	1
Rock art localities			1									
Neolithic												
Foraging localities	5			3	3			22				
Structural localities									3		1	2
Rock art localities												
Multicomponent	[4]		[1]	[2]				[2]			[1]	
Total	5		1	7	3		1	22	3	1	1	3

lacustrine environments in the Ulan Buh and Tengger deserts were transformed into salt marshes or eliminated during the first half of the Holocene. These events undoubtedly had considerable impact on hunter–gatherers experiencing the associated extinctions, shifts in zonal vegetation and changes in the quantity and distribution of water. These shifts may have been especially critical in the area around the great bend of the Yellow River where many of China's major vegetation zones, and the climatic regimes which control them, intersect and where they are most susceptible to change (Winkler & Wang, 1993). It is in this region where vegetational changes for the critical period between 12,000 and 6000 years ago were most dramatic (Winkler & Wang, 1993: 244–245, 252).

Previous Archaeological Research

In the 1920s, the area around the Helan Shan was a target for scientific expeditions to Mongolia, the Ordos, and the Tarum Basin. Shuidonggou, the best-known site in the region, is one of several sites in the Ordos originally discovered and tested by Pierre Teilhard de Chardin & Émile Licent (1924). The Sino-Swedish expeditions of the 1920s, led by Sven Hedin, identified and mapped a series of sites north of the Helan Shan (Hedin, 1968). In 1928, Roy Chapman Andrews and other members of the American Museum of Natural History's Central Asiatic Expeditions, were looking for and recording sites only 40–50 km north of our study area. Andrews, in fact, was forced to turn back when he encountered the Tengger Shamo and:

> ''Utterly exhausted from pushing, we left the cars where they were and dragged ourselves forward half a mile to the western rim. A depression so wide that its limits could not be seen lay before us like a yellow blanket, specked with olive green . . . only camels could carry on to the other side. It marked the end of the trail for us'' (Andrews, 1932: 380).

With the exception of continuing excavations at Shuidonggou (e.g. Jia, Gai & Li, 1964; Jia & Huang, 1984; Zhong, Dong & Zhang, 1987) and the investigation of quarry sites near Hohhot such as Dayao Village (Wang, 1980; Wang & Olsen, 1985), little formal archaeological research relating to the Late Palaeolithic and transitional periods has been accomplished since this early work. Only in the last two decades has any work focused on the Ordos and the deserts of Inner Mongolia, and most of that research has consisted only of very brief visits (e.g. Wang, 1963; Dai, Gai & Huang, 1964; Zhong, 1964; Yikezhao League Cultural Relics Work Station, 1981; Ji & Ma, 1982; Inner Mongolian Archaeological Team, 1985; Wang & Olsen, 1985; Miller-Antonio, 1992), or has focused on Neolithic and historical sites (e.g. Xu & Li, 1988; Xu, 1985, 1993).

Surveys and Results

We have conducted exploratory surveys over a period of three years involving a variety of settings (sand dunes, alluvial fans, stream margins and lake-marsh shorelines) on both sides of the Helan Shan, along fan heads at its eastern foot, mid-fan locations on the southern end of the Helan Shan, the interior of the Helan Shan, dune margins on the extreme southern end of the Tengger Shamo along the Yellow River, and in areas up and downstream from the Shuidonggou site. Twelve survey areas were investigated (Figure 1); six on the eastern (or Ningxia) side of the Helan Shan, and six on the western (or Nei Mongol) side. None of these areas was exhaustively surveyed, as the object was merely to determine whether sites were present in the same kinds of environmental settings as sites in the Great Basin.

Forty-seven localities were recorded in 10 of these survey areas (Table 1). Following current archaeological convention in China, each of these ten areas was identified as a single ''site'', with ''localities'' designating distinct cultural depositions which are clearly separate in space and time. In keeping with new Chinese Cultural Relics regulations no surface collections were made and all of our assessments are based on direct field observations. Following the age determinations described below, the localities range in age from Late

Palaeolithic to Late Neolithic. Seventeen localities contain Late Palaeolithic components, while 40 have Early to Late Neolithic components. Ten of the 47 are multi-component localities. Twenty-two localities were recorded in detail and the remainder were noted cursorily.

Four of the survey areas (Ningxia No. 2, Ningxia No. 3, Nei Mongol No. 1 and Nei Mongol No. 4) are at canyon mouths in the Helan Shan at the heads of broad alluvial fans, locations favoured in the Great Basin by hunter–gatherers and farmer–foragers because of the ready access to multiple resource zones (e.g. Madsen & O'Connell, 1982; D'Azevedo, 1986). Late Palaeolithic depositional localities were identified in each survey area on the western side of the mountain. None were identified on the eastern side, but recent alluvium has completely obscured earlier depositional surfaces. No Neolithic sites were identified in any of these four areas. A rock art site, possibly containing elements ranging from Late Palaeolithic to Historic in age (Xu, 1993), was recorded in the Ningxia No. 3 area.

Three survey areas (Ningxia No. 4, Nei Mongol No. 5, and Nei Mongol No. 6) are at mid-fan locations where water seeping through the alluvial fans reaches the surface to form springs and small spring bogs. Each of these contained Late Palaeolithic to Neolithic depositional palimpsests. At Ningxia No. 4 and Nei Mongol No. 5, where some horizontal stratification occurred, multiple locations were recorded. Two of the sites contain Neolithic structural localities. Two survey areas on the western side of the Helan Shan (Nei Mongol No. 2 and Nei Mongol No. 3) are located at fan toes where water from Helan Shan alluvial fans seeps into the dunes of the Tengger and Ulan Buh sand deserts, and where relatively more productive habitats occur. Permanent water was available along the southeastern shore of Jilantai, and marsh environments may have been available during the Late Pleistocene/Early Holocene. Large numbers of Early- to Mid-Neolithic localities occur in interdunal blowouts in both survey areas; those at Jilantai contain structures. Two Late Palaeolithic localities occur at Nei Mongol No. 2. In these dune margins, the number of ''localities'' is more a function of sand movement than of discrete depositional factors.

Two survey areas (Ningxia No. 1 and Ningxia No. 5) are located along the incised channels of small permanent streams at the margins of sand deserts. Palimpsests of Late Palaeolithic and Neolithic materials occur in interdunal blowouts in both areas. The Ningxia No. 1 survey area is east of the Yellow River on the southern margin of the Mu Us sand desert (extending into Nei Mongol) and contains the site of Shuidonggou. The stratified deposits and associated radiometric dates (e.g. Zhong, Dong & Zhang, 1987) provide some chronological controls for adjacent localities. Ningxia No. 5 is located along a small stream on the extreme southern margin of the Tengger Desert where its sands cascade into the Yellow River and are swept ultimately into the sea. The remaining survey area (Ningxia No. 6) is in the central Helan Shan immediately below the upper tree line. Hunting-related sites are common in the alpine zones of isolated Great Basin mountain ranges (e.g. Bettinger, 1991), but none were identified here. However, the Helan Shan is composed of steep, almost cliff-like peaks in its central reaches and supports only limited alpine grasslands. Early reports on Helan Shan large mammal populations (e.g. Prejevalsky, 1876), suggest such sites are to be expected, but they may occur at lower elevations, particularly on the west.

Analysis

For comparative purposes, we focus here on the 22 localities recorded in detail and their relationship to the Sino-Swedish materials we previously analysed from the central Alashan Desert (Bettinger, Madsen & Elston, 1994). In that study we focused on a large group of Neolithic sites of comparable age. By contrasting assemblage variability, we were able to classify sites into basic functional categories and define a central Alashan Neolithic subsistence-settlement system. We contrasted this system with very limited numbers of Late Palaeolithic sites and suggested a rapid colonization and intensification of land-use at the end of the Pleistocene in what is now the central desert. Unfortunately, sample size and the inability to collect representative materials precludes a similar approach here. We did, however, locate and study a relatively larger number of Late Palaeolithic sites, permitting us to evaluate technological changes that occurred at the end of the Pleistocene in a way we could not do with the Hedin collection.

Northern Chinese archaeological sequences spanning the Late Palaeolithic–Neolithic transition are not well known; radiocarbon dates are relatively few, and continuous sequences through the transition are missing (e.g. Shuidonggou), making it difficult to tell exactly when, and at what rate, various technologies (such as blades, microliths, and grinding stones) were added to the tool kit or were abandoned. Consequently, because temporally diagnostic artefact types and/or assemblages have not been formally defined, dating of surface items remains problematic, hindering interpretations of assemblage variability and settlement patterns.

Generally, blades and microblades are found in both Late Palaeolithic and Neolithic contexts in north China and are not thought to be particularly diagnostic (Gai, 1985; Tang & Gai, 1986), although some specific tool and core types are chronologically useful (Chen & Wang, 1989). Specifically, one Chinese school of thought holds that there is a gradual reduction in tool size over time (Jia, 1978; Chen & Wang, 1989), and a proliferation and refinement of manufacturing techniques (Jia & Huang, 1985). Exactly when microblades appear is unclear. Tang & Gai (1986) suggest they are present in the Shiyu site in Shanxi (28 945 ± 1390 BP), but not in Salawusu (Sjara-osso-gol), in the eastern Ordos of Nei Monggol (35 340 ± 1900 BP), or the Palaeolithic deposits of Shuidonggou (26 230 ± 800 to 17 250 ± BP). However, Miller-Antonio's (1992) quantitative technological analysis of lithic assemblages from Shiyu and Salawusu, suggests that neither contains evidence of true microblades.

We think that microblades appear in the Late Palaeolithic, but that it may be possible to distinguish Late Palaeolithic and Neolithic blades and blade tools with reference to production techniques that have been frequently lumped with each other and with production techniques having nothing to do with formal blade production at all. As Gai (1985: 226) notes:

> ''Throughout the history of Chinese research into the subject, the meaning of the term *microlithic* has undergone many fundamental changes . . . [and the term has] . . . appeared in many Chinese publications in a variety of cultural contexts and stages of technological development.''

He further notes that:

> ''. . . the concept of a microlithic industry has become more clearly defined and limited in scope and is no longer used in reference to small tools in general. Today, the term *microlithic industry* usually indicates an assemblage of artifacts that includes microblades, scrapers, points, small projectile points with flat or concave bases, and a variety of microcores used to produce the blades themselves. *Microblades* are defined as thin strips of stone about 2 mm in thickness with a triangular or trapezoidal cross section. Typical microblades are characterized by roughly parallel sides with a maximum width of less than 10 mm.''

It appears possible that the earlier and later complexes can be distinguished by blade size, core type and, possibly, production technique (but see Flenniken, 1987). For example, only conical and boat-shaped cores are present at Xiachuan between 21 700 and 19 600 BP, conical, boat-shaped and wedge-shaped cores are at Xueguan *c.* 13,500 BP, and only wedge-shaped cores are found at Hutouliang by 11,000 BP (Gai, 1985: 231–232). In addition, in the earlier assemblages (Xiachuan and Xueguan), blades are rarer relative to cores, and blades and cores are proportionally less well represented than in Neolithic assemblages (Bettinger, Madsen & Elston, 1994: 95). These changes may reflect a more basic transition from direct to indirect production techniques, but this is not yet clearly defined, and, moreover, they are in very different environmental settings.

Lithology

Two stone tool complexes, characterized by different lithic raw material (or toolstone), are evident in our sample (Table 2). Most abundantly represented is a Neolithic complex characterized by what appears to be imported siliceous cryptocrystalline materials, mostly yellow, brown, and red cherts, and composed almost entirely of microblades and microblade production debris. The raw materials are very similar to those described by Maringer for central Alashan quarry areas of Ukh Tohoy-Hara Dzag (Maringer, 1950: 104). Like those in the central Alashan, the Helan Shan microblades are very uniform, consistently less than 10 mm in width, usually less than 6 mm wide. Late Palaeolithic blades in the Helan Shan area are also sometimes made on high quality cryptocrystallines, but generally of a different kind (e.g. Nei Mongol No. 6, Locality A). Relative to their Neolithic counterparts, however, these Late Palaeolithic cryptocrystalline blades are typically more than twice as large, and much wider relative to length, and fall outside the generally accepted Old World limits for microblades by width (12 mm) and often length (50 mm). Since raw material quality is not limiting when one compares these Late Palaeolithic cryptocrystalline blades with their Neolithic counterparts, the differences in blade shape and size must be technical and intentional. In short, our sample suggests that in the Helan Shan area, and by extension elsewhere in north China, it may be possible to distinguish Neolithic microblades and related tools and debris from Late Palaeolithic blades, cores, and blade tools according to technically-related morphology.

The second toolstone complex is produced from locally available coarse-grained cryptocrystalline quartz and quartzite commonly found as cobbles in the alluvial fans of the Helan Shan and along the small streams which feed the Yellow River. Cobble-derived tools and manufacturing detritus are ubiquitous at all sites in our small sample, and in themselves are not time sensitive. The relatively coarse-grained cobbles have been variously broken, reduced, and flaked at localities we interpret as Late Palaeolithic, Early Neolithic and Middle Neolithic. Flakes, reduced cores, and random chunks have been bifacially flaked along one or more edges to make crude cutting/chopping tools. Many of these are made on blade-form flakes (e.g. twice as long as wide), perhaps struck from bifacial cores, and, when finished are difficult to distinguish from tools made on true blades. Jia & Huang (1985: 214) suggest that ''. . . the use of small, irregular flakes and the employment of direct percussion in the fabrication and retouching of tools'' continued from the Middle Palaeolithic to the Late Palaeolithic. Since it is unlikely all our sites contain only Late Palaeolithic components, it would appear this cobble-derived tool tradition continues into the Neolithic (see also Bettinger, Madsen & Elston, 1994: 80).

Here again, we tentatively identify two technological complexes. The earlier one is Late Palaeolithic and is centred on the production of flakes and blades that were later worked into tools. The later one is Neolithic

Table 2. Presence/absence of tool types at 22 Helan Shan localities

		Cobble Industry									Microblade Industry				Neolithic Diagnostics					
															Pottery					
	Ostrich shell	Core	Point	Blades	Blade end/side scrapers	Expedient end/side scrapers	Bifaces	Battered cobbles	Flakes	Shatter	Point	Cores	Blades	End/side scrapers	Cord marked	Plain	Painted/ footed	Ground stone	Axes	Possible structures
Nei Mongol No. 1, Locality A				X	X	X	X	X	X	X										
Nei Mongol No. 6, Locality A				X	X	X	X	X	X	X										
Nei Mongol No. 4, Locality A		X	X	X	X	X	X	X	X	X										
Ningxia No. 4, Locality A				X	X	X	X	X	X	X		X								
Ningxia No. 4, Locality C			X	X	X	X	X	X	X	X		X	X	X					X	
Ningxia No. 4, Locality B				X	X	X	X	X	X	X		X	X	X						
Ningxia No. 1, Locality A	X	X	X		X	X	X	X	X	X		X	X	X	X	X		X	X	
Ningxia No. 1, Locality D	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X		
Nei Mongol No. 2, Locality A					X	X	X	X	X	X			X	X	X	X				
Nei Mongol No. 2, Locality B	X		X	X	X		X	X	X	X	X		X		X	X			X	
Nei Mongol No. 2, Locality E							X	X	X	X			X		X	X		X		
Nei Mongol No. 5, Locality A							X	X	X	X		X	X	X	X		X	X	X	X
Nei Mongol No. 6, Locality B								X	X	X		X	X	X	X	X				X
Nei Mongol No. 3, Locality A									X	X			X	X	X			X		X
Nei Mongol No. 3, Locality B									X	X		X	X	X		X	X	X		X
Nei Mongol No. 6, Locality C													X							X
Ningxia No. 5, Locality A							X	X	X	X					X	X	X	X		
Ningxia No. 5, Locality B							X	X	X	X					X	X	X	X	X	
Nei Mongol No. 2, Locality C							X	X	X	X					X	X	X	X	X	
Nei Mongol No. 2, Locality D							X	X	X	X					X	X	X	X		
Ningxia No. 1, Locality E	X						X	X	X	X					X	X		X		
Ningxia No. 1, Locality B							X	X	X	X					X	X		X		

and is aimed more at working cobbles directly into crude chopping and cutting tools. The difference should be relatively easy to detect with reference to tool/debitage ratios but the two assemblages remain outwardly similar and it will not always be possible to make chronological assessments merely by the presence of crude cobble-derived implements.

In short, while both the stream cobble flake and chopper industry and the microblade industry may be time-sensitive, the recognition of chronologically useful features at the survey level is fraught with difficulties, and differences in their simple presence or absence at sites and localities around the Helan Shan may as easily be ascribed to differences in site function as to differences in antiquity. This creates a problem for us, since our long-term goal is to compare the use of archaeological landscapes by hunter–gatherers and farmer–foragers in the deserts of China and the Great Basin, and it is critical that we be able to chronologically distinguish a broad array of surface sites without resorting to radiometric dating techniques and/or a detailed on-site analysis of lithic technology. A close examination of Table 2, however, does suggest some useful connections between time and lithic assemblage.

Functional Versus Temporal Categorization

With the exception of localities at Ningxia No. 4, which we think may be transitional in nature, the narrow prismatic chert blades we identify with the microlithic are invariably associated with Neolithic diagnostics such as pottery, polished stone axes and ground stone. Therefore, although microlithic cores and blades have been reported from pre-Holocene contexts elsewhere in China (e.g. Tang & Gai, 1986), we are confident that the presence of microblades [as An (1978), Gai (1985), Miller-Antonio (1992) and ourselves have defined them] identifies post-Late Palaeolithic (i.e. transitional to Neolithic) components in the southeast Alashan and western Ordos (see also Wang & Olsen, 1985; Olsen, 1987). Abundant microblades and cores are also positively associated with the presence of possible house structures at localities in our sample. Structures are present at six of the eight localities where food processing artefacts and microblades/cores occur in significant numbers (one to three microblades were identified at six of the 22 Neolithic sites in the dune margins of the Tengger Desert). The exceptions are two localities in Ningxia No. 1, where the size of the collection and the presence of burned clay suggests the former presence of structures subsequently obliterated by deflation.

The absence of microblades does not necessarily imply older occupation. Stream cobbles were used as a locally expedient toolstone source throughout the Neolithic. At localities such as those on the dune margins of the Tengger Desert, cobblestone quartzite is the only toolstone present. For example, Nei Mongol No. 2, locality C is characterized by footed ceramics, ground stone and polished axes, and is clearly middle Neolithic in character despite the absence of a microblade industry. As a result, we cannot necessarily conclude that a site/locality with only ‘‘small, irregular flakes fabricated with simple direct percussion’’, is necessarily Palaeolithic, since it could just as easily be a special purpose, short-term Neolithic site where artefacts like pottery and ground stone were simply never used and consequently never deposited (but see Olsen, 1987: 144).

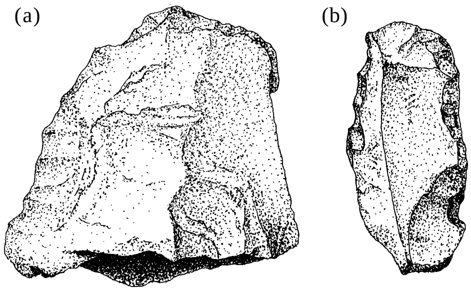

Figure 3. (a) Typical cobble-derived expedient scraper from Nei Mongol No. 4, locality A. (b) Typical cobble-derived blade end scraper from Ningxia No. 4, locality A (both actual size).

Two related tool types may be diagnostic of Late Palaeolithic occupations (Figure 3). One consists of expediently made crude cobble flakes or chunks unifacially retouched into end/side-scrapers. These are often quite large, exceeding 7 cm in length, with edge angles greater than 50° and usually more than 70°. We call these expedient scrapers to distinguish them from a group of thinner end/side-scrapers, also Late Palaeolithic in age, made on blades derived from prepared cores. Our ‘‘expedient scraper’’ is characterized by a very steep working face that tends to distinguish them from otherwise similar ‘‘side-scrapers’’ from Shiyu (Miller-Antonio, 1992: 170) and scrapers from Xiachuan and Xueguan (Tang & Gai, 1986; Chen & Wang, 1989). Examples of what we call expedient scrapers, however, are clearly present at Shuidonggou, Ningxia, directly across the Huang He from the Helan Shan (Chen & Olsen, 1990: 283, figure 15.4, 5–6). Yamanaka (1993) notes that these scrapers are very common in the Shuidonggou assemblage collected by Teilhard de Chardin and Licent in 1923 and that similar tools are typical in the Late Palaeolithic of far-eastern Asia.

Also potentially diagnostic of the Late Palaeolithic are a group of large, direct-percussion blades and thin, steeply retouched ($\geqslant 50°$), end/side-scrapers fashioned from such blades. Materials are a mixture of high quality chalcedony and all the various kinds of local cobblestone also used for expedient scrapers in the Late Palaeolithic and for expedient cobble-derived tools in Neolithic assemblages. The Late Palaeolithic specimens made on cobble-derived blades are surprisingly thin and morphologically uniform, and in this respect quite distinct from irregular, expediently-manufactured cobble-derived flake tools common through the Palaeolithic into the Neolithic in north China. In comparison to their cobble-derived counterparts, the Late Palaeolithic chalcedony blades and blade tools are narrower (15–20 mm vs. 20–30 mm), probably as a function of material quality, but still much larger than and readily distinguished from microblades and microblade tools. Expedient scrapers and thin blade scrapers co-occur at 15 of the 16 localities with what we have defined as Late Palaeolithic components. At several sites, more widely recognized diagnostics, such as lame à crête blades, also occur. Less steeply bevelled cobble-derived scrapers may also be diagnostic, but we are not yet convinced they are not part of the transitional-Neolithic tool kit as well.

The distribution of cobble-derived end/side-scrapers, both at localities where they occur alone and at those where they co-occur with Neolithic materials, makes it difficult to be fully confident of our chronological placement in the absence of radiometric dates. The expedient and blade scraper categories we employ here are not usually separated in most Chinese archaeological reports (but see Chen & Wang, 1989), and it is difficult to define their spatial and chronological distributions. This is particularly true of the expedient scrapers, which occur relatively frequently, but are infrequently reported (Olsen, 1994, pers. comm.). The distinction between pointed tools made ''. . . on small chunks of flint rather than on specially struck flakes'' made by Wang & Olsen (1985: 248) at the Dayao quarry is also rarely made, but may be related. Farther north in Mongolia and Siberia similar large, chunky steeply bevelled scraping tools known as ''skrebli'' are recognized as diagnostic of the Late Palaeolithic and Mesolithic (e.g. Aksenov, 1969*a*,*b*; Michael, 1984). Similar tools are also recognized in the Late Palaeolithic of south China (for example at Tongliang), where they are thought to be a holdover from the Early Palaeolithic (e.g. Jia & Huang, 1985).

Based on the associations and reasoning outlined above, we believe these implements are Late Palaeolithic, although it is possible they are specialized tools manufactured and used by Neolithic groups along the eastern and western margins of the Helan Shan. Simple cobble-derived flake tools are found at all Neolithic localities we identified and the steeply bevelled retouched cobble blade and expedient scrapers were found with Neolithic diagnostics at 10 of 39 localities. We think these are multi-component sites, but microblades and microblade tools clearly served different functions from those served by these larger, coarser scrapers, and it may well be that the occurrence of these tools at some sites and not at others is related to a functional difference in Neolithic tool use rather than to chronologically separate depositions.

The chronological placement of the cobble derived scraper industry within the Late Palaeolithic of north central China remains problematic. Given the extended length of the period (from around 35,000 to 10,000 BP) and the paucity of well dated and well stratified sites, it is difficult to define change in this industry. We are struck by its overall uniformity from site to site within our sample, and, with the possible exception of the Ningxia No. 4, we see no evidence of a transitional industry. We certainly see no evidence of the kind of gradual evolution in core and blade technology suggested by Jia (1978). There are at least two possible explanations for this. First, the end of the Late Palaeolithic period may simply not be represented in our sample because of its limited size, because of geomorphological factors, or because the region was abandoned for millennia. None of these reasons is entirely satisfactory. Second, we view the elaboration of core-and-blade technology and an increase in the blade edge per core ratio as a product of reduced mobility and the need to husband toolstone resources. Where toolstone is locally abundant and/or hunter–gatherer mobility is high, the number of blades per core is not a critical concern. The lack of an elaborated Late Palaeolithic lithic industry in the Helan Shan area may therefore be a product of continued high residential mobility and not a product of regional abandonment. We think this the more likely explanation and one that is supported by what little chronological evidence is available (e.g. Kozlowski, 1971).

In a more general way, change in blade technology captures the essential elements of the Late Palaeolithic to Neolithic transition in North China. The connecting mechanisms remain unclear, but we are convinced the increase in blade number and decrease in blade size during this interval parallels a dietary shift that involved the handling of greater numbers of smaller individuals and smaller species, plant and animal alike. Large tool technology was moving in the opposite direction: well-formed flaked tools with what appear to be specialized working edges were replaced both by a range of expedient tools minimally retouched (if at all) for short-term, non-demanding tasks, and by specialized groundstone implements such as axes.

Colonization, Intensification and Changing Land-Use Strategies

If cobble-derived expedient and blade scrapers are Late Palaeolithic time markers, it is possible to compare land-use patterns in our small Helan Shan sample with those we identified in the central Alashan Desert (Bergman, 1945; Maringer, 1950; Bettinger, Madsen & Elston, 1994). There, data are available for 61 sites, possibly nine of which were Late Palaeolithic and the remainder Neolithic or transitional. This very preliminary analysis suggests that, by the early Holocene, people in the central Alashan Desert employed a variety of settlement types. In the Great Basin we would be inclined to interpret this as a logistic organizational response to differential seasonal and spatial availability of resources. The paucity of Late Palaeolithic sites in the Sino-Swedish sample indicates a less intense and less differentiated use of that landscape by Pleistocene hunter–gatherers.

We (Bettinger, Madsen & Elston, 1994) arrived at a number of admittedly conjectural conclusions: (1) we linked Neolithic adaptive intensification and complexity with increasing post-Pleistocene resource abundance. We suggested that the Neolithic was characterized by reduced residential mobility and a concomitant increase in the extraction of increasingly more available local energy at higher per unit costs. This kind of change is unexpected, since hunter–gatherers should avoid such costly trade-offs where the availability of resources is increasing. Generally, mobility should increase and diet breadth decrease as higher-ranked resources become more abundant (Stevens & Krebs, 1986). We explained this apparent contradiction by arguing that (2) the central Alashan Desert contained very small quantities of resources prior to the Holocene, so that the appearance of Neolithic groups was more a product of colonization than it was a product of intensification. Our Helan Shan data now allow us to modify and refine those conclusions.

In terms of numbers alone, our sample suggests a more modest increase in occupational intensity between the Late Palaeolithic and the Neolithic around the Helan Shan. There seems to have been a relatively continuous occupation of the Alashan and Ordos desert margins from the Late Palaeolithic through the Neolithic, and there is little or no evidence of the ‘‘colonization’’ which characterizes the central Alashan Desert sequence. There does, on the other hand, appear to have been a change in subsistence/settlement strategies. Although our sample is small, Late Palaeolithic assemblages are more widely distributed and assemblages tend to be located closer to canyon mouths on the mountain front, or at springs in the middle reaches of fan trenches where access to game and the zonal ecological diversity of the mountains was greater. In contrast, Neolithic material tends to be located closer to fan toes or at lower to middle fan springs where water could have been more easily directed for agriculture. The distribution of Late Palaeolithic hunter–gatherer sites matches our expectations, although we should expect to find such sites along lake margins as well (Madsen & O’Connell, 1982; Jia & Huang, 1985; Willig, Aikens & Fagan, 1988). Indeed, the Late Palaeolithic sites in our Ningxia No. 4 survey area occur on the beaches of extinct ponds and the Late Pleistocene Jilantai beach may contain similar material.

This change in the distribution of sites across the landscape is accompanied by an apparent change in mobility as well. The limited array of both tool and material types at the Late Palaeolithic sites suggests they represent short-term camps. The Neolithic sites, on the other hand, contain the broad array of material we think characterize residential bases and seasonal base camps (i.e. ceramics, ground stone, axes, structures, etc.) (Bettinger, Madsen & Elston, 1994: table 4). The Neolithic assemblages along the margins of the Tengger dunes, for example, appear to represent a focus on the intensive seasonal processing of wild seed crops and small animals. We cannot yet determine if they are a product of seasonal foraging by local farmers or represent occupation by full-time hunter–gatherers and/or pastoralists. Regardless, these sites represent longer stays and, concomitantly, an increase in the extraction of available local energy. There does, in short, appear to be evidence of Neolithic adaptive intensification and complexity along the western margin of the Helan Shan.

By combining the central Alashan and Helan Shan data sets, we can modify and extend our earlier hypotheses. We now suggest the following spatial/temporal and subsistence settlement frameworks for our larger comparative project.

(1) We expect to find a high degree of localized residential mobility among Late Pleistocene hunter–gatherers. Settlement should be focused on areas of high local environmental diversity, high productivity, and high resource rank—such as riverine environments and lake-margin marshes. Areas characterized by low-ranked resources, limited diversity, and long distances between procurement areas (i.e. where transport costs are high) should show only limited evidence of occupation. That is, we should find larger numbers of short-term Late Palaeolithic sites along streams and lakes near the flanks of major mountain chains such as the Helan Shan, Lang Shan and Yabrai Shan, and limited numbers of Late Palaeolithic sites in the central Alashan Desert.

(2) With the change to warmer and wetter conditions at the close of the Pleistocene, the central Alashan began to support larger, more diverse, and higher ranked resources, whose extraction in cost/benefit terms was comparable to that found along the desert/mountain interface. This change in the nature and distribution of resources led to the colonization of the central Alashan habitats and possibly to an increase in population of hunter–gatherers in the general Helan Shan region. During this time we envision a continuing high degree of residential mobility spread over a large area, and we expect to find relatively fewer numbers of residential bases than in subsequent periods.

(3) During the Early–Middle Holocene, as environmental conditions in the Tengger Shamo west of the Helan Shan began to degrade and hunter–gatherers were forced to broaden their diet both to include lower ranked resources and to develop higher-cost extraction techniques with which to process them, residential mobility was decreased and longer-term residential bases began to be more evident. This decrease in mobility and concomitant reduced access to toolstone led to an elaboration in production technique and a change in blade size which resulted in an increase in the

ratio of edge length per core. It is in this period of Early Neolithic adaptive intensification and complexity that the seeds of the agricultural revolution may have been sown. We expect, however, to find a mix of wild and domestic resources driving the subsistence settlement system. Perhaps this Early Neolithic adaptive strategy in north central China was very like that utilized by the mobile farmer–foragers of the eastern Great Basin (e.g. Madsen, 1989; Simms, 1986).

(4) As agriculture developed during the Middle–Late Neolithic, and as conditions gradually became more arid, settlement increasingly focused on locations where water for crops was readily available. The mobility of farmer–foragers was dramatically reduced, possibly to the point of year-round residence. The alternative solution to these increasingly arid conditions was to shift back to a highly mobile settlement pattern, but in this case relying on the use of domesticated animals. In short, pastoralism and full-time farming were both born of a response to more arid conditions following the early Holocene moist period; responses very unlike those found in the Great Basin (Madsen & O'Connell, 1982; D'Azevedo, 1986).

Conclusions

This operational model is not unlike that produced by Neeley & Clark (1993: 222) for the Pleistocene/Holocene transition in the Levant, although we view change as more an individual response than a systemic one. Nevertheless, the similarity in the models of Pleistocene/Holocene change in two desert areas of the world is striking, and these kinds of economic models allow us to focus more directly on the comparative questions which direct our research. We are beginning to accumulate enough information to allow us to at least categorize sites in Ningxia and western Inner Mongolia. We think that Late Palaeolithic sites can be distinguished by the absence of microlithic tools *and* the presence of large, steeply bevelled cobble-derived scrapers. This combination is important because there is some evidence to suggest that sites without microblades, but with other crude cobble-derived tools, may be related to Neolithic occupations. This gives us some chronological control, but, as yet, we have insufficient data to identify differential site functions and mobility patterns within the Late Palaeolithic.

If our analysis of the Sino-Swedish data from the central Alashan and of our own from the Helan Shan is valid, we can begin to identify changes in Neolithic residence patterns and subsistence focus by identifying a variety of site types representing different kinds of mobility patterns. What may be most important here is the relationship between the development of agriculture and the appearance of a microlithic technology. We have previously noted the correlation between the distribution of microblades and the reduced seasonal availability of wild resources north of an isoline delimiting a temperature range exceeding 30° (Bettinger, Madsen & Elston, 1994; see also Gai, 1985; Domrös & Peng, 1988). We think that the relationship between decreased residential mobility, the increased need for stored resources, the colonization of marginal environments and the development of improved resource extraction techniques go hand in hand. It does not seem unreasonable to look for the antecedents of northern Chinese farming in regions where these features co-occur and where the Pleistocene/Holocene shifts in climatic regimes and associated vegetational zones were most dramatic (Winkler & Wang, 1993). That is, we have suggested it is likely that the earliest evidence for agriculture in north China may be found along the great bend of the Huang He and its environs, well north and west of where it is traditionally thought to be (e.g. Chang, 1986; Crawford, 1992). The surface archaeology of the Helan Shan extends our knowledge of changing Palaeolithic to Neolithic settlement systems in the region and strengthens that conviction.

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