CHRONOLOGY OF POST-GLACIAL SETTLEMENT IN THE GOBI DESERT AND THE NEOLITHIZATION OF ARID MONGOLIA AND CHINA

by

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DEDICATION

With love, for James H. Lee, who has brought me the joy of his companionship since I started my graduate work at the University of Arizona and who I hope will still be my partner in life at the end of my career. And to Sophia V. and Vivianne E. Lee, who have spent their entire lives until now sharing me with my dissertation.

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ABSTRACT

Prior to this study, knowledge of Gobi Desert prehistory was mostly limited to early and mid-20th century descriptions of undated stone tool assemblages from unanalyzed museum collections. This research focuses on the use of extensive existing museum collections to establish a baseline chronology of technology, economy, and land-use for prehistoric Gobi Desert groups. Radiocarbon and luminescence dating is used to establish an artefact-based chronology and provide a relative age for 96 archaeological site assemblages. Interpretations of land-use derived from lithic analysis are compared to detailed regional and local palaeoenvironmental records in order to contextualize residential mobility and subsistence. Results indicate that a dramatic shift in land-use after about 8000 years ago was related to a combination of widespread forestation and the increased productivity of lowland habitats during a period of high effective moisture. Hunter-gatherers organized their movements around dune-field/wetland environments, but utilized a range of both high- and low-ranked foods such as large ungulates from adjoining plains and uplands, and seeds and/or tubers from dune-fields and wetlands. New radiocarbon dates indicate that the use of dune-fields and wetlands persisted into the early Bronze Age, overlapping with the rise of nomadic pastoralism across Northeast Asia. These findings illuminate the period just prior to the rise of nomadic pastoralism in Northeast Asia and add considerable depth to our understanding of hunter-gatherer adaptations within arid environments following the Last Glacial Maximum.

CHAPTER 1 – INTRODUCTION

Spanning southern Mongolia (Mongol Uls/Outer Mongolia) and a vast area of northern China (including the western Inner Mongolia Autonomous Region or Nei Menggu Zizhiqu, northern Gansu, and the northeastern Xinjiang Uyghur Autonomous Region), the Gobi Desert is bounded by the Altai Mountains in the west and north, the Mongolian steppe to the northeast, the Hexi Corridor and Qinghai-Tibet Plateau in the southwest and the North China Plain far to the east (Figure 1.1). Today, it is covered by extensive mountain ranges, plateaux, erosional basins, former lake beds, gravel plains, desert-steppe, and dune-fields. Annual extreme temperatures range from +40^{o}C in the summer to -40^{o}C in the winter and the average rainfall is less than 200 mm/year. The continental desert environment separates two distinct ecological and cultural zones of East Asia – the fertile Central Plains of China and the vast northern steppes of Central and Northeast Asia. By the third century BCE, highly complex stratified agricultural and nomadic pastoral societies had emerged to the south and north of the Gobi Desert respectively, forever altering a base of hunter-gatherer subsistence economies typical of Palaeolithic populations since the appearance of anatomically modern *Homo sapiens* in Eurasia.

The transition from hunter-gatherer to either sedentary agriculturist or nomadic pastoralist represents a key trajectory in the prehistory of East Asia. Although the two modes of food production developed in close proximity, sharing very similar technological traditions since the Upper Palaeolithic, intense political opposition following the early Bronze Age polarized these two economic strategies within the ideology of local inhabitants (see Janz, 2007). As such, the Gobi Desert serves as a geographical barrier between two environmental zones that were the setting for significant but divergent economic and cultural developments. Agriculture was central in the establishment of early Chinese states, which is why the study of domestication its contribution to the establishment of sedentary village communities and social complexity is a focal point of Chinese archaeology. Likewise, the adoption of domesticated herd animals and the spread of nomadic pastoralist economies allowed for the rise of powerful pastoralist states, including the Mongol Empire, whose conquests and migrations shaped the history of cultures across Eurasia – from Mongolia, to Eastern Europe, the Middle East, and South Asia.

Despite our current knowledge of this long-standing mutual influence and interaction between “the steppe and the sown”, knowledge of prehistoric hunter-gatherers and the transition from hunting and gathering to herding is severely limited in East Asia. It is surprising that the prehistory of the Gobi Desert has been recently so little studied, since the strategic geographic nature of the region implies a central crossroads in the divergent technological and cultural developments of Neolithic Northeast Asia. Understanding the trajectory and origin of technological development and subsistence economies in the Gobi Desert is essential to furthering our understanding of technological and cultural transmission between the forerunners of powerful nomadic pastoralist communities and emerging sedentary agriculturalist civilizations in China and eastern Central Asia. Across this region, new technological achievements spread from the West, such as bronze metallurgy and certain types of animal husbandry, reaching agriculturalists settled along the Yellow River (Huang He) and contributing to the florescence of the Chinese state.

Figure 1.1 Map of Northeast and Inner Asia indicating study area. Base map copyright of maps.com, used by permission.

The study of Gobi Desert prehistory began with the discovery of hominid fossils and stone tools by Western scientists in the early 1900s (Andersson, 1943). These discoveries led to the inclusion of archaeologists in two important scientific expeditions in Mongolia and China during periods of tumultuous local political upheaval in the 1920s and 1930s. The Central Asiatic Expeditions were led by Roy Chapman Andrews under the auspices of the American Museum of Natural History in New York City. Sven Hedin led the Sino-Swedish Expeditions, which were funded by the Swedish State, the Chinese government, Deutsche Lufthansa and several private donors (Hedin, 1943).

Recovered archaeological materials from these expeditions spanned all occupation periods, from the Palaeolithic to modern times, but the vast majority of finds were Stone Age and considered to represent the Mesolithic and Neolithic periods (Nelson, 1926a, 1926b; Maringer, 1950, 1963). Artefacts from almost 500 Stone Age sites were shipped to the United States and Sweden for analysis along with other materials recovered by expedition scientists. Half of the materials collected during the Sino-Swedish expeditions was left in China and eventually studied by Chen Xingcan in the 1980s (see Fiskesjö and Chen, 2004). Most were derived from surface assemblages and a few from excavated contexts. Heightened political tensions and civil war, followed by the rise of isolationism among the communist governments, effectively terminated work by Western scientists.

Collections made by Central Asiatic Expedition archaeologists Nels C. Nelson (1925) and Alonzo Pond (1928) are currently housed at the American Museum of Natural History. These collections have been studied briefly by a number of archaeologists, including Richard Morlan (1976). A list of sites, artefact illustrations, and portions of original journals and unpublished manuscripts were published by Walter Fairservis (1993). However, no extensive analyses had been undertaken until several sites from the Shabarakh-usu locality were studied as part of my Master's thesis research (Janz, 2006) and ostrich eggshell specimens from Shabarakh-usu and the Baron Shabaka Well locality (Site 19) were radiocarbon dated in 2007 (Janz et al., 2009).

Collections made by the Sino-Swedish Expedition archaeologist, Folke Bergman, were supposed to have been returned to China following study. For many years the Stone

Age remains were believed to have been repatriated to China, as had been a portion of the Chinese Neolithic material excavated by Andersson, and most of the historic remains uncovered at Etsin Gol (Edsengol/Ejina He). During his tenure as Director of the Museum of Far Eastern Antiquities in Stockholm in the early 2000s, Magnus Fiskesjö discovered Bergman's collections which had been stored at the museum while being studied and published by Johannes Maringer. Indeed, the collections had not been re-examined since Maringer's work in the 1940s (Maringer, 1950, 1963). My initial assessment of Nelson's and Pond's finds suggested that valuable data could be salvaged from the assemblages, and the renewed availability of the Sino-Swedish archaeological collections made the project even more appealing. The sheer geographic extent represented offered a sample that could not be reproduced under modern logistical and political constraints. With recent advances in chronometric dating on ostrich eggshell and pottery, the collections could be used to establish connections between Gobi Desert groups and contemporaneous environmental and cultural influences.

Between the collections from the Central Asiatic and Sino-Swedish expeditions, I studied over 100 sites from three Gobi Desert regions – the East Gobi, the Gobi-Altai, and the Alashan Gobi, producing a sample size of approximately 6,000 artefacts. In February 2010, I was able to examine additional collections at the Institute of Archaeology, Mongolian Academy of Sciences in Ulaanbaatar, and the Institute of Archaeology and Ethnology, Russian Academy of Sciences, Siberian Branch in Novosibirsk. Analysis of these collections reinforced my initial impressions of chronology, but these assemblages were not included in this analysis.

Although my dissertation research focused on the analysis of existing museum collections, fieldwork experiences have contributed to my understanding of Northeast Asian prehistory. My fieldwork in Mongolia has included the excavation of Bronze Age ceremonial structures in Arkhangai aimag, full-coverage survey and mapping of prehistoric and historic sites in Dundgov' aimag (Middle Gobi province), excavation at the open-air Palaeolithic Tolbor locality in Bulgan aimag, and an exploratory survey of the Shabarakh-usu locality in Ömnögov' aimag (South Gobi province). I have also participated in the excavation of Kurma XI, a Serovo/Glazkovo period cemetery in the Lake Baikal region of Siberia. These experiences have been invaluable in building my knowledge of archaeological landscapes and interpretation of land-use, and have helped me to situate the Gobi Desert within a larger body of Northeast Asian archaeology.

Prior to this study, only two post-Last Glacial Maximum (LGM) archaeological sites in the Gobi Desert proper had been dated (Derevianko et al., 2003; Janz et al., 2009) and so our knowledge of the region consisted mostly of broad generalizations (Maringer, 1963; Fairservis, 1993; Derevianko et al., 2003). While recent studies have focused on the relationship between the effects of climate change on desert hunter-gatherers and the development of agriculture in northwestern China (Bettinger et al. 2007, Bettinger et al., 2010a, 2010b), very little is known about the subsistence and settlement strategies of desert inhabitants living on the margins of agricultural China. In order to understand how domestic herd animals and nomadic pastoralism were first introduced to Mongolia and northern China we must consider the organizational strategies of post-LGM hunter-gatherers, who would have been the first to adopt domesticated herd animals and incorporate them into existing subsistence strategies.

Based on the geographic range of collections and the distinct variability of their geological and environmental contexts, three target regions were selected for further research as part of the present study. Localized variability in Gobi Desert palaeoclimatic records illustrates that major regional variation in the influence of monsoon regimes and subtle deviations in vegetation, hydrology, and geography could have fostered the development of divergent archaeological records. Each target region was collected under the direction of an individual archaeologist, and regional samples were expected to be relatively cohesive due to consistency in collection strategies. The three target regions are defined below and illustrated in Figure 1.2.

The East Gobi (collected by Alonzo W. Pond)

The East Gobi is a desert-steppe environment of basins, small lakes (*nuur*/*nur*/*nor*), steppe, and mesas, being dissected by numerous drainage channels, riverbeds, and dry gullies. The easternmost bend of the Yellow River borders the western edge of this region, while the northeastern edge is bordered by the Hushandake Sandy Land. Isolated patches of dune-fields are distributed across the region. The archaeological collections that I studied came from three major subregions: Southwest, is located just above the north-easternmost bend of the Yellow River, and is typified by plains and mountains, the latter of which seem to have been an area of lithic raw material procurement; Shara

Murun River, covers the area along the Shara Murun river system, extending over badlands, valleys, dune-fields, small lakes/lake basins, and mesas across the neighbouring plains, and bordered by southern uplands; and farthest east, the Great Lake Basin is flanked on the eastern edge by mountains over 1500 m a.s.l. (Hill, n.d.: 21, 22), and is characterized by badlands, plains, valleys, many mesas, numerous small lakes, and dune-fields along the southern and eastern margins (see Figure 1.2 for map of subregions).

The southern edge of the East Gobi falls under the influence of the East Asian summer monsoonal system and is located along what is today a temperate desert to temperate steppe transitional zone. During its period of northward migration, the East Asian Summer Monsoon system would have more heavily influenced the East Gobi than the Gobi-Altai and the Alashan Gobi. Increasing humidity, warmer temperatures, and a decrease in aeolian activity are evident in different parts of this region between about 13.0-10.0k cal BP, and woodlands invaded steppe-dominated environments by the mid-Holocene (Wang et al., 2001; Li et al., 2002; Yang et al., 2004).

The Gobi-Altai (collected by Nels C. Nelson)

The Gobi-Altai is a desert to desert-steppe environment surrounding the easternmost foothills of the Altai Mountains. The region is characterized mostly by sparsely vegetated gravel pavements (*gov'* is the Mongolian root word for the Gobi), but is interspersed with dune-field accumulations. Long-lived, internally-drained lake basins, shallow brackish former or seasonal lakes, and wetlands are scattered throughout lowland habitats. Large alluvial fans and scattered west-to-east-trending ranges divide the Gobi-Altai and Alashan Gobi regions. The collections are derived from three subregions: Shabarakh-usu constitutes the area around the Neolithic type-site of the same name, and is characterized by uplands and basins where many dune-field accumulations are situated around dry or seasonally filled shallow lakes and riverbeds, some with *Haloxylon ammodendron* “forests” (*zakh*/*dzag* or saxaul); the Arts Bogd-Ulan Nuur (Nor) Plain is an area particularly rich in high quality lithic raw materials such as jaspers and chalcedonies, and is characterized by a few scattered dune accumulations around numerous shallow seasonal or dry lakes and former wetlands; and the Valley of the Gobi Lakes, a large valley scattered with dune-field accumulations and east-west trending sub-valleys situated between the southern slope of the Khangai (Khangay) Mountains and the southeastern-most extent of the Altai massif, home to four major semi-saline lakes (Böön Tsagaan Nuur, Adagin Tsagaan Nuur, Orok Nuur, and Tsagaan Nuur) fed by rivers draining from the Khangai Mountains. Due to its northerly position, the valley is largely outside the influence of the Asian summer monsoon system.

An arid desert reached its maximum extent in the Gobi-Altai during the LGM and then again after 13.0k cal BP (Feng et al., 2007). Climatic amelioration, recognized primarily in palaeoclimatic records by a high in effective moisture, reached its height around 8.5k cal BP and continued until about 5.0k cal BP (Owen et al., 1998; Herzschuh, 2006; Feng et al., 2007). The region would likely have remained an arid grass and shrub-land environment, interspersed with more stable and better vegetated river valleys, stream channels, and playas (Owen et al., 1997).

The Alashan Gobi (collected by Folke Bergman)

The Alashan Gobi is a semi-desert region characterized by dune-fields, dissected badlands, and gobi pavements. Dune-fields are more extensive here than in the East Gobi or Gobi-Altai regions. Archaeological collections are derived from several subregions of the northern Alashan Desert: the Eastern Alashan, just west of the Yellow River and foothills of the Langshan Mountains; the Galbain Gobi, an extensive basin of dunes, badlands, and dry lake basins which stretches along the border between Mongolia and Inner Mongolia; the Goitso Valley, situated along the southern margin of the Galbain Gobi depression, where near surface-level groundwater hosts many small oases and supports rich pasture land; the Ukh-tokhoi/Khara Dzag Plateaux, an upland zone along the northern margin of the Badain Jaran Desert, rich with high quality tool stone and characterized by drift sand and relict higher elevation marshlands; the Juyanze region, located in the far west, represents lakes and oases of the terminal palaeolake system fed by major river drainages from the Qilian Mountains; and, finally, the Gurnai Depression, a major erosional basin situated between the Ruoshui/Heihe drainage system and the Badain Jaran Desert.

Climate change, as indicated by local palaeoenvironmental records, is more similar to the Gobi-Altai region than the East Gobi. Terminal Pleistocene and early Holocene desert environments were characterized by increased humidity before 7.0k cal BP, with a drought event occurring between 7.0-5.0k cal BP (Chen, 2003). The middle Holocene was much less arid with a warm and wet climate between ca. 5.6-3.9k cal yr

BP, when arid to desert-steppe vegetation dominated (Herzschuh et al., 2004; Mischke et al., 2005).

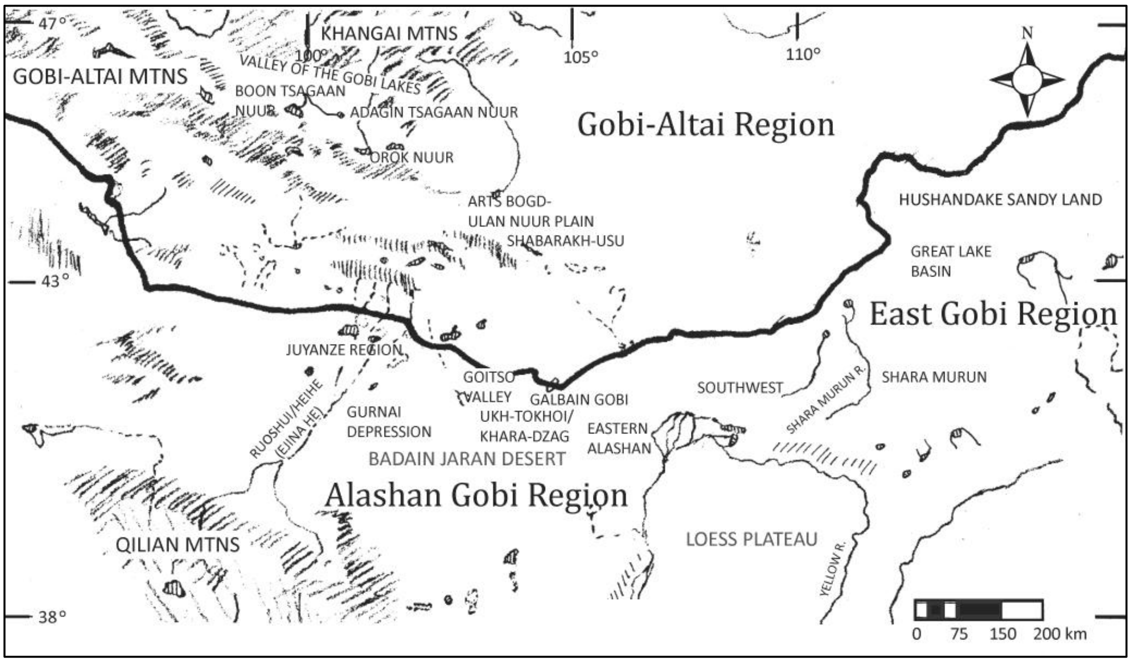

Figure 1.2 Map of Gobi Desert locales, target regions, and subregions.

I collected data from Gobi Desert assemblages with two primary objectives: understanding local chronologies; and reconstructing Gobi Desert settlement systems for the terminal Pleistocene to late middle Holocene. The role of external stimuli, such as climate change and the development of nearby emergent farming and herding economies were explored in order to contextualize contemporary patterns of Gobi Desert technological and economic change.

A study of plant and animal domestication processes and economic change is especially important in order to contextualize Gobi Desert land-use and subsistence within broader patterns of post-LGM technological and economic developments. Chapter 2 details the chronology of post-LGM technology and economy in Northeast Asia and presents the history of and existing literature on Gobi Desert archaeology. An examination of the origin and intensification of herding practices in Northeast Asia and the rise of nomadic pastoralism in Mongolia are especially relevant to the issue of transitional hunter-gatherer strategies at the end of the Neolithic and the beginning of the Bronze Age.

Accelerator mass spectrometry (AMS) radiocarbon dating of ostrich eggshell artefacts, and pottery (O'Malley et al., 1998; Kuzmin and Shewkomud, 2003; Janz et al., 2009), as well as luminescence dating of pottery (Aiken, 1985; Feathers, 2003) provide chronological control for key sites. The results of chronometric dating are presented in Chapter 3, along with a study of defining technological developments in neighbouring regions of Northeast Asia. The use of contextual data in building local chronologies is imperative for recognizing and contextualizing inter-regional trends, and helps to construct a comparative framework for both directly and indirectly dated assemblages. Recognition of diagnostic stone tool and ceramic types associated with dated assemblages, enabled cross-dating at many additional sites.

Based on contextual data and chronometric dates, I initially formulated testable hypotheses in Chapter 4. Lithic analysis was used to reconstruct patterns of raw material use and draw inferences about residential mobility and relative length of occupation in various ecological zones. The relative length of site occupation was determined based on patterns of lithic reduction and use/retouch. Less residentially mobile groups can more easily stockpile raw materials, while more highly mobile hunter-gatherers tend to organize technological systems around formal, diachronically curated, and intensively used tools (Shott 1986; Parry and Kelly 1987; Torrence 1989; Kuhn 1994; Wallace and Shea, 2006). A general picture of duration, site function and temporal shifts in residential mobility for the entire Gobi Desert, and for each target region, were based on relative site density, variability in artefact assemblages, and the results of lithic analysis.

Detailed analyses of existing local and regional trends in climate and palaeoenvironment are presented in Chapter 5 and related to local trends in land-use for each target region. Although woodlands are restricted in modern times, recent research on the ecology of relict desert forests suggests that riparian and upland forests were much more widespread in prehistoric times. Published palaeoenvironmental data allowed for a synthesis of early to late middle Holocene environments in each of the target regions. In Chapter 6 the resulting palaeoenvironmental synthesis was used to interpret land-use, mobility, and subsistence as they relate to ecological expressions of climate-mediated environmental change, including the seasonal availability and density of local resources. Lastly, the relationship between changes in residential mobility and technology among hunter-gatherer groups, and the emergence of pastoralist economies is addressed.

This study used existing museum collections to establish a baseline chronology of technology and land-use for post-LGM hunter-gatherers in the Gobi Desert. A holistic and in-depth approach to collections analysis allows us to move beyond seriation, and speculations about climate-mediated culture change. A wide range of data was employed in the evaluation of Gobi Desert archaeology, including contextual knowledge of technological and economic developments in neighbouring regions, chronometric dating, archival data, qualitative artefact analysis, quantitative lithic analysis, and a synthesis of detailed regional and local palaeoenvironmental data. The resulting observations represent the first substantive step in addressing issues of residential mobility, responses to climate-mediated environmental change, economic strategies, and subsistence. This study establishes a foundation upon which new researches in museum collections analysis and excavation can be used to refine and enrich our knowledge of Gobi Desert prehistory, as well as our understanding of cross-cultural interactions within the transitional economies of Neolithic Mongolia, China and beyond.

CHAPTER 2 – CHRONOLOGY OF TECHNOLOGICAL DEVELOPMENTS AND NEOLITHIZATION IN POST-GLACIAL NORTHEAST ASIA

Following the Last Glacial Maximum (LGM) a number of technological trajectories were shared among hunter-gatherers in Northeast Asia. Even as late as the Neolithic, geographically delineated decorative and technological styles suggest close interaction or cultural affinities across economic boundaries (Maringer, 1950; Larichev, 1962; Debaine-Francfort, 1995; Cybiktarov, 2002; see also illustrations in Chard, 1974). Post-LGM material culture in the Gobi Desert is consistent with this observation and bears evidence of affinities with areas to both the north and south (Maringer, 1950; Okladnikov, 1962).

These widespread stylistic similarities are not remarkable since Gobi Desert hunter-gatherers lived in close proximity to and probably had some knowledge of or contact with their agriculturalist and pastoralist neighbours. At the same time, it is unfortunate that reconstructions of Mongolian and Gobi Desert archaeology have been based largely on analogies with neighbouring regions. Pottery styles reminiscent of those from better known cultures in Siberia or agricultural China has resulted in an emphasis on migration theories and influenced interpretations of economic activity (Maringer, 1963; Okladnikov, 1962; Chard, 1974:82). This circumstance has led to a state in which the actual chronology and nature of local economic and technological developments are relatively unknown. In order to assess the relationship between technological and economic developments amongst Gobi Desert groups and other contemporaneous populations within China and Mongolia, it is essential to establish a clear chronological understanding of developmental processes, including the adoption of local and foreign plant and animal domesticates throughout Northeast Asia.

This chapter highlights both the broad similarities and the notable divergences between late Pleistocene and early Holocene groups in Northeast Asia. The purpose is to outline cross-regional generalizations, while promoting increased understanding of distinct regional chronologies and unique variations of such broadly characterized concepts as the "Neolithic package," especially for the Gobi Desert. In short, this chapter summarizes those developments in order to contextualize regional chronologies of technology, land-use, and subsistence throughout the terminal Pleistocene until the late middle Holocene.

2.1. Key technological developments in Northeast Asia

Northeast Asia extends across eastern Siberia and the Russian Far East, Mongolia, Korea and northern China, encompassing a wide range of cultures across varied ecological zones that include sub-boreal and temperate mixed forests, forest-steppe, steppe, desert-steppe, alpine, basin-range, maritime, lacustrine, and riverine environments. Despite the vast geographic range covered, there is also continuity amongst the Stone Age technological traditions of this region. The most notable of these are the widespread use of microblade technology beginning sometime before 24.0 ka (Kuzmin et al. [Eds.], 2007), and the early use of ceramic vessels which predates 16.0ka (Keally et al., 2003).

Highlights of developmental trajectories throughout key regions of Northeast Asia are illustrated in Figure 2.3. This study focuses primarily on developmental trajectories across the Upper Yensei River and Lake Baikal regions of Siberia (including Cis- and Trans-Baikal; see Figure 2.1), northern China, and Mongolia, between which the strongest cultural affinities have been noted (Maringer, 1950, 1963; Okladnikov, 1962; Larichev, 1962).

Figure 2.1 Map of key locales discussed in Chapter 2. Base map copyright of maps.com, used by permission.

2.1.1. Terminology

Assemblages characteristic of the period following the Last Glacial Maximum (LGM; ca. 21.3-19.0 kya[1] [after Herzschuh, 2006]) are variously referred to as Terminal Upper Palaeolithic, Late Palaeolithic, Palaeolithic-to-Neolithic transition, Mesolithic or Epipalaeolithic. After Zhang (2000), the term Epipalaeolithic is used to designate the terminal Old Stone Age period, which was followed by the New Stone Age/Neolithic. Microblade core reduction sequences are typical of the Epipalaeolithic and although in some regions they pre-date the LGM, they are more regularly used during following the LGM period. This florescence of microblade technology may be related to post-LGM repopulation by microblade-using groups, as an increase in the number of radiocarbon dates following the LGM suggests elevated population density across northern China and other regions (Barton et al., 2007). Although a variety of new tool types were introduced during the Epipalaeolithic, lithic technology across Northeast Asia was overwhelmingly and increasingly microblade-based.

In regions where agriculture did not develop until historic times, the Epipalaeolithic was followed by the widespread use of pottery and characterized by a more complex and varied lithic tool kit. The spread of and increased reliance on processing technologies like ceramic vessels and grinding stones are typical of the New Stone Age in Northeast Asia (Derevianko and Dorj, 1992; Lu, 1998; Cybiktarov, 2002; Cohen, 2003; Kuzmin and Shewkomud, 2003). While emerging sedentary agricultural

[1] All uncalibrated radiocarbon dates were converted to calibrated years BP using the online version of CalPal-2007 online (Danzeglocke et al., 2011) and are written as “k cal yr BP.” The original published dates or ages are given in brackets. Calibrated radiocarbon dates are reported as published and written as “k cal yr BP.” Luminescence dates are given as “ka.” “Kya” is used when discussing the timing of specific events. “Kya”, “ka”, and “k cal yr BP” are all considered to be roughly equivalent.

communities in North China began to abandon microblade technology and focus on the production of polished stone and bone tools (Lu, 1998; Guo, 1995a; Jia, 2007), formalized microblade technology continued in much of Northeast Asia and was complimented by well-executed bifacially pressure-flaked tools like projectile points (usually referred to as "arrowheads") and knives (Derevianko and Dorj, 1992; Nelson [Ed.], 1995; Keally et al., 2003; Janz, 2006).

According to Russian terminology, the adoption of pottery signals the beginning of the Neolithic, but extremely early post-LGM dates for pottery in Japan and the Russian Far East make this appellation less than ideal. In order to maintain coherency in this chapter, the dichotomous terms *Epipalaeolithic* and *Neolithic* will be used when necessary, as outlined above, but the reader should remember that the terms refer to the presence/absence of ceramics rather than differences in economy. The existing terminology is discussed in more detail in Chapter 3.

2.1.2. Microblade technology

Microblade technology is the hallmark of the Northeast Asian Epipalaeolithic. The production of microblades (parallel-sided flakes less than 10 mm in width; after Seong, 1998) from prepared cores was employed as the primary method of lithic reduction in Northeast Asia just prior to or following the LGM. According to the existing data, some form of microblade technology may have been used prior to 25.0 kya in different regions of Northeast Asia, especially Siberia, but was distributed more widely between about 25.0-20.0 kya (Keates, 2007; Kuzmin, 2007; Gladyshev et al., 2010).

Figure 2.2 Map of archaeological sites mentioned in Chapter 2. Base map copyright of maps.com, used by permission. 1. Xiachuan; 2. Nanzhuangtou; 3. Zhoukoudian; 4. Hutouliang; 5. Yujiagou; 6. Cishan; 7. Banpo; 8. Lingkoucun; 9. Kexingzhuang; 10. Dadiwan; 11. Xishanping; 12. Xindian; 13. Dahezhoung; 14. Changshan; 15. Pigeon Mountain Basin; 16. Zhongri; 17. Donghuishan; 18. Ukh-tokhoi/Khara-dzag Plateaux region; 19. Shabarakh-usu; 20. Chikhen Agui; 21. Altan Bulag; 22. Ulan Khada; 23. Tamsagbulag; 24. Xinglongwa; 25. Xiaoshan; 26. Dabasu; 27. Yinggeling.

Goebel (2002) suggested that precursors to microblade technology developed early in the northerly reaches of Northeast Asia and dispersed southward as populations were pushed back by extreme glacial climates. Standardized microlithic technology would then have developed in the south and been re-introduced following the LGM. This model is supported by slightly earlier dates for transitional forms of microlithic technology in the Altai Mountains of Siberia, and a lack of evidence for the use of microlithic technology in the same region immediately following the LGM. Still, the many scattered finds of developed and standardized microblade technology in Northeast Asia are not sufficiently dated to test Goebel's hypothesis (see Kuzmin et al. [eds.], 2007). Possible transitional forms were also found in northern China at Shuidonggou Locality 2, and dated to 28.7-33.9k cal yr BP (29.0-24.0k yr BP) (Madsen et al., 2001).

Human populations apparently contracted, abandoning large parts of Northeast Asia, during the LGM (Vasil'ev et al., 2002; Barton et al., 2007). Such a population decline or geographic shift would have affected the overall distribution of archaeological sites, as well as the geographic range of microblade use. A gap between about 28.5-18.2k cal yr BP in the archaeological record of northern Mongolia (Gladyshev et al., 2010) supports a late Pleistocene occupational hiatus, with repopulation commencing early in the post-LGM period. It has been suggested that microblade technology may have been adopted as a means of creating standardized flakes for well-made composite hunting tools in the face of increasing long, harsh winters and declining large herbivore populations (Elston and Brantingham, 2002). In contrast, human populations in northern China, presumably under stress from harsh winter climates and less predictable prey, actually appear to have favoured a highly expedient technological strategy using poor quality and easily available local raw materials like quartz (Barton et al., 2007). Despite differences in reduction strategies, which may be related to differential access to lithic raw materials, the manufacture of inset flakes for use in composite tools indicates an underlying shift in hunting technology that emerged prior to the LGM, but became increasingly important during the terminal Pleistocene and early Holocene.

Microblade technology is representative of terminal Pleistocene and early Holocene sites over a vast area. Developed microblade technology, with a wider array of core forms, had been incorporated into tool kits across Northeast Asia and Alaska by

15.4-11.5k cal yr BP (13.0-10.0k yr BP) (Aikens and Akazawa, 1996; Ackerman, 2007). Post-LGM occupations at the Tolbor locality in northern Mongolia are typified by an emphasis on microblade core technology with retouched microblades and other small tools (Gladyshev et al., 2010).

The decline of microblade technology in Northeast Asia was highly variable, but appears to have disappeared earliest in regions of declining mobility and/or agricultural production. By about 12.9k cal yr BP (11.0k yr BP) microblade technology was replaced by flake technologies in much of Japan and Korea, though it lasted somewhat longer in northern Japan (Aikens and Akazawa, 1996; Seong, 1998; Sato and Tsutsumi, 2007). In central China, microblade core reduction strategies were gradually supplanted by polished stone and bone tools after about 8.9k cal yr BP (8.0k yr BP) as plant cultivating groups became increasingly sedentary (Lu, 1998). By 8.0k cal yr BP developed microblade assemblages in North China and Northeast China typically included pottery, milling/grinding stones, as well as both polished and bifacially retouched stone tools. Although microblade use declined or nearly disappeared in some regions, especially after 5.8k cal yr BP (5.0k yr BP), the technology was still widely employed in other parts of Northeast Asia (Lu, 1998). The decline of microblade technology in northern China seems to be partially associated with an increase in sedentism (see Lu, 1998). Hunter-gatherers in arid northern China and Mongolia continued to rely heavily on microblades until at least the early Bronze Age (Aikens and Akazawa, 1996; An, 1992a, 1992b; Lu, 1998; Xia et al., 2001; see also Chapter 2).

2.1.3. Pottery

Pottery is often associated with sedentary agricultural societies, but ceramics were first used by hunter-gatherers in the Russian Far East, Japan, and southern China. The initial adoption of pottery in Northeast Asia, beginning by 16.5k cal yr BP (Keally et al., 2003) is extraordinarily early in comparison to elsewhere in the world – after 11.0k cal yr BP in Saharan Africa and after 9.5k cal yr BP in western Asia (Close, 1995; Moore, 1995; Rice, 1999). Environmental contexts for the first pottery use in Northeast Asia tend to be characterized by mixed coniferous-broadleaved forests and forest-steppe (Keally et al., 2003; Kuzmin and Shewkomud, 2003). Various types of tool kits were associated with early Northeast Asian ceramic sites, including: assemblages predominated by partially ground and chipped stone adze/axes, blades, and large bifacial points in northern, eastern and central Japan; microblade complexes in western Japan; and a combination of microblade core reduction, bifacial shaping and some polishing in the Russian Far East (Keally et al., 2003; Kuzmin and Shewkomud, 2003).

The variety of artefact assemblages found with the first pottery makes it difficult to associate the early use of ceramic vessels with a particular pattern of technological change or subsistence strategy. Vessel forms are difficult to reconstruct from the small shards that have been recovered, but analyses of carbon and organic residues on the interior and exterior surfaces indicate that they were often used for cooking (Keally et al., 2003). The most broadly applicable explanation for the invention (as distinct from adoption) of pottery at different times across the globe is that new processing technologies were required by distinct changes in subsistence during the terminal

Pleistocene or early Holocene (for summaries see Pavlů, 1997; Rice 1999). Such explanations have been applied to the adoption of pottery in Northeast Asia (Ikawa-Smith, 1976, 1986; Underhill, 1997; Keally et al., 2003; Kuzmin and Shewkomud, 2003). The earliest pottery in southern China may be associated with evidence for intensive bone marrow and grease extraction. It has been argued that pottery was first introduced to facilitate bone grease rendering (Elston et al., 2011), although earlier evidence for grease rendering in Europe is not associated with pottery (Manne and Bicho, 2009; Manne et al., 2012). There is currently insufficient data to associate early Northeast Asian pottery with any one subsistence strategy.

Outside of the Russian Far East, Japan, and southern China, pottery-use may have been highly localized until after 10.0k cal yr BP. In the Trans-Baikal region of Siberia, numerous dates on both charcoal and potshards indicate that ceramics were probably first used around 13.0k cal yr BP (O'Malley et al., 1998; Kuzmin and Orlova, 2000), but the weight of associated radiocarbon dates for Siberian assemblages indicate that pottery was probably not widely used until after 9.0k cal yr BP (Kuzmin and Orlova, 2000). The earliest ceramic assemblages in North China date to 11.1 ka for Yujiagou (Xia et al., 2001) and about 11.9k cal yr BP for Nanzhuangtou (Wu and Zhao, 2003; Kuzmin, 2006); but, as in Siberia such early sites are rare. Dates from the earliest ceramic site in Korea, on the western end of Jeju Island, suggest that pottery use in Korea does not pre-date 7.9k cal yr BP (Nelson, 1993; Bae and Kim, 2003; Kuzmin, 2006). New direct dates on pottery from northern China and Mongolia indicate that the earliest Gobi Desert pottery dates to at least 9.6k cal yr BP (see Chapter 3). After about 7.0k cal yr BP, pottery was an important technology across most of Northeast Asia.

2.1.4. Grinding stones

Grinding or milling stones have been found across the globe in much earlier contexts than pottery. Recent research has identified starch grains from various wild plants, including cattail and fern, on grinding tools from a variety of European Palaeolithic contexts dated to between about 32.0 to 28.1k cal yr BP (Revedin et al., 2010). Grinding stones appear to have been used even earlier for tasks like grinding ochre in southern Africa (McBrearty and Brooks, 2000). Such implements are usually small and appear to have been chosen based on the natural form of suitable cobbles. Grinding tools occur sporadically in Palaeolithic contexts, making it difficult to as clearly link the origins of such technology with post-LGM developments as pottery (but see Soffer, 2000). It is clear that the use of grinding stones in much of Northeast Asia intensified during the early Holocene, and assemblages came to include more formalized forms with reduced portability (Nelson [Ed.], 1995; Shelach, 2000; Cohen, 2003; Keally et al., 2003; Janz, 2006). Such formalized technology is usually thought to be associated with increased plant processing and sedentism, though the record of such developments in the Gobi Desert is more complex (see also Hoopes, 1995; Bright and Ugan, 1999; Eerkens et al., 2002; Eerkens, 2003, 2004).

The earliest evidence of increasing reliance on grinding stones in Northeast Asia comes from China and is probably related to food processing as well as grinding of the mineral pigment ochre. Xiachuan, a site in Shanxi, features formal microblade technology, some evidence of polishing, and at least 27 stone grinding slabs varying in size from 8 to 35 long and 8.5 to 21 cm wide (Cohen, 2003). Judging by the youngest of six radiocarbon dates for the stratum within which the microlithic assemblage was found, an age of about 20.0k cal yr BP can be proposed (Tang, 2000; but see Elston et al., 2011). Comparably early sites in North China are not yet known.

Dates on excavated remains from around the foothills of the Helan Mountains, west of the Yellow River, indicate that thin, lightweight grinding stones were used prior to 13.5k cal yr BP (11.6k yr BP) (Elston et al., 1997). Similar grinding stones are typically associated with microlithic assemblages in the western Gobi Desert and differ from formal rollers and saddle querns, found both in agricultural regions of northern China and in the East Gobi. East of the Yellow River grinding slabs are associated with a developed microlithic assemblage at Hutouliang (ca. 12.9k cal yr BP or earlier), while at Nanzhuangtou (ca. 11.9k cal yr BP) slabs and rollers were found along with pottery, possible domesticated animals and a tool kit that did not include microlithic technology (Cohen, 2003; Liu, 2004). Chipped adze/axes are also often associated with such assemblages (Lu, 1998). Similar dates are reported in Japan, where large querns and grinding stones are associated with rounded stone axes and chipped stone axes between 15.0 and 13.3k cal yr BP in the southwest (Keally et al., 2003; Habu, 2004). After 11.0k cal yr BP, grinding stones and mortars were used more frequently across Japan (Underhill and Habu, 2006).

Less information is available for sites in Northeast China and Korea, where there appears to be less evidence of transitional Palaeolithic-to-Neolithic economies. In these regions, grinding stones are usually part of the Neolithic package, which includes regional variants of microblade technology, pottery, and polished stone tools. The Dabasu site in Jilian Province might be an exception, as the assemblage is thought to date to about 10.0k yr BP (11.5k cal yr BP) and contains one grinding slab in association with many small flake tools, microblades and microcores, along with chipped adzes and knives (Lu, 1998). Most early assemblages in Northeast Asia that contain grinding stones are dated to between 8.0 and 7.0k cal yr BP (Nelson, 1993; Guo, 1995a; Jia, 2007).

In the Gobi Desert, grinding stones are only associated with post-LGM assemblages although the timing of their introduction has not been established. East Gobi sites are distinctive in that they contain much higher numbers of grinding stones, including more formal styles like saddle querns, pestles, and rollers (Fairservis, 1993). Such forms are seldom found in the more western Gobi Desert and Alashan Gobi sites rarely contain grinding stones of any type (Maringer, 1950; Fairservis, 1993; Janz 2006). This variation in distribution is likely related to differences in subsistence and may indicate some association in the East Gobi with emerging agricultural communities.

2.1.5. Polished stone tools

The earliest evidence of polishing as a means of shaping and finishing stone tools is in the form of chipped tools or pebbles with polishing marks. Chipped adze/axes with localized polishing may be transitional to fully polished forms that occur in the later Neolithic, but chipped and polished specimens persisted in the Gobi Desert, where fully polished axes are rare. Formal grinding stones generally exhibit shaping through directed polishing and are contemporary with other polished stone tools. Polished bone artefacts become important during the Neolithic, and in some cases people seem to have relied most heavily on bone as a raw material; however, the technology is representative of earlier Upper Palaeolithic technological developments. For that reason, only polished stone tools are discussed in this section.

Polishing is commonly associated with the manufacture of Neolithic macrotools in Northeast Asia, particularly adzes and axes, but the earliest evidence for the use of edge-ground adze/axes comes from the Upper Palaeolithic in Japan and may be older than 34.0k cal yr BP (>27.0k/30.0k yr BP) (Oda and Keally, 1992). Such tools were widespread in Japan and were used widely prior to 27.5k cal yr BP (23.0k yr BP), when they were largely abandoned until after about 18.0k cal yr BP (15.0k yr BP) (Oda and Keally, 1992). Small gravel fragments with polished scratches, found at the Shandingdong (Upper Cave) site in Zhoukoudian, Beijing are considered to be the first evidence of polishing technology at about 30.0k cal yr BP, but the evidence is contentious (Wu and Zhao, 2003). In the Russian Far East, the earliest ceramic assemblages (~16.5k cal yr BP) included polished points (arrowheads), knives and bifaces (Kuzmin and Shewkomud, 2003).

In many regions of Northeast Asia, polished stone tools are reported in combination with ceramics, but in many cases the technology predates the use of ceramic vessels. This point is supported in Siberia by finds of polished slate shanks for composite fishhooks, an adze, and a perforated stone object from pre-pottery layers at Ulan-Khada in the Lake Baikal region – a scenario that is repeated in other habitation sites around Lake Baikal (Khlobystin, 1969; Goriunova and Khlobystin, 1991; Weber, 1995). Similarly, at the pre-ceramic Hutouliang site in Hebei Province, a point associated with dates of about 12.5k cal yr BP (10,690 $\pm$ 210 BP) provides the earliest clear evidence of polished stone in northern China (Wu and Zhao, 2003).

After 8.0k cal yr BP, polished stone tools were increasingly important across much of Northeast Asia. Polished stone tools are part of the typical Neolithic package which appears in Northeast China and Korea between 8.0 and 7.0k cal yr BP (Nelson, 1993; Guo, 1995a; Lu, 1998; Jia, 2007), but there is little evidence of polished stone tools prior to this period. In parts of Northeast China where flake tools and microblades were more prominent, polished stone tools may comprise up to 30% of the total assemblage. Many sites with evidence of long term settlement are characterized by tool kits with even higher frequencies of polished tools such as adzes, knives, and rollers (Lu, 1998). By this time, sedentary farming villages were typical of habitation sites in the Central Plains of China and subsistence was focused on millet as a cultivated staple along with exploitation of domesticated pigs, dogs, and possibly chickens (Liu, 2004). Grinding and polishing stone and bone were the primary methods of tool manufacture (Lu, 1998).

Considering the frequent negative correlation between polished stone and microblade technology, it is probable that polished tools met a new need amongst some early to mid-Holocene groups for which microblade technology was either less proficient or unsuitable. The simultaneous decline of microblade technology and florescence of polished stone tools have been associated with the rise of agriculture (Lu, 1988), but a similar correlation does not exist amongst hunter-gatherer groups in Japan and Siberia. One possibility that has not been explored is that shifts in land-use and mobility would have dramatically increased or decreased the availability of various raw materials. Despite being more time consuming, polishing allows stone adze/axes or knives to be resharpened with little loss of surface area. The technology is thereby more conservative of raw material than microblade core reduction sequences. This is especially true in circumstances when wear on tool edges is highly intensive, such as woodworking or in conditions where enormous amounts of food had to be processed in a short time (Hayden, 1989). Additionally, raw material requirements for ground and polished tools are more flexible, making the use of local resources more viable. Polished bone tools may also have been more available with agriculture and increased sedentism as bone would have remained from animals slaughtered and/or processed at a long-term habitation site. As such, it can be hypothesized that a reliance on polished stone is probably related to both the functionality of ground edges and a shift in the accessibility of various raw material types.

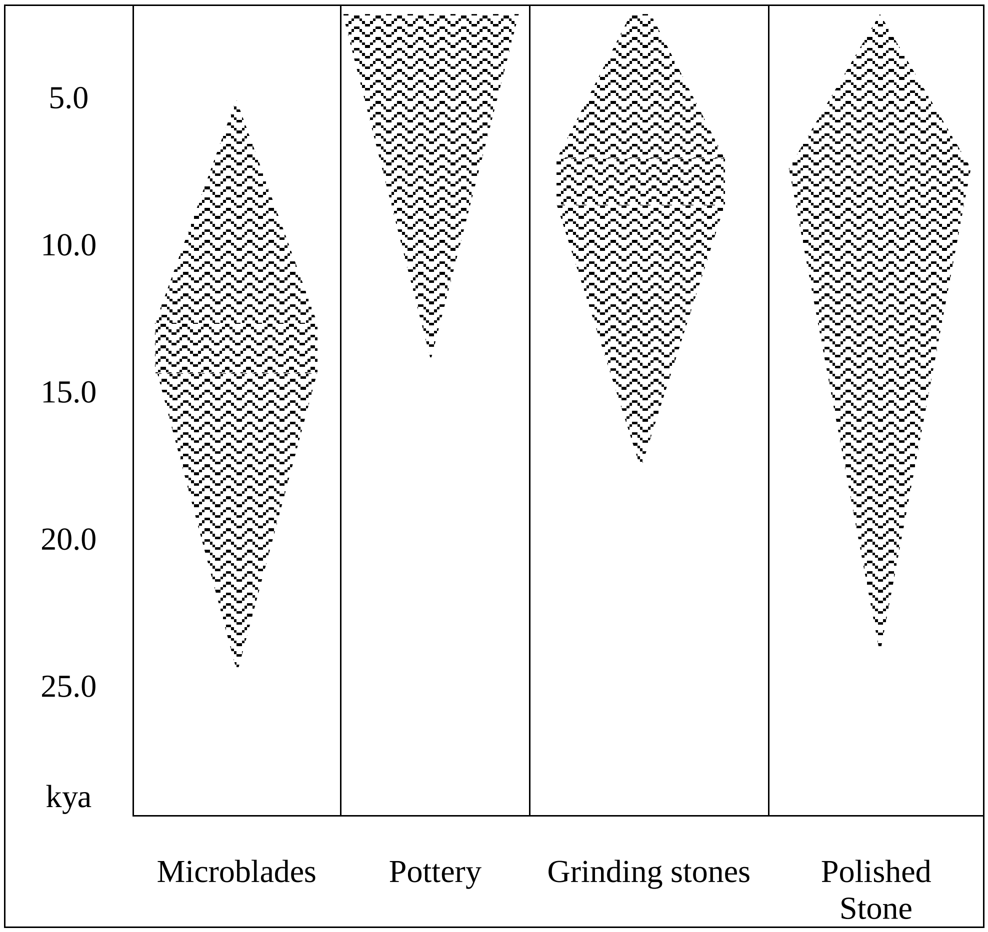

Figure 2.3 Relative frequency of key artefact types in Northeast Asian chronology.

2.2. Chronology of food-production in Northeast Asia

As in many other parts of the globe, one of the defining developments in early to mid-Holocene Northeast Asia is the emergence of production economies dependant on domesticated plants and animals. As in other Old World centres of agriculture and urbanization (e.g., North Africa and the Middle East), politically separate pastoralist and agricultural communities had emerged by the mid-Holocene. Domesticated plants and/or animals that formed the bases of production economies in Northeast Asia were either domesticated locally or domesticated in other parts of the world and later introduced. Many species integral to the economic base of pastoralists (e.g., horses, cattle, sheep, wheat) were first domesticated in the Middle East or Central Asia, while most of those exploited by sedentary agriculturalists (e.g., pigs, millet, rice) were domesticated from species indigenous to East Asia.

Some researchers have proposed that early to mid-Holocene Gobi Desert hunter-gatherer groups practiced cultivation of grass seeds, based on the increased use of grinding tools and pottery in what are defined as Neolithic sites (Derevianko and Dorj, 1992; Cybiktarov, 2002; but see Janz, 2007). Nomadic pastoralism developed in the region sometime between 3.5-3.0k cal yr BP, and although the economy was based on domestic herd animals, local diets were still complemented by a range of wild resources (this chapter). In order to assess possible relationships between Gobi Desert hunter-gatherers and contemporary developments in domestication and production economies elsewhere in Northeast Asia, a clear understanding of regional domestication processes is necessary.

2.2.1. Brief chronology of plant domestication

It is becoming clear that prior to domestication people around the world exploited a wide range of local plant species (Revedin et al., 2010), but there is a widespread pattern of evidence for intensive processing and storing of plant foods in the early Holocene that is not characteristic of the Palaeolithic record and culminates in the genetic alteration of certain species. Plant cultivation is the key marker of food production in modern agricultural zones of Northeast Asia, providing the first evidence of intensive exploitation and unequivocal domestication of a food resource. Both millet and rice agriculture characterize early agricultural communities in the Central Plains of China, but due partially to ecological constraints on early varieties of domesticated rice, millet was initially the primary cereal crop in Northeast Asia. The process and timing of domestication, particularly as understood in the sense of genetic alteration, is poorly understood in East Asia and the relationship between the reliance on or extensive use of certain plants and their actual domestication is still in the early stages of research (Crawford, 2006; Jiang and Liu, 2006; Fuller et al., 2007).

Considering the relative abundance of archaeological data, millet (including the species *Echinochloa crus-galli*, *Panicum miliaceum*, and *Setaria italica*) appears to have been the first and most important domesticated cereal crop in North China. Evidence for the large scale storage of broomcorn or common millet (*Panicum miliaceum*) is present at the Chinese Neolithic site of Cishan between 10.3-8.7k cal yr BP, but morphological evidence of domestication was not identified (Lu et al., 2009). Further west, at the Dadiwan site, increased human reliance on millet is indicated by the apparent provisioning of domesticated dogs with millet and meat by 7.9-7.2k cal yr BP, and pigs by 6.5-4.9k cal yr BP (Barton et al., 2009). Charcoal concentrations in conjunction with an increase in Poaceae pollen at Xindian in the middle Yellow River valley indicate “slash-and-burn” methods of cultivation beginning around 7.7 ka (Li et al., 2009). While the early dates from Cishan suggest that broomcorn millet was domesticated first in North China, barnyard millet (*Echinochloa crus-galli*) was domesticated locally in northern Japan (Crawford, 1997, 2006). Lithic assemblages and site structure at Xinglongwa in Northeastern China also hint at intensive exploitation of cultivated plant foods by 8.0k cal yr BP (7240 ± 95 yr BP), but the only botanical remains reported are wild walnut (*Juglans mandshurica* Maxim) and/or chestnuts (Guo, 1995a; Shelach, 2000). Even though the earliest substantial evidence for agriculture in North China dates to sometime between 10.0 and 8.0k cal yr BP (8000-6000 BC) the practice of cultivation probably began much earlier (Crawford, 2006; Lee et al., 2007).

Millet remains are found in mid-Holocene Northeast Asian archaeological sites across North China, Northeast China, Korea, and Japan. The earliest known evidence for the use of domesticated millet in Korea consists of foxtail millet (*Setaria italica*) grains dated to 5.3k cal yr BP (3360 BC) (Crawford and Lee, 2003). Foxtail millet was used much later in Neolithic sites in the Central Plains and was relatively rare in early contexts (0.4-2.8% of grain crops by 8.0k cal yr BP [7235 ± 105 yr BP]) (Lu et al., 2009). Although wild barnyard millet is common in the late Early Jomon site of Hamanasuno in Hokkaido, it is not until about 4.5k cal yr BP (2500 BC) that seeds are consistent with the larger domesticated barnyard millet in the same region (Crawford, 2006). Considering that the earliest evidence of domesticated millet in Korea and Japan are of varieties uncommon in the Central Plains of China, it is probable that each species was domesticated locally. It is not clear what influence the increasing frequency of food producing economies may have had on local decision making processes associated with domestication, but the influence of foreign developments in cultivation may have contributed to local developments.

During the Longshan period, beginning about 4.5k cal yr BP (2500 BC), exotic crops were being added to the existing agricultural suite of cultigens. The intensification of agriculture that occurred at this time may be associated with extensive provisioning of domestic animals (Crawford, 2006). By the middle Holocene (7.0-4.6k cal yr BP), various agricultural communities had been established along the Yellow River and its tributaries in North China, growing crops like soybean (*Gylcine soja*), adzuki bean (*Vigna* sp.), hemp (*Cannabis sativa*), Chinese cabbage (*Brassica chinensis*), buckwheat (*Fagopyrum* sp.), along with weedy plants such as chenopods (*Chenopodium* sp.), canola/rapeseed (*Brassica rapa*), and other mustards (Brassicaceae) (Crawford et al., 2005; Lee et al., 2007; Li et al., 2009). Rice (*Oryza sativa*) was domesticated south of the Central Plains and was also found in agricultural contexts during the Longshan period, as was wheat (*Triticum aestivum*), which would have been introduced from the west (Crawford et al. 2005). The earliest evidences of wheat in China come from Gansu Province, at the Donghuishan site in Minle County (5.0-4.5k cal yr BP [3000-2500 BC]), and Xishanping (4.6k cal yr BP) (Li, 2002; Li et al., 2007). Such finds may illustrate a path of introduction from Central Asian pastoralists.

Similar dates are observed in other regions of Northeast Asia. Rice was introduced to Korea between 5.0-3.5k cal yr BP (3000 to 1500 cal BC), where agricultural groups cultivated a similar suite of crops to those in the Central Plains of China. By 3.0k cal yr BP agricultural production intensified in Korea and included wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) (Crawford and Lee, 2003). A similar situation occurred in neighbouring Northeast China, where sedentary communities cultivated millet, rice, barley and sorghum (*Sorghum* sp.) by 3.2k cal yr BP (3000 BP) (Jia, 2007).

Agriculture seems to have spread more slowly north of the fertile river valley of the Chinese Central Plains. Shelach (2000) contends that soybeans and millet may have been domesticated locally in Northeast China independently of influences from the south, but it was not until about 5.0k cal yr BP (3000 BC) that groups in the eastern part of what is now the Inner Mongolia Autonomous Region, People's Republic of China (PRC) show evidence of partial reliance on agriculture (Guo, 1995a; CICARP, 2003; Jia, 2007). It is possible that the use of domesticated plants in Northeast China predates this evidence, as plant processing technology associated with semi-subterranean houses, organized in what appears to be a sort of village community is found at Xinglongwa, dated to 8.0-7.2k cal yr BP (CICARP, 2003).

Evidence for use of domestic plants among sedentary or semi-sedentary communities in neighbouring mainland territories is broadly contemporaneous with Northeast China. In Korea, plant taxa from archaeological sites associated with cultivation indicate an early reliance primarily on *Chenopodium* sp. (36.8%), foxtail millet (35.5%), some use of broomcorn millet (9.1%), as well as wild millet at about 5.3k cal yr BP (Crawford and Lee, 2003). Increasing use of foxtail millet culminated in a focus on millet and soybean agriculture after about 3.3k cal yr BP (1300 BC) (Lee, 2001; Crawford and Lee, 2003; Underhill and Habu, 2006). Foxtail millet cultivation is dated to at least 4.7k cal yr BP (4150 ± 60 BP) in the temperate Primorye region of the Russian Pacific Coast, where wild foods continued to be exploited as evidenced by the presence of wild millet, acorn and walnut (Kuzmin, 1998; Vostretsov et al., 2003; Jia, 2007). A similar pattern is suggested in eastern Mongolia at the Tamsagbulag site, where cattle and millet were exploited along with fish and other wild species (Derevianko and Dorj, 1992).

Wild resource use in concert with low-level food production is perhaps best understood in Japan, where plant remains are abundant and well studied. Mainland domesticates, including rice, were not adopted in Japan until after about 2.5 kya (Rowley-Conwy, 1984). Although a fully formed agricultural production economy was introduced late, barnyard millet was domesticated locally and it is becoming clear that native Japanese plant species – chestnut, sumac, adzuki bean, perilla (shiso/beefsteak plant) – supplemented the diet and provided raw materials (Crawford, 2006; Matsui and Kanehara, 2006). Across Japan a general pattern was established of fishing and marine mammal hunting in the summer, collecting nuts and other plants in the autumn, hunting terrestrial mammals in the winter, and collecting shellfish in the spring; however, this general pattern of subsistence progressively included more intensified use of some resources at the regional scale (Habu, 2004).

Low-level cultivation, complimented by the hunting and gathering of wild resources, is more typical of the early Holocene in Northeast Asia than is the development of sedentary agricultural communities. Use of domesticated plants became more widespread by 5.0k cal yr BP and intensified after 3.0 kya. It is not clear to what extent nomadic pastoralist groups in Northeast Asia exploited domesticated plant resources prior to the Iron Age, when sedentary communities emerged within the larger pastoralist system (Janz, 2007). The wealth of cultivated plant remains in sedentary communities and the apparent reliance on wild species amongst more mobile foragers indicates a correlation between decreased mobility and plant domestication.

2.2.2. Detailed chronology of animal domestication

The chronology of animal domestication in Northeast Asia is less well understood at the regional level than plant domestication; however, new genetic data on major domesticated species is making important contributions. Several key species in Northeast Asian food-producing economies, including pigs, chickens, yaks, and water buffalo, were domesticated in East Asia. Camels, dogs, and cattle may have been domesticated independently in East Asia, but the record for these species is either more difficult to interpret or, in the case of camels, very sparse. Several western species also became important to subsistence in Northeast Asia and the timing of their introduction is an important consideration. An overview of current knowledge about animal domestication and adoption is offered in order to better contextualize evidence for various species in the faunal record and the possibility of domestication in regions with few faunal remains.

Dogs

Dogs ae the earliest known domesticated species (faunal or floral) in the world. Archaeological finds of domesticated dogs occur earliest in Europe, where cranial fragments from Russia and Germany date to the terminal Pleistocene, and more recently in Belgium at 35.5k cal yr BP (31,680 ± 250 yr BP) (Nobis, 1979; Olsen, 1985; Sablin and Khlopachev, 2002; Germonpré et al., 2009). Genetic data indicate that domestication began around either 40.0 kya or 15.0 kya (Savolainen et al., 2002), and although domestication in multiple geographic regions is suggested there is strong evidence of dominance in the role of Middle Eastern wolves (von Holdt et al., 2010). Evidence of genetic contribution from East Asian wolves indicates that local species also played an important contributing role to modern genetic profiles (Olsen and Olsen, 1977; Vilà et al., 1997; Savolainen et al., 2002; Pang et al., 2009).

Dogs were associated with early Neolithic sites in China (after 13.0k cal yr BP) and there is direct evidence of provisioning domestic dogs with millet by 7.5-7.1k cal yr BP (Barton et al., 2009). By the time of the Chinese Neolithic and Early Bronze Age, distinct breeds of dogs had already developed in northern China (Shigehara et al., 1998). Dogs appear to have also been important to Siberian hunter-gatherer groups. Dog and human burials at the Ushki Lake site in northeastern Siberia date the use of domesticated dogs to at least 11.9k cal yr BP (Kuzmin et al., 2008). In the Lake Baikal region dog interments in burial contexts date dogs to about 7.8-7.0k cal yr BP (Losey et al., 2011). These dates are not surprising considering evidence that domestic dogs were probably used by Palaeoindian hunter-gatherers, having presumably crossed into North America with humans migrating from Siberia (Olsen and Olsen, 1977; Fiedel, 2005). The oldest dog remains in Japan date to approximately 10.5k cal yr BP (9,300 BP). These Jomon dogs appear to have one phylogenetic origin, and it is suggested that they may have accompanied humans migrating from the Asian mainland (Shigehara and Hongo, 2000).

Conversely, some of the earliest archaeological evidence for the use of domestic dogs in Northeast China is clay figurines from Upper Yinggeling, dating to about 3.2-3.1k cal yr BP (3025 $\pm$ 90BP, 2985 $\pm$ 120 BP) (Tan et al., 1995a). In Korea, dogs appear first in the Early or Middle Chulmun (7.5-4.7k cal yr BP), but it is difficult to constrain the dates for faunal remains as they do not appear to have been separated by stratigraphic level (Nelson, 1993). The domestic dog probably spread through most of Northeast Asia by 7.5k cal yr BP, though inhabitants of Northeast China and Korea may have adopted the animals somewhat later.

Considering the early dates for dog domestication in Europe and the lack of evidence for anatomically modern humans in Northeast Asia until the late Pleistocene, it is possible that dogs accompanied some of the first anatomically modern humans into East Asia as they expanded out of western Eurasia. At the same time, evidence of an important domestication event in southern China after 16.3 kya (Pang et al., 2009) could also support the theory that domestic dogs spread north amongst hunter-gatherer bands over several thousand years, reaching the Central Plains by about 13.0, Siberia by 11.9, and Japan by 10.5k cal yr BP (Shigehara and Hondo, 2000; Cohen, 2003; Liu, 2004; Kuzmin et al., 2008). Dogs seem to have been an important resource for sedentary farming communities in the Central Plains, semi-sedentary Jomon peoples, and mobile hunter-gatherers in Siberia. They may have variously provided food, protection from other predators, traction, and/or aid in hunting. The frequent use of dog skeletons in mortuary and ceremonial contexts suggests some ritual significance of the animal that may have been associated with their importance in hunting, the symbolic ability to control nature or simply companionship (see Losey et al., 2011).

Pigs

Pigs appear to have been the primary animal domesticated for food in the early Neolithic of China. Analyses of mitochondrial DNA (mtDNA) from both European and Asian domesticated pigs indicate that at least two distinct centers of early domestication existed, one of which was in East Asia (Watanabe et al., 1999; Giuffra et al., 2000; Larson et al., 2005). Tentative evidence for early domestication of pig, along with dog and chicken, appear in the Central Plains sites of Nanzhuangtou (12.4-11.0k cal yr BP [10,500-9,700 BP]) and Hutouliang (12.9k cal yr BP [11,000 BP]) (Cohen, 2003; Liu, 2004). Mortality profiles (60% between the ages of 0.5 to 1 year), tooth measurements, and context of deposition have all been used to assert that domesticated pigs were being exploited at the Cishan site in the Central Plains by about 8.9k cal yr BP (Yuan and Flad, 2002). Isotopic signatures amongst pigs from the Dadiwan site in northwest China further indicate feeding of pigs with millet beginning sometime between 7.2-5.8k cal yr BP. Other individuals from the same time period are thought to represent wild animals raiding millet fields or free-range animals that were only occasionally provisioned (Barton et al., 2009). By 9.0-7.0 kya sedentary life in farming villages included not only the use of millet as a common staple, but domesticated pigs, and possibly chicken[2] (Yuan and Flad, 2002; Liu, 2004).

In Northeast Asia, beyond the Central Plains, pigs were widely exploited in both domestic and hunted contexts. Pig and deer are common animals species represented in early Neolithic sites in Northeast Asia such as Xinglongwa at 7.2k cal yr BP (5290 ± 95 BC) (Wa, 1992); along with birds these two animals were also represented in art work on ceramic vessels at Xiaoshan (4.7-4.6k cal yr BP [4110 ± 85, 4200 ± 85]) (Wa, 1992). The mortality profile of pigs at Xiaoshan indicates a pattern (mostly aged 1-2 years) consistent with that of domesticated animals, but it is not accompanied by clear evidence of skeletal changes associated with domestication (Shelach, 2000). The later Neolithic group referred to collectively as Hongshan, (5.5k cal yr BP [3535 ± 110 cal BC, 2180 BC]) relied heavily on domesticated pigs and may have practiced pig sacrifice in ritual activities (Wa, 1992).

Wild boar was a key hunted resource on the Korean Peninsula and may have been domesticated during the Chulmun period (8.0-3.3k cal yr BP) (Nelson, 1993). Domesticated pigs might also have arrived from North China by 2.0 kya (Kim and Choi, 2002). More careful analysis of faunal remains is necessary to determine the status of early *Sus* remains. Pigs, along with dogs, were some of the first domesticated animals in the Russian Far East. In the Primorye coastal region, bordering Northeast China, Bronze Age occupations were typified by the exploitation of pig and dog around 4.5-2.5 kya

[2] Considering the zoogeographic distribution of *Gallus gallus gallus* or red junglefowl, the wild ancestor of domesticated chickens, it is clear that chickens were domesticated farther south than the Central Plains of China. As such, the earliest evidence of chicken domestication should be sought further south in sites pre-dating Cishan and Peiligang at 7.5k cal yr BP and about 5.5k cal yr BP respectively based on dendrochronologically calibrated radiocarbon dates (West and Zhou, 1988; Akishinonomiya et al., 1994).

(Kuzmin, 1995). Japanese wild boar (*Sus scrofa leucomystax*) was also extensively exploited on Hokkaido and Izu Islands in northern Japan, which are outside the record of natural wild distribution, suggesting that beginning in the Early Jomon (7.0-5.7k cal BP), wild pigs were transported, and possibly kept and bred, by humans in Japan (Yamazaki et al., 2005). Though not yet domesticated, some sort of early management has been suggested for the Okinawan Islands by at least 7.8 kya (7000 BP) (Matsui, 2005). Considering the evidence, it is probable that pigs were domesticated first in the Central Plains prior to 8.9 kya and then spread across Northeast China, Korea, and Japan, perhaps being locally domesticated in one or more of these other regions.

Cattle

Cattle, sheep, and horses form the basis of nomadic pastoralist economies across Central and East Asia. Cattle (*Bos taurus*) are exploited by both sedentary agriculturalists and mobile pastoralists in East Asia. While water buffalo (*Bubalus bubalis*) and yak (*Bos* [*Poephagus*] *grunniens*) were domesticated locally, *B. taurus* is often considered to be a western domesticate. A regionally specific haplogroup among Northeast Asian cattle indicates that local aurochs (*Bos primigenius*) were incorporated into the gene pool of domestic cattle either through a separate domestication episode or incorporation of wild female animals into existing herds (Mannen et al., 2004). In India, zebu (*Bos indicus*) was domesticated separately from west Asian breeds before 7.5 kya (Loftus et al., 1994; Meadow, 1996; Chen, S. et al., 2010), but frequencies of zebu haplotypes are low amongst Northeast Asian cattle breeds (Mannen et al., 2004).

The earliest evidence of domestic cattle use in Northeast Asia is from the Zhongri sites in Qinghai[3] at about 5.6-4.0 kya (Flad et al., 2007) and Hongshan sites in Northeast China at 5.7-5.4k cal yr BP (Guo, 1995a). The Tamsagbulag site in eastern Mongolia, probably dating to sometime between 6.4-4.5k cal yr BP, also shows evidence of a reliance on cattle, though no research has been conducted on the status of these individuals as domesticated or wild. Similar dates can be assigned to the introduction of domesticated cattle in the eastern steppes of Siberia, where Afanasievo groups (5.5-4.0 kya [3500-2000 BC]) raised cattle, sheep and horses (Frachetti, 2002).

Although it is likely that domesticated cattle were utilized in Northwest China by 5.0ka BP, the Qijia (Ch'i chia) culture (4.2-3.8ka – after Debaine-Francfort, 1995) appears to have been the first in northwest China to regularly incorporate cattle, sheep, and horses into their subsistence economy (Flad et al., 2007). In the Russian Far East, cattle raising was a common element of subsistence beginning at the end of the Bronze Age or the early Iron Age (3.0-2.0 kya), but may have begun as early as 8.5-6.7k cal yr BP (Kuzmin, 1995, 1997). "Ox" and "water buffalo" bones have been found in Korean sites dating to 5.0-4.7k cal yr BP, but their stratigraphic association and taxonomic designations are unclear (see Nelson, 1993).

Cattle could have been used for traction as well as meat and milk. The possibility of use in dairying is especially compelling in regions where cattle were most likely adopted directly from the western Eurasia, where dairying was established and utilized

[3] These remains are attributed to *Bos* sp., but it is not entirely clear that adequate faunal analysis was conducted to verify attribution to *B. taurus* or *B.* (*Poephagus*) *grunniens* (see Olsen, 1990, 1991). This lack of detail should be noted since Qinghai may have been a center of yak domestication (Rhode et al., 2007).

extensively as early as 8.0 kya (Evershed et al., 2008). Organic residue analysis of ceramics should be employed at sites where cattle are reported in order to assess the possibility of this function, particularly within the geographic limits of modern milk consumption.

Ovicaprids

Neither sheep nor goats seem to have been domesticated locally in Northeast Asia. Genetic evidence does indicate more than one domestication episode for both species. Domesticated goats (*Capra hircus*) are thought to have had three separate geographic areas of original domestication, one of which was in South Asia as genetic markers for this episode are found only in Pakistan, India, Malaysia and Mongolia (Luikart et al., 2001; MacHugh and Bradley, 2001). The importance of goats in South Asia is underscored by their initial prominence in faunal assemblages from excavations at Mehrgarh, along the North Kachi Plain in the Indus region (Meadow, 1996). Evidence of goats in Northeast Asia is less common and they may have been introduced from the west or south much later than other herd species.

Domesticated sheep (*Ovis aries*) show genetic evidence of domestication from two separate wild subspecies (Wang et al., 1990; Wood and Phua, 1996; Hiendleder et al., 1998; Hiendleder et al., 2002). One group is considered to be descended from the mouflon (*Ovis musimon/Ovis orientalis*), with wild ancestors from the region of modern Turkey and western Iran (*O. orientalis anatolica* and *O. orientalis gmelini*). The roots of the other major domestic sheep branch (*O. aries*) are still unknown, but derivation from either the wild urial of the Aralo-Caspian Basin (*O. vignei bochariensis*) or argali species (*O. ammon* spp.) of Central Asia and Mongolia has been discounted (Hiendleder et al., 1998; Hiendleder et al., 2002). Considering these lines of evidence, it can be inferred that both sheep and goats were domesticated elsewhere and introduced to Northeast Asia.

Archaeological evidence supports an introduction of fully domesticated species. The earliest reported evidence of sheep exploitation comes from Shaanxi Province at Lingkoucun (7.3-6.2 kya) and from Banpo (6.9-5.8 kya), but these individuals may have been from local wild populations (Flad et al., 2007). More likely candidates for the first domesticated sheep, from Longshan sites, are older than 4.0 kya (Flad et al., 2007). It is proposed that domestic sheep, along with cattle and horses, were part of a suite of domesticates used by the agro-pastoralist Qijia peoples and may have been introduced along with wheat sometime between 5.0-4.0 kya (Debaine-Francfort, 1995; Flad et al., 2007); however, Hongshan sites in Northeast China contain evidence of cattle, sheep and pig, dating to between 5.7-5.4k cal yr BP (Guo, 1995a). The status of Hongshan sheep is not entirely clear, but such an early age for domesticated individuals might lend credence to the domestic status of sheep at Lingkoucun and Banpo. Later sites of sheep exploitation in Northeast China include the Lower Xiajiadian archaeological culture sites (> 4.0 to about 3.5k cal yr BP), which are broadly contemporaneous with the Qijia in northwest China and typically include faunal remains of dogs, pigs, cattle, sheep and deer as well as broomcorn and foxtail millet (Guo, 1995b).

By 3.3k cal yr BP, sheep were of special economic importance for both sedentary agriculturalists and nomadic pastoralists in Northeast Asia. Among early Bronze Age pastoralist sites in the steppe and mountain zones of southeastern Siberia and Mongolia, sheep remains are sometimes found in association with horse bones in burial or ceremonial contexts. Horses and sheep have complementary grazing patterns (Honeychurch and Amartuvshin, 2006) and were probably introduced as part of an established herding strategy that developed farther west in Central Asia. The earliest evidence for the pastoralist suite of animals in Northeast Asia comes from Afanasievo burial remains (5.5-4.0 kya) in the eastern steppes of Siberia (Frachetti, 2002).

Horses

While sheep are characteristic of pastoralist and agro-pastoralist communities in Northeast Asia, the enhanced mobility that horses (*Equus caballus caballus*) enabled was integral to the development of nomadic pastoralist economies across Eurasia during the later Bronze Age. Wild horses (*E. ferus* spp.) were widely distributed across the Eurasian steppe during the Late Pleistocene, but disappeared from the fossil record of many regions by about 10.0 kya (Bennett and Hoffman, 1999; Vilà et al., 2001). Domestication occurred later than that of the other species described here and in further contrast, genetic analysis indicates that domestication from different wild herds occurred numerous times (Vilà et al., 2001). Dispersal of techniques in capture and taming could have led to the spread of horse domestication as a practice, as opposed to the spread of pre-domesticated individuals (Vilà et al., 2001; Jansen et al., 2002). Archaeological evidence for local domestication episodes at both Botai (Kazakhstan) and Dereivka (Ukraine) date primary domestication to about 6.5-5.5 kya (Anthony and Brown, 1991, 2000; Levine, 1999a, 1999b; Olsen, 2003; Outram et al., 2009).

Evidence of domesticated horses in Northeast Asia is restricted until the early Bronze Age. Occasional finds of horse remains have been made in Neolithic contexts dating to between 5.0-3.7 kya, but are within the natural range of wild species and cannot be definitively attributed to domestic animals. Horse remains at Qijia sites in northwest China date to about 3.7 kya and provide some of the first secure evidence of possible horse domestication in Northeast Asia (Yuan and Flad, 2005). By 3.4-3.0 kya, horse breeding was an important activity for Shang aristocracy in China and included symbolic participation by the king (Yuan and Flad, 2003). Horses were a common domesticate in northern China by 2.5 kya (Yuan and Flad, 2005; Flad et al., 2007). In Mongolia and southern Siberia, horse remains were often incorporated into early Bronze Age monuments called *khirigsuurs* (by at least 3.2-2.8 kya) (Fitzhugh, 2009). These monuments are often associated with the first incursion of nomadic pastoralists into the region (Honeychurch and Amartuvshin, 2006). Similarly, horse bones were included, along with other domestic animals, in Bronze Age burials (< 3.0 kya) from the Song Nen (Songjiang-Nenjiang) Plain region of Heilongjiang Province in Northeast China (Tan et al., 1995b). Horses were not introduced until much later in Korea and Japan and there is no direct evidence in those regions of domesticated horses in the Neolithic or early Bronze Age.

There is earlier evidence for the exploitation of equids in early Holocene Gobi Desert archaeological sites, but may relate to hunting (see artefact lists in Fairservis, 1993). Of the few faunal remains recovered from sites in this desert region, it is notable that the vast majority are equids (presumably *E. ferus przewalski* or *E. hemionus hemionus* as both species were widespread in the Gobi Desert until the late Holocene). Despite this, there is no evidence that the animals were domesticated. Hunting of equids as a key food source in the early Holocene would not be surprising since horse bones are also common in Pleistocene Chinese sites (Han and Xu, 1985; Deng, 2005; Yuan and Flad, 2005). As such, we might expect that Holocene hunter-gatherers regularly hunted local wild equids, although there is no reason to reject the possibility that some individuals from later sites were domesticated.

Camels

Bactrian or two-humped camels have been important herd animals throughout arid regions of Central, South, and East Asia. The wild ancestor of *Camelus bactrianus* is *C. ferus*, which was once distributed from the great bend of the Yellow River in China, through Mongolia and central Kazakhstan. Two-humped camels are well-represented in the rock art of the Altai, Tul-Kun, Tamurasche, Uryankhai, Turgai, and Minusinsk regions between Inner Asia and Siberia (Peters and von den Driesch, 1997; Potts, 2004). Although two-humped camels are thought to have been first domesticated in the Gobi Desert, phylogenetic analysis of eighteen domestic and three wild two-humped camels indicates that the existing wild individuals from northwestern China and southwestern

Mongolia do not share a recent common ancestor with domesticated breeds (Ji et al., 2009). The same study suggests a single domestication episode for the Bactrian camel. A clearer understanding of Pleistocene and early Holocene East Asian *C. ferus* distribution and phylogeny is required in order to gain a better sense of this singular event, including the relationship between modern wild camels and the subspecies ancestral to domesticated breeds.

It is more difficult to ascertain the timing of camel domestication than for other domestic species because there are currently no osteological criteria for distinguishing domestic from wild animals (Olsen, 1988). As such, domesticated status is usually accorded to animal remains outside the natural home range (Peters and von den Driesch, 1997). The most convincing early evidence of camel domestication is older than 5.0 kya and comes from the Kopet Dagh foothills of southern Turkmenistan. Not only were camel bones identified, but clay figurines of two-humped camels were also present and even the earliest levels contained some clay representations of camels harnessed to carts (Masson and Sarianidi, 1972: 109; Peters and von den Driesch, 1997). There are also claims for the use of camel by peoples of the Indus Valley civilization (about 4.0 kya) and artistic representations of two-humped camels were found in early Pakistani and Indian sites dating from 3.0-2.0 kya (Köhler-Rollefson, 1996; Peters and von den Driesch, 1997). Andronovo peoples in Xinjiang are also known to have bred camels and contemporary sites suggest that their use of domesticated camel dates to about 4.0k cal yr BP (Kuzmina and Mallory, 2007: 252). By 3.0 kya Bactrian camels are found in archaeological contexts from northern China to Bactria (northern Afghanistan/southern Uzbekistan), and were even more widespread by 2.5 kya (Olsen, 1988; Potts, 2004).

Since these regions bear no evidence for the Holocene existence of *C. ferus* in either local palaeontological or archaeological contexts, it seems that domestication must have occurred earlier farther east (Peters and von den Driesch, 1997). Although an ancestral relationship between existing wild populations and domesticated Bactrian camels remains unproven, prehistoric zoogeographic distribution of wild camels have led most researchers to conclude that camels were domesticated in the desert regions of southern Mongolia and northern China. Considering the earliest evidence for use of domestic camels in Turkmenistan, one may suggest that camels were first domesticated in the arid regions of southern Northeast Asia, perhaps Xinjiang, by 5.5kya. In this case, it is notable that evidence of the animal appears in Turkmenistan before other parts of Northeast Asia. This could indicate some level of reciprocal contact between desert groups in Central Asia at a very early stage in prehistory. Conversely, it could be suggested that *C. ferus* existed farther west than current evidence suggests.

Animal	Region	Earliest Evidence (k cal yr BP)
Dog	North China	12.9
	Northeast China	3.2-3.1
	Korea	7.5-4.7
	Japan	10.5
	Siberia	11.9, 4.5-2.5 (Primorye)
	Mongolia	Unknown
Pig	North China	12.9-8.9
	Northeast China	7.2
	Korea	8.0-2.0
	Japan	7.0-5.7?, after 2.5
	Siberia	4.5-2.5 (Primorye)
	Mongolia	Unknown
Cattle (*B. taurus*)	North China	5.6-4.0
	Northeast China	5.7-5.4
	Korea	5.0-4.7?
	Japan	after 2.5
	Siberia	5.5-4.0 (Eastern steppe)
	Mongolia	6.4-4.5?
Sheep	North China	7.3- 4.0
	Northeast China	5.7-5.4
	Korea	Historic
	Japan	after 2.5
	Siberia	5.5-4.0, Historic
	Mongolia	by 3.0
Horse	North China	3.7
	Northeast China	3.0
	Korea	after 2.5
	Japan	after 2.5
	Siberia	5.5-4.0 (Eastern steppe)
	Mongolia	4.5-3.5
Camel (*C. bactrianus*)	North China	4.0, 3.0
	Northeast China	2.9
	Korea	N/A
	Japan	N/A
	Siberia	4.0
	Mongolia	before 4.0?

Table 2.1 Earliest evidence for use of major domesticated animal species in Northeast Asia.

2.2.3. Animal domestication in the Gobi Desert

Regional suites of economically important domesticated animals in Neolithic Northeast Asia were derived from a variety of contexts and should be considered to reflect local ecology, community needs, and interaction spheres. The types of animals domesticated within a society indicate several things, including the suitability of each species for domestication, a pre-existing relationship between local people and the wild progenitor, and the needs of the group. Pig breeding is most closely associated with higher levels of sedentism or village communities. Unlike sheep, goats, cattle, and horses, pigs are not suited to mobile pastoralism, but can be easily contained and will do well feeding on the concentrated refuse produced by sedentary communities. On the other hand, animals associated with nomadic pastoralism are grassland-adapted and need ample pasturage. While sedentary humans with plenty of access to grazing land can quite successfully manage small herds of these species, especially if winter fodder is grown, large herds are less labour intensive for mobile people who can move with the animals to find seasonal pasture and offer regular protection from predators. Considering the sedentary nature of many early communities that exploited domesticates it is not surprising that herd animals are rare in Northeast Asia prior to the spread of nomadic pastoralism.

When we consider possible early domesticates in the Gobi Desert, it is important to consider local plant and animal communities, as well as existing patterns of land-use. High residential mobility and a varying seasonal focus on upland plateaux and lowland dune-field/wetland environments are suggested for early to middle Holocene hunter-gatherers in arid Northeast Asia (Janz, 2006; Bettinger et al., 2007). Equids and ovicaprines were common species across the Gobi Desert and wild camel would also have been included in the local fauna of the western regions. Wild boars were probably present in parts of the East Gobi, as well as wild millet, but the lack of evidence for sedentism makes early domestication of such species unlikely. Geographical proximity to Afanasievo stock-raising peoples west of the Gobi Desert makes the possibility of hunter-gatherer adoption of species like sheep, cattle, and horses intriguing, but compatibility with existing land-use and subsistence strategies must also be considered.

Domestication can be seen as a type of technological change. As with any technological change, the structure of a society must be modified in order to accommodate new elements. If dune-field/wetland environments were consistently productive it seems less likely that hunter-gatherers would adapt organizational strategies to incorporate sources of subsistence that would require vigilant protection from predators and constant access to forage. In this case, people would have needed to accept major organizational changes, such as devoting less time to other regular tasks, in order to benefit from herd-raising (see Lechtman, 1977; Lemonnier, 1992; Schiffer, 1992, 2001). This implies that certain tasks and benefits would be differentially valued in various societies (Schiffer, 2005). The perception of herd animals as a luxury item, or the security of having regular access to meat and/or milk are two types of benefits that might have justified the adoption of smaller herd animals like sheep or goats.

Consequently, if high residential mobility was typical of the society and consistent with the needs of proto-domesticates, it would have been easier to incorporate them into existing economic regimes. High residential mobility would also have contributed to perceived benefits for the use of animals like horses and camels, which would have made long-distance moves easier (Hämäläinen, 2003). Established patterns of high residential mobility would have reduced new pressures associated with constantly providing new forage, particularly if traditional moves coincided with localized seasonal appearance of pasture. Ease in following and hunting highly mobile prey species would also have benefited hunter-gatherers. In order to assess the relationship between Gobi Desert hunter-gatherers and the emergence of pastoralist economies in Northeast Asia, it is necessary to examine the chronology of such developments in the region.

2.2.4. Chronology of nomadic pastoralism in Northeast Asia

Pastoralism is considered to have evolved first in the Near East. Here, agricultural communities of fully or semi-sedentary farmers began managing wild herds of animals, such as sheep and goats, in a way that produced long-term changes in behaviour and morphology (Garrod et al., 1996; Hole, 1996; Zeder, 2001, 2005). Similarly, herding practices in East Asia are also thought to have originated in agricultural villages (Chang, 1987). Scholars in both regions have speculated that an increased focus on herding arose when agricultural populations expanded and marginal farmers were forced to adopt strategies that allowed them to survive in more arid or colder environments (Christian, 1998; Chang, 1987; Garrod et al., 1996).

Pastoralism as an independent subsistence economy was originally thought to have become possible only with the "Secondary Products Revolution," when the use of products like wool and milk allowed herders to be more independent of agriculturalists

(Krader, 1959; Sherratt, 1983). On the Eurasian steppes, pastoralists appear to have become more mobile by about 5.5k cal yr BP. Considering that horses were being domesticated between 6.5-5.5 kya, it is possible that the domestication of this species contributed greatly to the potential mobility of pastoralists; however, Kohl (2007: 137-144) argues that the introduction of heavy wheeled carts and wagons pulled by oxen was associated first with increased mobility. Ox and carts were probably widely used by 5.0 kya (end of the fourth millennium BC). This theory deserves careful consideration since the earliest evidences for horse domestication and riding was localized in only two centres – the Ukraine and Kazakhstan. Both carts and horses would have facilitated mobility, but in much of Central Asia cattle were the primary focus of pastoralist activities in the early period.

Milk and wool are also important to the modern Eurasian pastoralist economy and presumably would also have been regularly exploited. Despite this, it is unlikely that the development of dairying played a pivotal role in allowing herders the freedom to become less sedentary as organic residue analysis of pottery vessels has recently revealed that milk was used early as 8.0 kya (seventh millennium BC) (Evershed et al., 2008). It is not known when wool production began, but wool from sheep would have provided access to an extremely versatile raw material that has since proven central to mobile pastoralist economies in the Eurasian steppes, including in the construction of portable houses. Large scale production of woollen textiles is known to have been practiced in Mesopotamia by about 5.0 kya (late fourth or third millennium BC). Woollen rugs and carpets have also been found in Early Bronze Age burial monuments (Kohl, 2007: 164-166).

Nevertheless, the use of wool rather than bast fibres (e.g., linen, nettle, hemp) and the development of wagons, which were roughly contemporaneous innovations, do not explain why pastoralism became viable enough for a widespread shift in economic focus. The emergence of arsenical copper/bronze metallurgy might also be an important motivating force since primary access to the highly localized raw materials, as well as distribution, would have been easier for those with improved forms of transportation. Early Bronze Age metal artefacts from the western Eurasian steppes were probably produced locally and with the most basic techniques on ingots from the Caucasus (Kohl, 2007:166-180). The role of developing trade networks as an aspect of the "Secondary Products Revolution," for controlling trade of both bronze and "secondary" pastoralist products, has not been investigated.

Domesticated herbivores such as cattle and sheep predated the emergence of mobile pastoralism. Prior to the institutionalization of nomadic pastoralism, subsistence strategies were fairly flexible as peoples on the western Eurasian steppes were known to have relied on fishing and hunting, as well as stockbreeding and agriculture (Christian, 1998; Benecke and von den Dreisch, 2003). At the beginning of the Eurasian Bronze Age (5.5-5.0k cal yr BP), evidence of sedentary settlements disappear and raised burial monuments are common markers of the new nomadic pastoralist society (Kohl, 2007: 144-145). In some regions, settlements do become more common again in later periods.

Evidence for intensive gathering of wild plant foods such as goosefoot (*Chenopodium*) and amaranth (*Amaranthus*) was found in Late Bronze Age levels in the Samara Valley, along the middle Volga River in western Russia. This system of subsistence was later augmented with barley (*Hordeum vulgare*), wheat (*Triticum dicoccum*, *T. compactum*), and millet (*Panicum miliaceum*) in the final stages of the Bronze Age (Kohl, 2007: 157). Cereal grains were probably either acquired through trade or locally cultivated, but this aspect of subsistence is not well studied. Hunting and fishing remained important economic activities that contributed to a subsistence base now including pastoralist products (Frachetti, 2008: 46). Neighbouring hunter-gatherers groups apparently continued to rely primarily on various species of deer, which were probably also of economic importance to early pastoralist communities who maintained flexible subsistence strategies that included hunting, fishing, and gathering (Kislenko and Tatarintseva, 1999; Honeychurch and Amartuvshin, 2006). In general, subsistence economies were mixed and varied from region to region, with a seemingly greater reliance on exclusive pastoralism in Kazakhstan and western Siberia. Considering the continued importance of wild foods, it seems that most early pastoralist economies on the Eurasian steppes were at least as flexible their predecessors. Distinguishing markers of early pastoralists are their increased residential mobility and the incorporation of domesticated species.

Pastoral strategies in the Early Bronze Age were dominated by the use of cattle, but also included sheep, goats and horses. Communities in the western Eurasian steppe are generally assigned to the “Yamnaya culture,” while the term “Afanasievo culture” is reserved for those groups in the eastern steppes of Kazakhstan and southwestern Siberia. Similarities in material culture and the "Caucasian" physiological type of both groups have been used as evidence to support the eastward migration of newly mobile western pastoralists (Kuzmina, 1998; Hemphill and Mallory, 2004). However, calibrated radiocarbon dates of Afanasievo material tend to be slightly earlier than those of similar cultures in the western steppe (Rassamakin, 1999).

The predominance of horse remains in the Botai "culture" sites in the north central steppes of Kazakhstan (99% of fauna) is markedly different from the Yamnaya and Afanasievo sites where the most common large-bodied domesticated species are cattle (Frachetti, 2008: 47). Botai peoples used horses for dairy, but are thought to have primarily relied on domesticated horses in order to aid them in hunting herds of wild horses (Olsen, 2003; Outram et al., 2009). This pattern of exploitation shifted rapidly to one more similar to neighbouring areas around 4.5k cal yr BP (2500 BC), when the exploitation of cattle, sheep and goats overtook that of horses (Benecke and von den Dreisch, 2003).

The Afanasievo (5.5-4.5 kya) are generally recognized as the first group of pastoralists in both Northeast Asia and more broadly across the Eurasian steppes. Central areas of interaction included the Yenisei River Valley and the Minusinsk Basin (Frachetti, 2002). Subsistence was likely not based on herd animals alone, but also included hunted animals, gathered plants and fish (Frachetti, 2002). Subtle changes in ceramic form and burial are indicative of a change in local communities, including a more complex material culture, and are considered to mark the emergence of the Okunev peoples (4.6-4.0 kya), who were physiologically more similar to Asiatic peoples (Gryaznov, 1969; Mallory, 1989; Hemphill and Mallory, 2004). This physiological change may be indicative of the incorporation of more eastern populations into pastoralist communities and speaks to the increasing influence of locally evolving pastoralist communities in Northeast Asia.

From about 4.5-3.0k cal yr BP, the nomadic pastoralist peoples who inhabited the mountain-steppe zone just west of the Gobi Desert are archaeologically recognized by their exploitation of domestic animals (particularly cattle and sheep), metallurgy, and distinct material culture, all of which are reflected in their burial complexes and rock art. The term “Andronovo” (4.0-3.3 kya) has been widely applied to such archaeological complexes, which post-date Afanasievo and Okunev deposits. In addition to the previous range of domesticated animals, Andronovo groups were also known to engage in camel husbandry (Kuzmina and Mallory, 2007). Settlement data from the Dzhungar Mountains in southeastern Kazakhstan (near the border of China and bounded by the Altai Mountains; see Figure 2.1) suggest seasonal occupation of lowland and midland zones along ravines and south-facing cliffs. The occurrence of rectilinear, semi-subterranean houses with substantial stone foundations, as well as small camps with similar types of house forms, suggest a pattern of long-term continuity and seasonal reoccupation of the same environments (Frachetti, 2008: 132). It has been suggested that these groups planted seed crops around their winter settlements and returned to harvest them in the fall, but it is also clear that pastoralists might have more easily taken advantage of the diversity of wild plants available across the array of local biomes that they inhabited seasonally (Gryaznov, 1969; Frachetti, 2008). This pattern of structured and invested seasonal habitation is quite different from that recognized at contemporaneous hunter-gatherer habitations in Mongolia and China.

The Karasuk period (3.3-3.0 kya) follows the Andronovo in the Minusinsk Basin and is contemporaneous with developments in the Late Bronze Age of Mongolia (Houle, 2010). Sheep may have been of more economic importance than cattle at this time, and their different pasturage requirements could suggest an increase in transhumance. Horse bones also become more frequent. Horses may have been most important as a means of transportation, as there is clear evidence of horse-back riding (Legrand, 2006). Burial and habitation sites are more widespread than in the preceding period and it is suggested that population increased. Metallurgy became progressively more developed and important, eventually culminating in the Iron Age Tagar period (Legrand, 2006). In northern Mongolia, many late Bronze Age ritual and burial monuments have been dated to between about 3.2 and 2.8k cal yr BP (Fitzhugh, 2009). These monuments include deer imagery and intensive ritual use of horses (rather than sheep). Such a pattern is divergent from the Karasuk culture and suggests that nearby Bronze Age groups in northern Mongolia were developing their own traditions.

Early agropastoralist communities in northwestern China are contemporaneous with Afanasievo settlements. By this time, sedentary groups using agricultural tools and domestic species had settled along watercourses in the more humid and temperate climate zones. Most early cultivators were ancestors of later agricultural specialists, though at this early period they practiced a more mixed economy of herding, hunting, gathering, and farming. Little is known about subsistence economies in the arid Gobi Desert during this period. Based on the occurrence of grinding stones and macrotools, some scholars have suggested that cultivation may have been practiced around dune-fields and shallow lake basins (Cybiktarov, 2002), but beyond the southeastern-most regions the low frequency of such artefacts is inconsistent with intensive cultivation and processing.

It is commonly thought that nomadic pastoralism was introduced to East Asia by migrations from Central Asia, but agrarian cultures in western China may have engaged in herding practices prior to the florescence of nearby nomadic pastoralist cultures (Mallory, 1989; An, 1992a; Christian, 1998; Flad et al., 2007). Cultural connections between agricultural China and northern pastoralist groups during the late Neolithic and early Bronze Age have been suggested (Jacobson, 1988; Li, 2002). Earlier direct interactions are unlikely, as there is little evidence of pastoralist activity in Xinjiang, Gansu, and southern Mongolia, until after 4.5k cal yr BP.

The best known early pastoralists from northern China are copper and bronze-using groups, known as the Qijia, who practiced both agriculture and herding. Physiologically Asiatic peoples, the Qijia were centred in eastern and central Gansu, but were also present in eastern Qinghai, southern Ningxia, and western Shaanxi (Debaine-Francfort, 1995: 13). Dates on Qijia sites fall in the period of roughly 4.8-3.8k cal yr BP (4260 ± 80 at Changshan, 3555 ± 95 at Dahezhuang) and the sites often overlie those of the Late Neolithic Majiayao (Machiayao) type, or in some regions appear to emerge from other local predecessors (Debaine-Francfort, 1995: 362-367). The Qijia are characterized by the presence of new western domesticates and increased social stratification (An, 1992b; Liu, 2004). Hemp was used for textiles and people subsisted on a variety of western and eastern domesticates. Plants included foxtail millet (*Setarica italica*), wheat (*Triticum* sp.), barley, and rye (*Secale montanum*). Pigs were of primary importance, followed by cattle, sheep, and goats. Horses and dogs were also raised. Deer were still an important hunted species (Debaine-Francfort, 1995; Flad et al., 2007). In succeeding cultures, sheep herding gained primary dominance amongst agropastoral people in the Gansu region (Debaine-Francfort, 1995: 347). Developments in pottery production, metallurgy, and social stratification at Qijia sites parallel developments in the Central Plains, but bear distinct impressions of unique trajectories that are more closely aligned with Central Asian pastoralist groups.

Qijia peoples appear to have had contact with those groups associated with the Longshan (5.0-4.0 kya) culture further east on the Central Plains. Similarities in tool and ceramic traditions with the Shaanxi variant of Longshan culture, as typified by Kexingzhuang II, have been interpreted to show this society as ancestral to the Qijia. Newer radiocarbon dates for Longshan and Qijia type sites now indicate that this similarity is more likely the result of interaction and trade between the groups settled on the periphery of their respective culture zones (Debaine-Francfort, 1995: 327-328). The Longshan were highly stratified, institutionalized agriculturalists, exhibiting evidence of intense intraregional conflict (Shao, 2000). Settlements were clustered in centers of abundant arable land with settlement focused along rivers (Liu and Chen, 2006). Although copper and bronze were an important aspect of Qijia culture, metal artefacts are limited in the Longshan archaeological record and were not treated as prestige items until the emergence of the later Erlitou and Shang entities (Shao, 2000). Following the Qijia period, contacts with eastern China continued. Debaine-Francfort (1995: 347-348) contends that an increased focus on pastoralism and affiliations with outlying pastoralist societies dramatically shifted the trajectory of cultures between northwestern China and the Central Plains.

As Gobi Desert sites north of the Qijia range have yet to be clearly interpreted, it is not known what type of interaction these horse-riding agropastoralists would have had with hunter-gatherers groups to the north. Likewise, the relationship between contemporary Neolithic agriculturalists and hunter-gatherers in the East Gobi has been largely ignored. Only after the rise of horse-centred nomadic pastoralism is the relationship between agricultural China and less sedentary neighbours addressed in the literature. By that time, Gobi Desert groups almost certainly had knowledge of their neighbours and may have engaged in trade, possibly exporting such products as furs and stone. By at least 4.0k cal yr BP, the full suite of both western and eastern domesticates (perhaps with the exception of chickens) would have been familiar to inhabitants of southern mainland Northeast Asia. By no later than 3.0k cal yr BP, nomadic pastoralism was well established across the Gobi Desert.

One notable trend among early pastoralists in northern China is the incorporation of pastoral strategies into established economies already reliant on domesticated animals and cultivation. Although modern communities in Northeast China are traditionally associated with nomadic pastoralism, prehistoric groups were practicing a very different type of production economy prior to the introduction of nomadic pastoralism. Nomadic pastoralism entered the region quite late, perhaps as a consequence of increasing political and military power of pastoralist communities on the Northeast Asian steppes. This increased military power, which became especially notable by 2.5 kya, was related to both the military advantage of an expert equestrian fighting force and the political consolidation of steppic groups.

Later Bronze Age mortuary complexes, artworks and monuments in Northeast Asia appear to have evolved locally (Jacobson, 1988, 2002), but share numerous attributes with their contemporaries farther west (Christian, 1998). In China, Central Asian pastoralists may have mixed with agricultural “barbarians” such as the Qijia, who were probably in frequent contact with people practicing irrigation agriculture along the fertile Yellow River valley and its tributaries (Chang 1987; Christian 1998: 106). This relationship became increasingly fraught with tension during the rise of military powers within both China and arid Northeast Asia. We can expect that due to the mobility and low population density of Gobi Desert hunter-gatherers, their relationship with Neolithic and early Bronze Age Chinese agriculturalists was different than that developing between agriculturalists and agropastoralists along the Yellow River and its western tributaries. Nevertheless, it is clear that with the rise of equestrianism, increasing contact, and increasing population densities, mobile communities throughout the northern and central reaches of mainland Northeast Asia were steadily more at odds with urban, agriculture China.

2.3. Current knowledge of the Neolithic transition in Mongolia

Although we are making inroads into understanding of the complexity of relationships between early agricultural, pastoral, and hunter-gatherer groups in the steppes of prehistoric Northeast Asia, our knowledge remains rudimentary. And, athough we are gaining a deeper understanding of individual societies and economies across mainland Northeast Asia (e.g., Frachetti, 2008; Weber et al. [eds.], 2010), the relationship between these diverse groups remains ambiguous. Positioning Mongolian prehistory with the larger framework of contemporary groups is even more difficult due to a lack of research in this time period. Archaeological studies in the country focus on the more visually impressive remains of nomadic pastoralist groups, particularly those most closely associated with modern Mongolian identity (e.g., Xiongnu [Hunnu], Mongol Empire). Knowledge of the unique trajectory of early Mongolian prehistory would almost certainly confirm the importance of this geographic region which was central in the development of Northeast, Central, and East Asian cultures since the earliest record of human habitation. Numerous post-glacial assemblages both remaining *in situ* and known from museum and university collections are largely unpublished since their discoveries. This situation is unfortunate, since trajectories of development and interaction would undoubtedly be revealing considering that the Gobi Desert exists as a transitional zone, separating both western Central Asia from developed agricultural and later pastoralist communities in Northeast China, and sedentary agriculturalists in southern Northeast Asia from dedicated nomadic pastoralists in the north.

As noted in the introduction, our knowledge of Mongolian and Gobi Desert (including parts of the Inner Mongolia Autonomous Region, PRC) prehistory comes largely from two sources – the collections of major early 20th century scientific expeditions and joint Soviet-Mongolian expeditions. Following the dissolution of the Union of Soviet Socialist Republics (USSR) in 1991, foreign researchers became more involved in archaeological research in Mongolia. One of the most notable of these early collaborations is the Joint Mongolian-Russian-American Archaeological Expedition (JMRAAE) (Derevianko et al., 1996, 1998, 2000).

A diverse array of Stone Age assemblages have been documented from across Mongolia, dating from the first hominid occupations of the region to the early Bronze Age. Dating of the early sites is not well constrained, although it is probable that the earliest ones in Mongolia are as old as or older than those in Siberia since the two regions are very similar environmentally and topographically along their common borders. However, the current study is concerned only with post-LGM sites.

Assemblages containing microblade core technology are often considered to date to the post-glacial period, though it is now clear that such technology, in the form of wedge-shaped cores, began as early as the beginning of MIS 2 (ca. 25.0-11.5k cal yr BP) (Gladyshev et al., 2010). The post-LGM period is typified by the use of percussion and pressure-flaked microblade cores in a variety of prismatic and sub-prismatic forms, along with tools made from retouched microblades. The existing literature mainly contains descriptive summaries of artefacts associated with different chronological periods;

however, very few Mongolian sites are dated, making it difficult to trace the region's developmental trajectory.

2.3.1. Post-LGM settlement and subsistence in Mongolia

Nels C. Nelson was the first archaeologist to discover, collect, and publish prehistoric assemblages from Mongolia. His publications primarily outline his findings and draw attention to the fact that many of the finds were made in dune-field environments (Berkey and Nelson, 1926; Nelson, 1926a, 1926b, 1939). Nelson did indicate that these extensive wind-blown sediments appeared to have accumulated under more humid conditions, when "living" dune-fields were gradually being enlarged from the lee shores of filled lake basins (Nelson, 1926a). He states that deposits from the primary find site of Shabarakh-usu (Bayan-dzak) were blown from the walls of adjoining promontory escarpments within the dune-fields, where flints, pottery and bone occurred in "distinctly stratified order" (Nelson, 1926a: 251). Since Nelson's time, continuing archaeological work has shown that dune-fields are the primary source for Gobi Desert Neolithic-type assemblages (containing pottery and ground-stone), suggesting that a specific adaptation to such environments was an important aspect of Neolithic land-use.

Johannes Maringer

The first archaeologist to seriously address the issue of land-use and site location in the Gobi Desert was Johannes Maringer (1963), who analysed and catalogued the artefacts recovered by Folke Bergman during the Sino-Swedish Expeditions in Inner Mongolia (Maringer, 1950). He also drew on Nels C. Nelson's publications and in 1956 he examined the Central Asiatic Expedition collections housed at the American Museum of Natural History. He also studied collections in Denmark made by H. Haslund-Christensen in Inner Mongolia (Chahar) (Jacobsen, 1940), and consulted Elisseeff's (1950) summary of materials from Altan Bulag (Altan Boulaq/Altan Bulaq) along the Mongolian-Siberian border, as well as Okladnikov's (1951) monograph on the Soviet Kiselev Expeditions. Maringer (1963) asserted that, as previously suggested by Nelson (1926b), Neolithic groups identified by the use of pottery, polished stone tools, grinding stones, and arrowheads expanded beyond the geographic range of their ancestral Mesolithic predecessors, covering a greater expanse of steppe and desert areas.

Drawing connections between changes in human land-use and climate change, he recognized that the early Holocene of Mongolia would have offered very different environments than in modern times. He pointed out that following the LGM, with the melting of glaciers, the Gobi Desert would have been much wetter and that all of Mongolia would have been typified by richer vegetation and the infilling of lowland basins and river beds. He hypothesized that by the time of the Mesolithic, aridity was again increasing and people were forced into shrinking areas of remaining water, where they relied heavily on fishing. The decline of large game would have forced them to rely on small and medium-sized animals, perhaps leading to the invention of the bow and arrow, which allowed them to hunt more mobile animals and birds. Neolithic habitations were mostly found around springs, lakes, playas, and river beds, suggesting that the period was typified by the use of loosely connected oases.

Maringer saw no evidence for agriculture among Neolithic peoples in Mongolia, though in some regions they may have been influenced by agricultural communities in China, perhaps through trade. He believed the absence of other agricultural tools indicated that grinding stones were probably used to grind wild varieties of grain. While Egami and Mizuno (1935: 61) had suggested that Stone Age peoples along the China-Mongolia border were involved in the herding of horses, camels, cattle, and sheep, and Teilhard de Chardin and Pei (1944: 38) interpreted material remains as suggestive of agricultural endeavours, Maringer rejected such possibilities for the Stone Age of Mongolia proper. He also pointed out that the few finds of bronze artefacts in these regions are insignificant and that Mongolia seems to have maintained lithic technology until the beginning of the Iron Age around 200-100 BCE (2.2-2.1 kya) when a "separate cultural and ethnic stratum" began to move into the region. As such, Maringer saw the Mongolian hunter-gatherers as a completely separate entity from the pastoralist peoples who later inhabited the region and displaced them.

Maringer's interest in the relationship between Mongolian hunter-gatherers and adjacent cultures is evident in his discussion of the origins of Mongolian Stone Age peoples and their contacts with contemporary neighbouring groups. Based on comparisons with assemblages described from Altan Bulag (Elisseeff, 1950) and material from the Lake Baikal region in Siberia (Maringer, 1950: 183-185), he linked original Palaeolithic hunters in Mongolia with the cultures of southern Siberia. Although he noted similarities between Palaeolithic assemblages on the Ordos plain and at Zhoukoudian (Choukoutien), he saw those as derived from southward-moving groups of Palaeolithic hunters (see also Maringer, 1950). Also noted is Okladnikov's assertion (1951, 1962) that Shabarakh-usu pottery bore remarkable similarities to the Isakovo and Serovo ceramics from the Lake Baikal region (ca. 6.2k cal yr BP, after Weber, 1995). As such, Maringer saw Mongolian and Gobi Desert groups as closely allied with their northern neighbours throughout prehistory. He believed that contact between sedentary agriculturalists and northern hunter-gatherers was also supported by finds of "northern Chinese type tools and shards of painted pottery" in the steppe and desert regions of Mongolia (see also Okladnikov, 1962; Cybiktarov, 2002), but did not explore the nature of such hypothetical connections.

Mongolian and Russian research (1940s to present)

Later work of Soviet and Mongolian archaeologists largely supported and expanded Maringer's original hypotheses about Mesolithic and Neolithic inhabitants of Mongolia. The relationship between cultures of the Lake Baikal region and Mongolia were emphasized and seemed to researchers strongest at sites in eastern Mongolia (Larichev, 1962; Okladnikov and Derevianko, 1970; Dorj and Derevianko, 1970; Dorj, 1971). Overall, local development was emphasized, but the relationship between the material culture of Mongolia and the Gobi Desert and that of Manchuria (Northeast China) and Siberia was thought to indicate an important and long-term developmental relationship between these regions.

Finds made by both Soviet and Mongolian archaeologists later in the twentieth century added great depth to an understanding of the diversity of adaptations existing in prehistoric Mongolia, particularly at the end of the Neolithic and beginning of the Metal Ages. The most striking contradiction to Maringer's model is the discovery of a very rich Bronze Age horizon. Burial and ceremonial monuments link Mongolia with contemporaneous developments in greater Central Asia, but suggest a local evolution of both Bronze and Iron Age cultures (see summaries in Cybiktarov, 2002, 2003). The Mongolian Mesolithic (post-LGM aceramic horizon) was thought to have continued until about 6.0-5.0 kya (fifth or fourth millennium BC) (Derevianko and Dorj, 1992: 171, 172) with dates presumably based on inferences from stratigraphy and contiguous developments. The Neolithic, which marked the introduction of pottery, followed the Mesolithic and was associated with population expansion.

Several phases of development are now thought to characterize the Neolithic. By the middle Neolithic, agriculture is believed to have become an important subsistence strategy in eastern and southern Mongolia, complemented by hunting and fishing. The Neolithic-to-Bronze Age transition or the early Bronze Age is thought to date to between about 4.0-3.0 kya and was typified by more temporary campsites than in the middle Neolithic. Tool kits included the increased frequency of bifacially retouched tools, primarily of chalcedony, including finely pressure-flaked projectile points. Flake tools such as scrapers and microblade inserts are still common in such sites and copper slag is occasionally found. This pattern, though identified at sites in north-eastern Mongolia, is also considered to be typical of sites in the western Gobi Desert. Animal husbandry is thought to have begun during the same period as plant cultivation, but was not widespread until the Bronze and early Iron Ages. The adoption of animal husbandry is usually associated with increasing aridity and the arrival of nomadic pastoralists from the west. A more nomadic lifestyle would have begun at this time.

One of the most striking discoveries from the Neolithic or Neolithic-to-Bronze Age transition is Tamsagbulag, a site near the Chinese border in eastern Mongolia. Organization of subsistence and settlement appear to be much more consistent with patterns in adjacent regions of Northeast China than contemporaneous finds elsewhere in Mongolia. The Tamsagbulag site consists of several rectangular wattle-and-daub and wooden semi-subterranean houses with roof entrances, located on the edge of an elevated terrace near a spring in the vicinity of palaeolake Buir (Buiir) Nuur (Okladnikov and Derevianko, 1970; Dorj, 1971; Derevianko and Dorj, 1992; Séfériadès, 2006). An economy based both on hunting-gathering-fishing and food production is suggested by faunal and plant remains, which include evidence of millet and cattle, as well as bird, pig and horse (Derevianko and Dorj, 1992; Séfériadès, 2006). The domesticated status of these faunal remains has not yet been demonstrated, although they have commonly been accepted as such. The assertion that this group practiced millet agriculture is supported by the presence of numerous grinding stones, hoes, and millstones (Derevianko and Dorj, 1992). Derevianko and Dorj (1992: 174-175) saw the Tamsagbulag site as evidence of an independent origin for agriculture, which emerged from a base of intensive hunting and gathering. No parallels in material culture or economy were thought to have existed in adjacent regions of Central, North or East Asia.

Burials under house floors indicate a continuation of the Palaeolithic tradition of using maral (red deer/elk) (*Cervus elaphus*) incisors in bead making. Mother-of-pearl and bone were also used for ornaments. Bodies at Tamsagbulag and other sites in the Kerulan valley were positioned in a contracted sitting posture, which is rare in Northeast Asia, but has analogies to some late Neolithic/Eneolithic burials in the southeastern Trans-Baikal region (Cybiktarov, 2002). Microblade insets were hafted in composite knives.

Having conducted his own excavations at Tamsagbulag, beginning in 1996, the French scholar Michel L. Sériadès proposed that the Tamsagbulag site excavated by Dorj and Okladnikov (Tamsagbulag 1) dated to about 6.5 kya (5th millennium BC). Radiocarbon dates were derived from organics in a trench yielding chipped stone tools and pottery, as well as charcoal and ash, which was located at the foot of the terrace not far from the Tamsagbulag spring. This material was dated to 6.4k cal yr BP (5590 $\pm$ 120 BP) and the nearby habitation sites were inferred to have been of about the same age. Another site was uncovered northeast of Tamsagbulag 1 on the eastern side of the lake within a small area of sand dunes on the eastern bank of a smaller, nearly dry lake. Lithic and ceramic materials collected from the windward slope of the dune were also associated with the long bone of a gazelle or antelope. An unreported radiocarbon date places this site at around 4.0 kya.

Séfériadès interprets the difference in site types as evidence that a period of sedentism occurred at Tamsagbulag 1 around 6.5 kya and was followed by increased mobility after 4.0 kya. He proposes that when the lake began to vanish, people would have moved to the dune site along the residual lake. Eventually, a return to year-round nomadism would have occurred sometime after 4.0 kya. Aside from the early date assigned to sedentary occupations at Tamsagbulag, this model is consistent with earlier Soviet and Mongolian interpretations of the Neolithic-to-Bronze Age transition.

In the Gobi Desert of southern Mongolia, Shabarakh-usu (the key archaeological locale excavated by Nelson during the Central Asiatic Expeditions, also known as Bayan-dzak [Baindzak/Bayn-dzak]), was further studied and identified as an early Gobi Desert Neolithic type site. An aceramic horizon recognized by Nelson in his earlier excavations was not observed by Okladnikov, but was later confirmed through excavation by Polish researcher Kozłowski and Mongolian colleague Huhnbator (Kozłowski, 1972), and by the joint Soviet-Mongolian team (Okladnikov, 1951), who found two distinct layers at other stratified sites. The earliest levels were found beneath the dune base layer. Ceramic decoration, arrowpoints, knives, and microblades led to the association of these assemblages with the Early Neolithic of the Lake Baikal region (or the Serovo period, which is now considered to belong to the late Neolithic – see Weber, 1995). Pottery was decorated with textile and woven net impressions and had a pointed bottom. This earliest level was found in a two-meter deposit of reddish-brown loam overlain by one meter of light grey buried soil and over 3.5 metres of sand in which the later archaeological sequence was situated (Chard, 1974). This later stage of development was characterized by similar microblade reduction sequences, but assemblages are dominated by bifacially retouched artefacts. The ceramics are thin-walled with flat bottoms. Painted ceramics were also reported from these layers, bearing traces of black ornamentation on a red or yellow background[4] (Okladnikov, 1962; Chard, 1974).

The southern Gobi Desert Neolithic is thought to be characterized by small-scale plant cultivation. Large numbers of grinding stones are claimed to have been discovered along with “hoe-like tools” (Derevianko and Dorj, 1992; Cybiktarov, 2002). Re-examination of Gobi Desert assemblages collected during Central Asiatic Expeditions and the Sino-Swedish Expeditions suggest that the collections – with the exception of those from the southeastern Gobi Desert – contain few grinding stones and almost no formal or large types (Fairservis, 1993; Marginer, 1950; Janz, 2006; also see Appendix C). Nor do field notes of expedition archaeologists indicate that such artefacts were found and left behind due to constraints on transportation (Nelson, 1925; Pond, 1928, n.d.). It is not clear if variation between American and Soviet reports is due actual differences in recovered artefact assemblages, or simply in their interpretations.

By the beginning of the Bronze Age, several distinct regional subsistence strategies are thought to have been in place in Mongolia. Analyses of Soviet-Mongolian collections led to the conclusion that there were distinct differences between the western, eastern and southern regions during the late Neolithic and early Bronze Age (Volkov, 1967, 1981; Novgoroda, 1989; Cybiktarov, 2002). Cybiktarov (2002) divides archaeological remains from the early Bronze Age into four distinct areas with varying cultural traditions evidenced by material remains: 1) eastern steppe (eastern Mongolia

[4] It should be noted that when I viewed these collections in February 2010 at the Institute of Archaeology and Ethnology, Novosibirsk and the Institute of Archaeology, Mongolia, no such artefacts were found or known to be included in the collections.

and southern Trans-Baikal); 2) eastern forest (forest zone within the same region); 3) western Mongolia; 4) southern Mongolia (Mongolian and Chinese Gobi Desert). Séfériadès (2006) published a nearly identical division of socio-economic and cultural entities in Mongolia based on the Soviet literature. His four regions included: 1) western Mongolia (including the Altai regions and west of the Khangai Mountains); 2) north-central region (south of Lake Baikal); 3) southern region (southern Mongolia and northern China); and 4) eastern region (northern Mongolia, west of Manchuria).

The characteristics of each of Cybiktarov's regions are summarized as follows: The first zone, in eastern Mongolia is considered to have been characterized by sedentism and a mixed economy based on hunting, gathering, fishing, and stock raising (horses, cattle, and sheep). Hoe-like implements and ring-shaped "counter-weights" are thought to indicate low-level agricultural production. Copper smelting is evidenced by pieces of slag and a few metal artefacts from sites in Siberia and along the border of Mongolia. Tamsagbulag is included in this eastern steppe group.

Forest-dwelling groups in the Khentei Mountains of eastern Mongolia are thought to have been separate from steppe and forest-steppe groups. They appear to have maintained a hunter-gatherer economy without the addition of domesticates, though they occasionally appear to have engaged in bronze metallurgy using local raw materials after 4.0 kya (early 2nd millennium BC) (Cybiktarov, 2002). Stone continued to be the most widely used raw material, but emphasis was placed on flake tools rather than prepared microblade core technology.

The early Bronze Age in western Mongolia is known mostly from rock art and burials and is considered to be the result of a local variant of the Afanasievo and Okunevo[5] groups found throughout eastern Central Asia. A connection with the early pastoralists of eastern Central Asia suggests a mixed economy that relied heavily on hunting and gathering, but incorporated elements of food production. No settlement or habitation sites have been excavated in this region.

Southern Mongolian archaeological sites have been found mostly in dune-field environments near dried-up rivers and lakes. Past environments are proposed to have been more semi-arid than arid, with forest-steppe landscapes. Fragmented grinding stones and "hoe-like" tools are thought to attest to a partial reliance on agriculture. Reports of painted pottery suggested a relationship with the early agricultural societies of China. The Gobi Desert is considered to have been a region of unique cultural developments. Remains from these sites were undated and their relationship to Bronze Age developments remains unclear.

More recent exploration has been undertaken by the Joint Mongolian-Russian-American Archaeology Expedition (JMRAAE), which is in many ways an extension of the joint Soviet-Mongolian Palaeolithic Gobi Desert and Mongolian Altai expeditions of the 1980s. Several interesting Neolithic sites were discovered or revisited during this project, although the primary goals of the expedition included the systematization and standardization of techno-typological classifications, elaboration of chronostratigraphic sequences, and reconstruction of palaeoenvironmental conditions and palaeoeconomy in

[5] Considering the dates proposed by Cybiktarov (2002), these groups would necessarily be more closely contemporaneous with the Andronovo entity.

Palaeolithic sequences (Derevianko et al., 1996). The cave site Chikhen Agui is the most notable post-glacial period discovery and offers a new perspective on the organizational strategies of post-LGM Gobi Desert hunter-gatherers.

Chikhen Agui is a rockshelter located near a spring at about 1970 m a.s.l. at the eastern extent of the Gobi-Altai mountain range. It was discovered by Derevianko and Petrin in 1988 and excavated by the JMRAAE team in 1996-1998 and 2000 (Derevianko et al., 2003). Site structure was indicative of a cold season short-term camp that was continuously reoccupied over a few millennia (Derevianko et al., 2008). Concentrations of grass may have served as bedding, while a large hearth near the entrance would have provided heat to the entire shelter. Microblade insets for composite tools were the most common artefact type and a wooden haft was also found. Ostrich eggshell beads and fragments of what may have been a vessel of the same material were also discovered. Faunal remains from Chikhen Agui include *Lepus capensis*[6] (hare), *Ochotona* cf. *O. Alpine* (pika), *Marmota* sp. indet. (marmot), *Spermophilus* sp. indet. (ground squirrel), Dipodidae gen. et sp. indet. (jerboa), *Equus hemionus* (wild ass/khulan), *Procapra gutturosa* (Mongolian gazelle), and *Capra sibirica sibirica* (Siberian ibex) (Derevianko et al., 2008). Excavators interpreted this site as a seasonal hunting camp used for processing game: animals may have been ambushed as they came to drink at the spring below the mouth of rockshelter (Derevianko et al., 2003). The addition of non-utilitarian artefacts such as beads, a serpentine-antigorite pendant, and a wooden post or pole near the west wall of the cave suggest to researchers that some type of ritual activity might

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[6] *Lepus tolai* is common in the Gobi Desert and throughout much of Mongolia and was previously included in *Lepus capensis*. It is not clear if this identification takes this new nomenclature into consideration.

also have occurred (Derevianko et al., 2008). Notably, the ostrich eggshell bowl contained unidentified grass seeds and was situated near the wooden pole.

Ten radiocarbon dates bracket the site between 13.4-6.4k cal yr BP (5630 ± 220 and 11,545 ± 75 yrs BP) (Derevianko et al., 2003), though the two earliest reported dates were later discounted and a date range of 13.4 to 8.7k cal yr BP (7850 ± 100 BP) was proposed as a more reliable estimate (Derevianko et al., 2008). Recently, additional pieces of ostrich eggshell from the site were dated to 12.2 and 11.6k cal yr BP (10,060 ± 50 and 10,330 ± 55 BP) (Kurochkin et al., 2009). Unfortunately, soil development was weak and heavily disturbed by rodent burrows, which made for a challenging stratigraphic profile. As such, it was not possible to draw many conclusions about changes in artefact assemblages over time. There do appear to have been changes in raw material use: lithics in the lower horizon were made primarily on dark siliceous sandstone, while jasper-like rocks and chalcedony were more common in the upper layer. The upper layer also yielded geometric microliths which are uncommon in Mongolian lithic assemblages and were not present in earlier strata (Derevianko et al., 2003).

Chikhen Agui is significant for a number of reasons. It was the first post-LGM site in the Gobi Desert to be dated chronometrically. The majority of dates are between 10.0 and 9.0k cal yr BP, identifying it as one of few known Epipalaeolithic habitation sites. Though only representative of a singular aspect of contemporary land-use, it offers a distinct contrast to the “dune-dweller” sites which dominate the archaeological record, particularly in the Gobi Desert. Whether or not ritual activity was practiced here, it represents a high elevation, short-term special purpose site, presumably occupied during the cold season (based on hibernation patterns of represented rodent fauna, the most likely time is the end of summer or early fall). Both large and small faunal remains indicate a range of species typical of both mountain environments (ibex, pika) and of the open plains (wild ass, marmot, ground squirrel, gazelle), suggesting a varied diet. It is also important to note that the rockshelter seems to have been abandoned after about 8.7k cal yr BP until modern or historic times.

Inferences of post-LGM Gobi Desert settlement and subsistence based on investigations in North China

Since 1989, a group of scholars from China and the United States have been investigating environmental constraints and settlement patterns in the terminal Pleistocene/early Holocene of North China, including the connection between the domestication of broomcorn millet (*Panicum miliaceum*) in northwestern China (as evidenced by the Cishan site) and the subsistence economy of post-glacial hunter-gatherers (Bettinger et al., 1994; Madsen et al., 1996; Elston et al., 1997; Richerson et al., 2001; Bettinger et al., 2007; Bettinger et al., 2010a; Bettinger et al., 2010b; Elston et al., 2011). Investigations included an analysis of the Sino-Swedish collections from the Alashan Gobi Desert based on Maringer's (1950) catalogue of the remains (Bettinger et al., 1994), survey around the Helan Mountains (Madsen et al., 1996), excavations at Pigeon Mountain Basin in the Helan Mountains foothills (Elston et al., 1997), and survey of the region around and north of the Neolithic Dadiwan site on the upper Wei River in the western Loess Plateau.

Analysis of the Sino-Swedish expedition materials was based on the presence or absence of particular artefact categories: cores, adzes/axes, bifaces, and unifaces (Bettinger et al., 1994). Sites from the Alashan Gobi Desert were divided into six groups, including residential bases, seasonal base camps, temporary camps, and procurement locales. Based on the assumption that almost all sites were Neolithic in age and were part of the same type of land-use and economic strategy, inter-assemblage variability was thought to have been related to site function and chronology was not considered. Two types of seasonal camps were identified based on the mutually exclusive presence of either bifaces or axes (adze/axes). Projectile points were considered separately from bifaces, although it is clear from my own study of the collections that most artefacts Maringer classified as projectile points were bifacially retouched. As such, the biface category includes a range of biface types, including both projectile points and knives. Bifacially flaked adze/axes were not included in this category.

Residential bases were indentified primarily in areas rich in lithic raw material such as around the Ukh-tokhoi (Ukh Tohoy) and Khara-dzag (Hara-dzag) plateaux, and along the dune-field/wetland region of the Mongolian border. Residential bases were interpreted as winter occupations, when increased sedentism would have allowed for craft production and more concentrated episodes of processing. Seasonal base camps with adze/axes but no bifaces were primarily located around the Lang Shan foothills, far from residential bases, and were proposed to have represented a separate kind of settlement system or satellites of residential bases along the border of Ukh-tohkoi/Khara-dzag.

Several important points emerge in this analysis of the Sino-Swedish artefact lists. The pattern of land-use postulated is similar to the collector-type model outlined by Binford (1980) and was believed to represent a more complex intensive and seasonally differentiated strategy that was a response to increasingly abundant resources at the end of the Pleistocene. Possible evidence of woodworking tools (adze/axes) was thought to represent specialized tasks and the exploitation of new resources. Use of ceramics inferred a decrease in residential mobility, functionally related to an increase in diet breadth that included more plant species. Microblades were similarly thought to be connected to subsistence intensification (see also Bettinger et al., 2006). Finally, the Neolithic occupations represented by these collections were thought to represent a colonization, rather than *in situ* development. This colonization was first proposed to have been driven by increased availability of resources at the end of the Pleistocene or the beginning of the Holocene.

The general picture drawn was one of post-LGM hunter-gatherers extensively reorganizing subsistence, mobility, and tool use as increased precipitation as many new opportunities for food procurement emerged during a period of increased precipitation and warming (see also Elston et al., 2011). Climatic amelioration has been suggested elsewhere as a possible motivating factor in broad spectrum foraging or domestication (Richerson et al., 2001; Elston and Zeanah, 2002), but this model is at odds with the more common models of intensification as symptoms of either increased population density (Binford, 1968; Flannery, 1969; Keeley, 1988; Redding, 1988; Stiner et al., 2000; Stiner, 2001) and/or unpredictability/scarcity of resources (Redding, 1988; Bar-Yosef, 1996;

Hillman, 1996; Winterhalder and Goland, 1993; Bar-Yosef, 2002; Marshall and Hildebrand, 2002).

Farther south, survey of sand dunes, alluvial fans, stream margins and lake-marsh shorelines along the foothills of the Helan Mountains suggested a trend towards reduced residential mobility over time and a progressive intensification in the use of the lower to middle reaches of alluvial fans with springs (Madsen et al., 1996). The researchers interpreted the use of such environments as an indication of early agricultural endeavours. As in the Alashan Gobi Desert, they identified both residential bases and seasonal base camps. Chronologically ambiguous sites along dune margins were thought to represent seasonal occupations focused on the intensive processing of wild seed crops and small animals (Madsen et al., 1996). Later excavation at Pigeon Mountain basin, a shallow drainage basin with springs in the Helan Shan foothills, indicates that the use of microblade technology was in place by about 15.1k cal yr BP (12,710 $\pm$ 70) and grinding stones by at least 13.5k cal yr BP (11,620 $\pm$ 70) (Elston et al., 1997). Unlike in the Alashan Gobi, possible house structures were sometimes associated with microblades and microblade cores, as well as other artefacts associated with food processing. Madsen and colleagues (1996) point out that while Late Palaeolithic sites suggest numerous short-term camps, a wider range of Neolithic-type sites are noted. They interpret similarities in core reduction strategies between periods as a sign of local development rather than colonization.

Based on their analysis of the Sino-Swedish Expedition catalogues and approximately twenty years of experience in the Helan Shan region, Bettinger et al.

(2007) proposed a tentative chronology of post-LGM land-use and agricultural developments for northwestern China. Although few radiocarbon dates are available for Helan Shan sites, we can expect that extensive survey of the region should have provided the researchers with some level of implicit understanding about local chronology. At the same time, the proposed chronology is hypothetical and should be supported by additional direct dating and excavation.

Dates from Pigeon Mountain Basin provide the first clearly dated expression of post-LGM hunter-gatherer occupation in arid North China. These sites belong to what is characterized as the Helan Period, a time when the frequent use of macrotools and a diverse array of tool forms suitable for plant processing suggest broader spectrum subsistence than would have occurred in earlier periods. Large archaeological site assemblages imply decreased residential mobility compared with the earlier period. The use of dune field margins near upland environments would have allowed inhabitants to take advantage of a wide range of resources. Upland sites are fewer in number but are generally more diverse, suggesting permanent base camps in higher elevation environments, perhaps occupied seasonally.

The Tengger Period represents terminal Pleistocene and early Holocene occupation (including the Younger Dryas period of increased aridity – see Madsen et al., 1998). An increased reliance on microlithic technology is characteristic (see Elston et al., 1997). A scarcity of milling stones and more evidence of faunal remains are assumed to result from sampling error, but hunter-gatherers during this period are expected to have been more focused on hunting relative to gathering due to the decreased abundance of plant species during the Younger Dryas. Dune-field resources became more important, but the pattern of short-term low-land occupations and upland base camps seems to persist.

In the early Holocene, it is suggested that increased humidity and interdunal lake and marsh infilling may have led to longer term habitation in dune-fields. Microblade technology is thought to have become more important. Wild millet may have been exploited more intensively during this period. Despite the attractiveness of this model, the researchers admit that no archaeological sites in the study area date to the early Holocene. In the southern study area, at the early agricultural site of Dadiwan, the post-Pleistocene record does not resume until 7.8k cal yr BP (6,950 $\pm$ 90) (Bettinger et al., 2007).

The lack of archaeological sites dating to the Early Holocene is a recurrent theme in North China, with Nanzhuangtou and Yujiagou being the only two dated sites with occupations from this time period (Xia, 2001; Cohen, 2003; Liu, 2004). The researchers do not see Neolithic habitation in North China as emerging from a local base (Bettinger et al., 2007; Bettinger et al., 2010a; Bettinger et al., 2010b). Instead, they suggest that desert hunter-gatherers familiar with the exploitation of millet were driven southward during successive intervals of drought in the early Holocene.

The model that they offer proposes that the Alashan Gobi was colonized by hunter-gatherers from the south, who were becoming more sedentary and expanding their populations into the more marginal northern desert regions. Geographic expansion would have been driven by progressively increasing population density along the less arid stretches of northern China, where the better availability of low-ranked resources during post-glacial climatic amelioration would have increased resource reliability, thereby stimulating a decrease in residential mobility, and a broadening in diet breadth. Such developments would have presumably involved decreased child mortality (Handwerker, 1983) and perhaps increased fertility (Hassan, 1973; Hassan, 1981).

Considering the geographic distance between the Helan Shan region and those regions of the Gobi Desert discussed in this work, the Gobi Desert chronology is not necessarily expected to conform to that proposed here. However, three important inferences about local hunt-gatherers can be taken from this analysis: a relationship between climatic amelioration and increasing dune-field use; the complementary seasonal use of upland and lowland habitats; and the possibility that the intensive exploitation of grass seeds by desert hunter-gatherers may be directly related to the development of sedentary agriculture in central China. Analysis of Gobi Desert assemblages will consider both these points.

Recent interpretations of the transition to nomadic pastoralism

Contrary to Maringer's (1963) suggestion that the Metal Ages in Mongolia were the result of colonization by iron-using foreigners around 2.2 kya, it is now clear that there was a locally developed Bronze Age. Research by Mongolian and Soviet scholars supports the likelihood that local hunter-gatherers exploited copper, possibly bronze, and domestic herd animals by at least 4.0 kya and probably earlier. Despite clear evidence refuting cultural and economic "stagnation" during the Neolithic, the possibility that true nomadic pastoralism was introduced through the expansion of western groups of different ethnic affiliations is still debatable. Recent doctoral work by North American scholars working in Mongolia has addressed this issue (Wright, 2006; Houle, 2010).

The late Bronze Age in Mongolia is considered to be the first period when fully formed nomadic pastoralism can be recognized. Burial/ceremonial monuments called *khirigsuurs* (kheregsuurs) are found across western and central Mongolia, including the Gobi Desert (see Eredenbaatar, 2004). Dates from both *khirigsuurs* and deer-engraved stelae (deer stones) indicate that the culmination of Bronze Age ritual culture would have occurred between about 3.2 and 2.8k cal yr BP (Fitzhugh, 2009), broadly contemporaneous with the Karasuk period in the Minusinsk Basin of Siberia (Legrand, 2006; Houle, 2010).

Bronze Age habitation assemblages from the Khanuy Valley in northern Mongolia suggest that as with the Karasuk, sheep and goats were most important for subsistence, followed by horse, then cattle, and finally musk deer (*Moschus* sp.) (Houle, 2010: 122-131). The intensive ritual use of horse in Mongolia is notably divergent from the ritual use of sheep and cattle most common in the Karasuk period burials (see Legrand, 2006). Deer imagery is also unique to Mongolia, and perhaps the Trans-Baikal region, until the Iron Age Scythian period (see Fitzhugh, 2009; Houle, 2010: 5-6). These unique ritual traditions illustrate a trajectory separate from Siberia and influential to later Central Asian pastoralist tradition.

Despite evidence of intensified ritual practices including the construction of major architectural structures, the late Bronze Age in Mongolia is distinct from what is found to the north and west. There is little evidence for the well-defined social stratification and differentiation that is apparent among pastoralists in the Minusinsk Basin. Specialized site function and potentially some level of social differentiation were noted by Houle (2010: 143-176) for the Khanuy Valley (see Figure 2.1). Earlier surveys in the Egiin Gol Valley (see Figure 2.1) further indicate little difference in land-use between nomadic pastoralist communities and earlier hunter-gatherers (Wright, 2006). In Mongolia, the occurrence of slab burials at Bronze Age pastoralist sites is a distinctive form of burial that can be associated with Okunev and Karasuk periods further west and is relatively late in comparison to neighbouring regions (the earliest may be 3.6k cal yr BP, with the majority of dates falling between 2.8 and 2.5k cal yr BP) (Wright, 2006: 279). Evidence of microlithic scatters around *khirigsuurs* and chipped stone projectile points within slab burials indicate that earlier local populations may have been ancestral or otherwise associated with Bronze Age pastoralists. Wright (2006: 199-263) argues that some *khirigsuurs* may have been constructed and used by pre-pastoralist hunter-gatherers and that slab burials were markers of the first true nomadic pastoralist groups, who may either have been derived from a local base or have been immigrants incorporated into the existing population.

Whether or not early monuments were built by microlith using hunter-gatherers, pastoralists, or hunter-gatherer pastoralists, it is clear that the trajectory and chronology of developments in Mongolia is different from that observed in the rest of Central Asia. Nomadic pastoralism may have been adopted at a variable rate across the region, but does not appear to have formed the basis of economies until sometime between 3.5 and 3.0k cal yr BP. This chronology places the rise of nomadic pastoralism in Mongolia slightly earlier or contemporaneous with parts of Northeast China. Here, cultures such as Baijinbao on the Song Nen Plain (3.3 kya) began to rely more heavily on herd animals, and the Upper Xiajiadian in the Chifeng region (3.0-2.3 kya) exhibited more extensive ties with Northeast Asian nomadic pastoralists (Guo, 1995b; Tan et al., 1995b; CICARP, 2003). The Xindian peoples (3.2-2.5 kya) in Gansu and Qinghai provinces also appear to have been nomadic pastoralists practicing limited agriculture (An, 1992b; Debaine-Francfort, 1995). It is also widely believed that the Zhou (3.0-2.2 kya) in the Central Plains of China were not related to the preceding Shang, but originated north and west of the Central Plains (Guo, 1995b; Barnes, 1999).

Pastoralism appears to have reached its initial height between 3.2 and 3.0 kya across Northeast Asia. Bronze Age developments such as metallurgy and equestrianism reached new heights during the Iron Age only a few hundred years later. Most importantly, we should consider that just as 4.0 to 3.0 kya is the span that includes the end of the Neolithic and the beginning of the Bronze Age, it is the period between 3.5 and 3.0 kya that would have marked the true decline of Neolithic hunter-gatherer societies and the rise of nomadic pastoralist economies.

2.4. Summary

The transition to food production in Northeast Asia was characterized by a series of long term technological and economic changes that had variable outcomes. Microblades, pottery, grinding stones, and stone polishing are hallmarks of terminal Palaeolithic adaptations, but these technological elements are never ubiquitious and do not seem to be definitively associated with specific developments in subsistence. Northeast Asia is notable for the fact that both civilizations based on sedentary agriculture and powerful nomadic pastoralist states were dominant in the same region. Having outlined the transition to agriculture and pastoralism, as well as agropastoralism, in Northeast Asia, it is clear that both local environments and cultural associations probably contributed to the formation of historical economic structures. This point should be remembered as we address the role of Gobi Desert hunter-gatherers within the context of neolithization in Northeast Asia.

Throughout the terminal Pleistocene and Holocene, Mongolia and the Gobi Desert region are characterized by a unique set of developmental trajectories. Neighbouring agriculturalist, agropastoralist, and pastoralist neighbours may have interacted with and influenced technological and subsistence change in the region, but the archaeological record prior to the Bronze Age attests to the long-term importance of hunter-gatherer economies as opposed to the steadily increasing prominence of domesticated species that is found elsewhere in Central Asia and China. The emergence of a post-LGM strategy in the Gobi Desert, which focused on the use of dune-field/wetland environments and the occasional use of Neolithic type tools such as pottery, grinding stones and polished stone tools, suggests that local hunter-gatherers may not have as regularly exploited domesticated species as in China and Central Asia, but were similarly developing new methods of adapting to changing local environments.

By about 5.0 kya, there was a definite shift in the broader context of subsistence economies across Northeast Asia as elements of production, or at the very least intensification, emerged. The wide dispersal of both foreign and local domesticated plant and animal species is a clear indication of this trend. Food production economies were firmly established in Northeast Asia by 3.0 kya, except in regions where extreme climates prevented the adoption of existing domesticates. Tentative evidence for earlier limited use of domesticated animals in Mongolia is compelling, and while current evidence is insufficient to support inferences about the status of domestication processes in the Gobi Desert, it is likely that hunter-gatherers would probably have had knowledge of domestic herd animals by 5.0-4.0 kya. Shifts in Gobi Desert land-use and artefact assemblages around this time must be taken into account and given some consideration as they relate to the possible introduction of domestic species.

This research focuses on modes of land-use and subsistence during what are traditionally thought of as the Mesolithic, Neolithic, and early Bronze Age periods. Since land-use is inextricably tied to environmental and cultural constraints, it is important to establish a more detailed chronology for local post-LGM developments which can then be compared to contextual data. By considering local artefact assemblages, palaeoenvironment, and the cultural and economic milieu of neighbouring regions, this study will build a series of hypotheses about late Stone Age groups in the Gobi Desert that can be further investigated through excavation and materials analyses. Due to distinct geographic differences across the Gobi Desert in environment and possible cultural contacts, three Gobi Desert regions were considered: the East Gobi, the Gobi-

Altai and the Alashan Gobi. This study contributes to understanding two major changes in the cultural trajectory of Northeast Asia: the nature of complex hunter-gatherer systems prior to the transition to food production economies; and the role that groups living on the peripheries of both Central Asian pastoralist complexes and agricultural villages played in the development of the dichotomous production economies that characterize modern Northeast Asia.

CHAPTER 3 – CHRONOLOGY OF GOBI DESERT ARCHAEOLOGICAL SITES

The absence of good chronological control limits our understanding of prehistoric land-use, technological developments, and subsistence in the Gobi Desert. Previous research on existing assemblages has taken various approaches to interpretation of the regional chronology (Maringer 1950; Okladnikov, 1951; Kozłowski, 1972; Bettinger et al., 1994), but few clear results have emerged. Although an artefact-based chronology built on surface associations and stratigraphic evidence has been impressed upon the consciousness of local archaeologists there is no consensus system for chronologically ordering prehistoric assemblages. Without temporal controls, it is impossible to relate shifts in settlement patterning to either ecological shifts (i.e., increased/decreased precipitation, dune stabilization, enhanced productivity of certain favoured plants or animals, longer winters), or cultural stimulus (i.e., technological innovation, increased cultural complexity, trade with agricultural or pastoralist neighbours, population expansion from Central Asia or China).

Estimated ages of archaeological sites outlined in Chapter 2 may be accurate, but have not been clearly justified. Chronological resolution has been too coarse to confirm or deny existing interpretations of temporal variability in technology, land-use, subsistence, or the role of climate change in influencing these trajectories. In order to move our understanding of this culturally and environmentally important geographic region forward it is necessary to begin disseminating a firm artefact-based chronology by which to recognize chronological ordering in the archaeological record.

The first step in this endeavour is to consolidate existing knowledge of artefact-based chronology for the terminal Pleistocene and early Holocene in Mongolia and adjoining regions. This task is daunting due to both the wealth of regional publications and the number of languages used in disseminating the data. The goal of this chapter is to synthesize the literature most accessible to English-speaking audiences, also drawing on available texts in other languages according to the author's ability in order to identify the most reliable temporal indicators in artefact assemblages. It is hoped that in the future Mongolian, Chinese, Russian, and other scholars might bring additional knowledge to bear in the chronology of the post-LGM Gobi Desert in order to collaborate on research that will be accessible to an international community.

It has been difficult to obtain secure chronometric dates for Gobi Desert sites since most are surface assemblages with few organic remains. Issues of preservation aside, because the majority of excavated assemblages were collected prior to the advent of radiocarbon dating, easily dated organic remains like charcoal were not recovered when present. With the advent of modern chronometric dating methods, excavation can now provide temporal data, as exemplified by research at the Chikhen Agui site (Derevianko et al., 2003; Derevianko et al., 2008); however, excavation is costly and this fact limits large scale recovery and necessarily constrains data to one component of a larger settlement system.

Existing collections hold a great deal of potential for building interpretations based on inter- and intra-regional data sets. The broader geographic perspective that they offer is especially promising. Archaeological collections used in this research are housed at the American Museum of Natural History (AMNH) and the Museum of Far Eastern Antiquities (MFEA). They are derived from large areas of the Gobi Desert region and represent a wide range of environmental and site-use contexts. The vast majority of these museum assemblages derive from recently deflated dune surfaces. Others were still partially embedded in the matrix. Detailed catalogues, journals and archival records allow for an understanding of possible collection biases (Nelson, 1925; Pond, 1928, n.d.; Fairservis, 1993; Maringer, 1950).

For this study, chronometric dating was applied to collections in order to constrain temporal range of assemblages, test assumptions about possible intermixing, and offer approximate dates for various diagnostics that might be used for indirect dating of additional sites. Some researchers dismiss the usefulness of surface collections due to the perception that they are necessarily chronologically incoherent. In the case of the Gobi Desert collections we can be confident that there are at least some "single component" assemblages. Detailed descriptions of excavation and collection clearly indicate the common phenomenon of small, localized site clusters (often surrounding hearths or accumulations of fire-cracked rock) within major find localities (Nelson, 1925; Pond, n.d.; Fairservis, 1993). Likely cases of intermixing were often noted by the original investigators. If we then concede that such sites are temporally coherent, we can address the issue of using chronometric dating techniques.

3.1. Chronometric dating

A total of 23 separate Gobi Desert archaeological sites were chronometrically dated (Appendix A) and provide indirect dates for additional sites based on comparative artefact typology. The most effective method of dating Late Pleistocene and Holocene archaeological sites is typically accelerator mass spectrometry radiocarbon (AMS) dating analysis. AMS can be used effectively on both organic remains and carbonates (though dating of aquatic mollusc shell raises issues of marine reservoir and other effects – see Ascough and Cook, 2005). Modified ostrich eggshell and pottery are often found in Gobi Desert assemblages and offer the best potential for AMS dating. Alashan Gobi sites less often contain ostrich eggshell and the pottery is usually heavily sand-tempered and without carbonized organics, so the sites in this part of the study area were most difficult to date. A second approach to chronometry, luminescence dating of pottery shards, was carried out on Alashan Gobi samples. Luminescence dating was carried out at the University of Washington Luminescence Laboratory

Many archaeological sites in the study collections contained fragments, decorated pieces, and disc beads of ostrich eggshell (Maringer, 1950; Okladnikov, 1962; Fairservis, 1993; Janz et al., 2009). Ostrich eggshell fragments and bead fragments from the AMNH collections were dated using AMS in 2007 (Janz et al., 2009). Additional dates were subsequently obtained from samples derived from collections at the MFEA. All ostrich eggshell fragments were dated using the selective dissolution process outlined in earlier published studies on dating ostrich eggshell (Freundlich et al., 1989; Vogel et al., 2001; Bird et al., 2003).

Pottery is more widespread in Gobi Desert archaeological assemblages than ostrich eggshell and has been used for direct dating in other Northeast Asian archaeological assemblages (O'Malley et al., 1998; Keally et al., 2003; Kuzmin and Shewkomud, 2003; Yoshida et al., 2004). Samples were derived primarily from collections housed at the AMNH, but one sample was taken from the MFEA collections. All shards were processed using low temperature combustion (400^{o}C) (O'Malley et al., 1998).

Obtaining the age of a site using dates on pottery is clearly limited to the period following the adoption of ceramic technology. It was hoped that ostrich eggshell dates would provide a source for dates on earlier archaeological sites, but there was concern over the possible use of fossil eggshell, as the practice of older shell use has already been documented in the Gobi Desert and other regions (Potts, 2001; Aseyev, 2008; Janz et al., 2009). On the other hand, radiocarbon dates on ostrich eggshell fragments associated with post-LGM assemblages (as recognized by the use of developed microblade technology) have shown that eggshell fragments might be consistent with archaeological assemblages even if they are occasionally be older than associated artefacts (Jaubert et al., 2004; Kurochkin, 2009; Janz et al., 2009).

3.1.1. Sample selection

A range of samples were taken from each of the three Gobi Desert target regions – the East Gobi, the Gobi-Altai, and the Alashan Gobi. Selection of particular specimens for dating was based on the suitability of materials for dating, association with other relatively common diagnostic artefacts, apparent temporal cohesiveness of associated assemblages, and the ability to date other assemblage artefacts to control for error (see Appendix A.2). Site selection was also based on how representative each site was of the respective region. Many sites outside dune deposits did not fit all the criteria outlined above, but artefacts from these localities were selected whenever possible in order to broaden the sample. Sampling was intended to minimize damage to assemblage integrity – unique artefacts were avoided in favour of more abundant types. Most samples came from site assemblages systematically analyzed for this study, although exceptions were made in the case of certain sites (e.g., Chilian Hotoga) because they fit the other criteria. Multiple samples were taken from several sites.

3.1.2. Dating methods

A number of studies have shown that ratite eggshell can provide reliable radiocarbon dates (Freundlich et al., 1989; Miller et al., 1999; Vogel et al., 2001; Bird et al., 2003). Samples of ostrich eggshell, especially those associated with pottery, were prepared by myself and Dr. George Burr (University of Arizona) and analyzed at the NSF - Arizona Accelerator Mass Spectrometry (AMS) Laboratory using a selective dissolution procedure designed to remove the outer layer of carbonate and avoid potential contamination (Burr et al., 1992), a procedure successfully applied to ratite eggshell samples from Australia by Bird et al. (2003). In a test sample, the radiocarbon content of successively dissolved eggshell fractions was measured to assess possible post-depositional carbon exchange. It was found that the multiple dates produced overlapped at the 2σ level and were therefore statistically indistinguishable from one another, suggesting that ostrich eggshell is relatively inert and should provide reliable results (Janz et al., 2009).

The primary concern in using ostrich eggshell to date archaeological sites is the possibility that fossil shell might have been used. Recent AMS dates from Shabarakh-usu, Mongolia (Janz et al., 2009), suggested that although fossil shell does occur in Holocene archaeological sites, dating multiple artefacts using complementary dating methods helps to establish the contemporaneity of eggshell with archaeological assemblages. Chronometric dates on ostrich eggshell have been used in northern and southern Africa to infer the age of archaeological assemblages with minimal consideration of the "old eggshell" problem (Freundlich et al., 1989; Vogel et al., 2001; Halkett et al., 2003). In those regions eggshell for bead-making is thought to have been obtained from broken water carriers or from eggs collected for consumption (Sandelowsky, 1971; Orton, 2008), implying temporal association between ostrich eggshell and archaeological occupations. In our original study, none of the samples yielding anomalously old dates displayed conclusive evidence of human modification. While it has not yet been proven that hunter-gatherers used only fresh eggshell, AMS dates do provide at least an upper limit to the age of sites (Janz et al., 2009).

Dating pottery using AMS is less commonly done, but has been employed successfully at other Northeast Asian archaeological sites (O'Malley et al., 1998; Keally et al., 2003; Kuzmin and Shewkomud, 2003). If viable, direct dating of ceramics offers a wealth of opportunities for dating both museum collections and site assemblages in arid regions of Northeast and Central Asia, where surface assemblages are most common and preservation of organics rare. All dated ceramic samples underwent a standard acid-alkali-acid (AAA)[7] pretreatment and low temperature combustion. Some samples needed to be treated two or three times with acid until all carbonates in the paste could be neutralized, whereas for others a single treatment sufficed. Similarly, samples with higher levels of humic acid and were treated with a base up to three or four times in order to remove all contaminants. All samples were combusted on a vacuum line with CuO at approximately 400^{o}C. Previous studies suggest that low temperature combustion is most reliable for AMS dating on pottery as it releases carbon from the temper, but is not hot enough to release old carbon from the clay (O'Malley et al., 1998). In these earlier studies, interior portions of the pottery were sampled in order to avoid contamination from the exterior surface. Bulk samples were not combusted at low temperatures, but exterior and interior portions were dated separately using low temperature combustion. Interior subsamples generally provided older ages than the exterior counterparts (O'Malley et al., 1998).

The source of carbon in the selected samples varied. In some cases the most obvious source of carbon was residue from burning on the vessel surfaces. Some of the shards had abundant fibre temper or other carbonated organics in the temper, as evidenced by the charred and blackened paste. Other shards did not have any obvious traces of such blackening. Many of the samples with no obvious traces of organic temper

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[7] This pretreatment is also known as an acid-base-acid (ABA) pretreatment.

or blackening produced very low carbon yields (e.g., 73/2796 B produced only 0.08 mg C or 0.07% of the sample, compared with 73/2797 A with a relatively high yield of ~1.0 mg C/0.87%). Samples with carbon yields under 0.10% tend to yield unreliable dates (George Burr, personal communication, July 7, 2011) and are marked with an asterisk in Table 3.1. As expected, the dates returned from the low-yield samples were anomalous with the archaeological assemblages, with the exception of AA89873/AMNH #73/887A (Shabarakh-usu 4) and AA89887/AMNH #73/2231C (Baron Shabaka, Site 19), which were consistent with other dates from the same localities.

Due to variation in the presumed origin of carbon amongst the samples, bulk portions were used for dating. Considering the finding that exterior portions of the shards tend to be younger and more variable (O'Malley et al., 1998), it is reasonable to assume that bulk samples may have included some younger carbon. As such, if inaccuracies do exist, we can expect that the AMS dates on pottery are minimum age estimates. Comparing AMS dates on pottery with ostrich eggshell dates and luminescence dates should contribute to a clearer understanding of such concerns.

Luminescence dating on pottery complements ostrich eggshell dating for Gobi Desert sites. Luminescence dating is more destructive than radiocarbon (a fragment of pottery must be at least 5 mm thick and 30 mm in diameter), but is more reliable because it provides a direct age range for the firing or use of the pot (Aiken, 1985; Feathers, 2003). Since ceramics are often more fragile and less likely to be used after breakage than ostrich eggshell, it is also less likely that shards were recycled or re-used. Although there is a larger degree of uncertainty in luminescence dating, it is effective in building a relative chronology for pottery types (Godfrey-Smith et al., 1997; Herbert et al., 2002) and for testing the applicability of AMS dates from eggshell. The utility of dating surface ceramics by luminescence has been demonstrated in several cases (Dunnell and Feathers, 1994; Sampson et al., 1997); the technique is especially useful in circumstances where multiple occupation episodes may have been intermixed (Feathers, 2003).

The main problem with using luminescence to date these samples is uncertainty in determining the external dose rate, which includes both gamma and cosmic contributions. For ceramics, an associated sediment sample is often collected for this purpose where *in situ* measurements cannot be made. Since the dated specimens were collected decades ago no such sediments are available. The problem was diminished by employing *fine-grained* dating (Feathers, 2003: 1496), which is less reliant on the external dose rate. The fact that the museum-curated samples come from the surface is advantageous, because the atmosphere contains little radioactivity, thus reducing the gamma contribution. Uncertainty in the cosmic dose rate and the potential for radon fall-out have been cited as problems in surface dating, but these concerns are often over-stated (Feathers, 2003) and at any rate minor compared to the uncertainty with the gamma dose rate. As such, range of error for samples dated using luminescence was much higher than those dated using AMS.

AMS and luminescence dating are complementary techniques. AMS provides dates with a low margin of error, while luminescence dates on pottery can be used in the absence of organic temper or surfical carbonization. Luminescence dating on pottery can also be used as a control on AMS from ostrich eggshell and as a method of establishing a relative chronology for diagnostic pottery styles. AMS determinations on human-modified ostrich eggshell in combination with dates on stylistically distinct pottery from key archaeological sites will help refine and test assumptions about chronology.

3.1.3. Results

Results of AMS and luminescence dates are summarized in Appendix A.3. Dates that could be reliably associated with archaeological remains are summarized in Table 3.1. Direct dates on pottery indicate that the majority of these archaeological assemblages date to the middle to late middle Holocene. Combined with radiocarbon dates from Chikhen Agui (Figure 3.1), we can record the earliest known post-LGM occupations in each macro-region as follows: East Gobi, 9.5k cal yr BP from Shara KataWell; Gobi-Altai, 13.4k cal yr BP from Chikhen Agui; Alashan Gobi, 5.6 kya from Yingen-khuduk. Since many aceramic archaeological assemblages have yet to be dated, we expect that the respective regions were inhabited prior to these dates. Dates for the earliest use of pottery north of the North China Plain and south of the Lake Baikal region can currently be assigned to 9.6k cal yr BP and are indicated by sample AA89868 (AMNH #73/466A) from Shara KataWell in the southeastern Gobi Desert.

Lab. No.	**Cat. No. (K.13 or 73/)**	**Site**	**14C age BP ± 1 σ or KA ± 1 σ**	**KYA (cal. to 68% range)**
UW2361	203: 5	Jabochin-khure	3500 ± 300	3.20-3.80
AA91693	207: 1	Gashun Well	3385 ± 40	3.59-3.68
UW2358	212: 6	Yingen-khuduk	3910 ± 300	3.61-4.21
UW2357	212: 123		5690 ± 350	5.34- 6.04
UW2360	212: 128		3910 ± 230	3.68-4.14
UW2856	248: 5	Dottore-namak	3540 ± 1060	2.48-4.60
UW2355	248: 6		2740 ± 200	2.54-2.94
UW2362	298: 15	Mantissar 12	6460 ± 700	5.76-7.16
UW2359	298: 25		3840 ±340	3.50-4.18
AA89872	655 A		4308 ± 40	4.85-4.95
AA89873	887 A*	Shabarakh-usu 4	3680 ± 76	3.92-4.13
AA89877	1189 A	Shabarakh-usu 10	3595 ± 41	3.86-3.96
AA89878	1194 A		3246 ± 39	3.42-3.54
AA89879	1609 A	Ulan Nor Plain	5116 ± 41	5.78-5.91
AA89880	1609 C		5061 ± 49	5.75-5.88
AA89881	1702 A	Barun Daban	1661 ± 42	1.53-1.62
AA89868	466A	Shara KataWell	8604 ± 51	9.54-9.63
AA89885	2229 A	Baron Shabaka Well	5609 ± 47	6.34-6.44
AA89886	2231 A		5954 ± 52	6.73-6.86
AA89889	2237 B		3115 ± 47	3.28-3.38
AA89887	2231 C*		5825 ± 85	6.53-6.73
AA89892	2526 A	Spring Camp	866 ± 51	0.74-0.88
AA89897	2797 A	Chilian Hotoga	6728 ± 45	7.56-7.64

Table 3.1 Results of chronometric dating. * indicates that the date may be unreliable due to a low carbon yield of under 0.10 mg C (AA89873, AA89887). For site locations, see Figure 3.3.

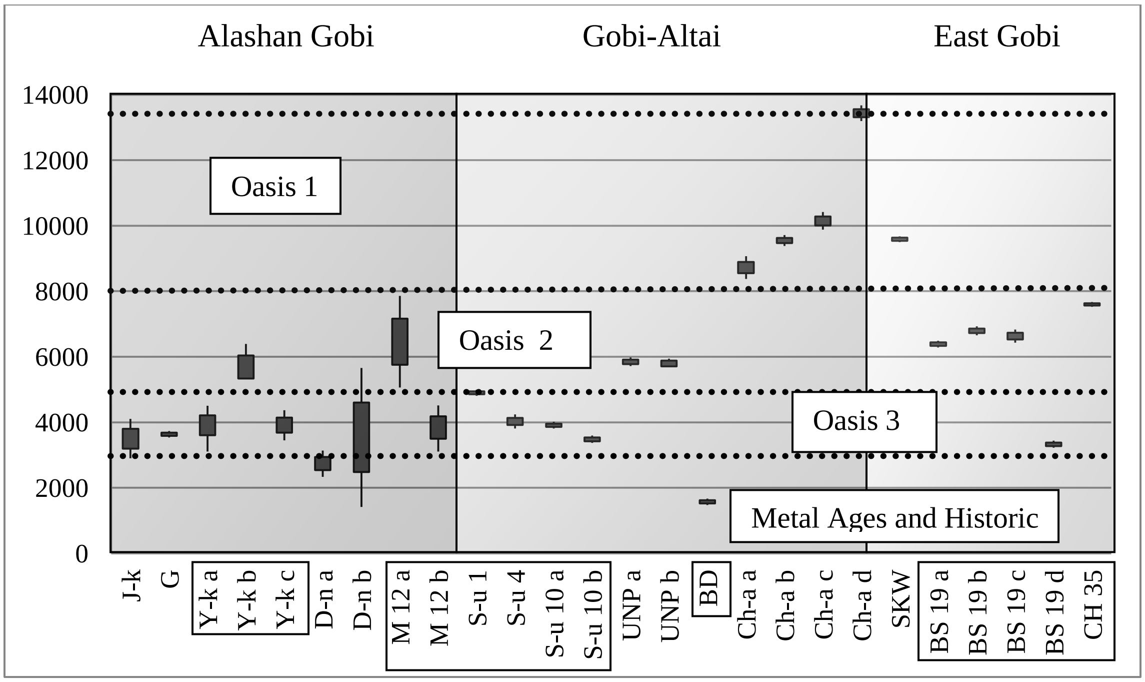

Figure 3.1 Dates (cal yr BP/ka [2 σ]) plotted for Gobi Desert sites according to target region and chronological period. Boxed site initials indicate dune-field/wetland sites.

The pattern of dune-field/wetland use is extremely interesting when compared across regions. The first East Gobi dune-field/wetland sites are markedly earlier (7.6k cal yr BP) than in the Gobi-Altai (4.9k cal yr BP) and Alashan Gobi (> 6.0 ka) and suggest that intensive use of dune-field/wetland environments in the more verdant eastern Gobi Desert may have occurred earlier than in the west. Alashan Gobi sites also tended to return dates that were in a slightly later range than those from the Gobi-Altai. The series of dates from all macroregions shows that the specialized use of dune-field/wetlands environments continued as late as the early Bronze Age, and that these environments were still occasionally exploited in historic times (Barun Daban, 374 ± 49 CE [AA89881, AMNH #73/1702A]).

While the earliest date on pottery from a dune-field/wetland site comes from Orok Nor, which is in the Gobi-Altai region, the very early date (11.6k cal yr BP [AA89884, AMNH #73/1792A; see Appendix A.3.) is suspect due to low carbon yields and the anomalously high-fired quality of the pottery sampled. The carbon yield was only 0.19 mg C/0.04%, which is too low to be considered reliable (see above) and should be treated with extreme caution. Unlike at other Gobi Desert sites, the ostrich eggshell at Orok Nor produced younger dates (9.4 and 9.3k cal yr BP [AA89882, AMNH #73/1790A and AA89883, AMNH #73/1790B]) than did the pottery. Due to the uncertainty of its accuracy, the Orok Nor pottery date is not reported in Table 3.1. Two samples, AA89873 (AMNH #73/887A) from Shabarakh-usu 4 and AA89887 (AMNH #73/2231C) from Baron Shabaka Well, did produce dates consistent with others from the same locality, despite yields of 0.04% and 0.06% respectively. These dates are reported in Table 3.1.

AMS dates on ostrich eggshell suggest that the material is often not contemporaneous with the Holocene archaeological assemblages with which it is found. Table 3.2 compares chronometric dates on ostrich eggshell with dates on pottery from the same site. The data suggest that middle Holocene peoples were indeed using ostrich eggshell from earlier contexts. As such, we can no longer state that the ostrich eggshell accurately dates associated human activities in the Gobi Desert (*contra* Janz et al., 2009). It should still be noted that ostrich eggshell from Pleistocene contexts in Northeast Asia has proven to be temporally consistent with associated artefact assemblages in some cases (Jaubert et al, 2004; Madsen et al., 2001). Decreased availability of ostrich eggshell following the extinction of ostriches sometime after 8.3k cal yr BP (according to eggshell dates from Shabarakh-usu 1; see Appendix A.3) would explain the use of fossil shell. In the middle Holocene the long-term importance of ostrich eggshell artefacts may have encouraged Gobi Desert peoples to continue using the material for bead-making thousands of years after the extinction of local ostriches. Clear knowledge of the timing of ostrich extinction would allow us to predict the use of older shell.

Despite discontinuity between eggshell and pottery dates at most sites, numerous eggshell dates from Shabarakh-usu are notably consistent. Fifteen out of 17 are within 1000 years of each other even though they are from many separate sites of a later age (Table 3.3). This led to the original assertion that they must correctly date the archaeological occupation (Janz et al., 2009). The dates are similar, but not close enough to have been from the same egg or clutch of eggs. One explanation is that ostrich may have been present in the region only for a brief interval of about a millennium (ca. 9.5-8.2k cal yr BP). Alternately, eggshells from that period may have been most accessible to hunter-gatherers due to middle Holocene human use of lake environments that were previously frequented by ostriches. Human populations contemporary with early Holocene ostriches might also have exploited fresh eggs, the shells of which were scavenged from middens by later inhabitants for bead-making. There have been verbal reports of eggshell middens associated with microliths at this locality and possible early Holocene occupations were reported by Soviet archaeologist A. P. Okladnikov (described in Chard, 1974: 82). So far, few terminal Pleistocene or early Holocene aceramic assemblages have been dated due to the lack of dateable materials.

Site	Ostrich Eggshell Date (cal yr BP)	Pottery Date (cal yr BP or ka)
Yingen-khuduk	45,646 ± 1605	3910 ± 300 5690 ± 350 3910 ± 230
Mantissar 12	> 49,900 > 48,500 > 48,800	6,460 ± 700 3,840 ± 340
Shabarakh-usu 1	8,295 ± 64 9,515 ± 22	4,900 ± 46
Shabarakh-usu 4	8,399 ± 25 9,484 ± 39 9,244 ± 91	4,027 ± 105
Baron Shabaka Well (Site 19)	14,829 ± 298 14,714 ± 333	6,388 ± 52 6,795 ± 67 6,632 ± 102 3,332 ± 53
Chilian Hotoga (Site 35)	12,549 ± 131 11,696 ± 202	7,601 ± 36

Table 3.2 Comparison of ostrich eggshell and pottery dates from Gobi Desert sites.

Shabarakh-usu, Site #	AA	Sample ID	$\delta^{13}C$ value	^{14}C yr BP	Cal yr BP
1	AA89869	648-01	-10.4	7,483 ± 47	8231-8359
	AA89870	648-02	-8.4	8,522 ± 50	9492-9537
2	AA76420	763-01	-10.3	8,159 ± 59	9045-9223
	AA76421	763-02	-9.6	8,184 ± 44	9061-9229
	AA76419	764-01	-9.1	7,969 ± 37	8754-8950
	AA76416	790-01	-9.0	8,396 ± 52	9335-9467
	AA76417	790-02	-11.1	8,268 ± 44	9169-9367
	AA76418	790-03	-10.7	30,490 ± 780	33,323-43,775
4	AA89874	894-01	-10.0	7,589 ± 47	8373-8424
	AA89875	984-01	-10.0	8,473 ± 64	9444-9523
	AA89876	998-01	-10.0	8,254 ± 47	9153-9335
7	AA76422	1034-01	-11.3	8,054 ± 43	8823-9015
	AA76423	1034-02	-11.6	38,600 ± 1000	42,204-43,850
	AA76424	1034-03	-10.7	8,439 ± 60	9407-9509
	AA76425	1035-01	-11.0	8,081 ± 49	8888-9080

Table 3.3. Ostrich eggshell dates from Shabarakh-usu.

Although ostrich eggshell dates cannot currently be used to date Holocene archaeological sites, chronometric dates on pottery can be used to help create a chronology for site assemblages. Understanding technological and economic developments in other regions of Northeast Asia are important in contextualizing Gobi Desert assemblages, especially in the earliest periods when little data is available in any one region. Without chronometric dates, it had been difficult to make appropriate associations with data from neighbouring regions, which could be used to identify temporally diagnostic artefacts and support a chronological framework. New dates for Gobi Desert sites further allow us to compare recognizable changes in technology and land-use with local palaeoecology in order to build hypotheses about subsistence and economy.

3.2. Artefact-based chronologies

Artefact-based chronologies in neighbouring regions of Siberia and China are better understood than those in Mongolia. Understanding the timing of cross-regional developments such as the introduction of various technologies, decorative styles, or lithic reduction strategies can help contextual Gobi Desert archaeology. Using better dated chronologies from surrounding regions in conjunction with new chronometric dates on Gobi Desert assemblages allows for the recognition of temporally diagnostic artefacts and can provide a general age for undated assemblages.

3.2.1. Definition of "Neolithic" and issues in terminology

As outlined in Chapter 1, the majority of the archaeological sites discussed here are described in the literature as either Mesolithic or Neolithic. The term "Neolithic" has been employed differently across geographic regions. Etymologically, the word means "New Stone Age", and was originally used by John Lubbock in 1865 to describe a period in technological development marked by the use of polished stone tools (Trigger, 1989: 94-95). In much of the world the term carries with it connotations of agricultural production, sedentary village life, and high levels of social complexity, as characterized by developments in the Middle East and Europe (Childe, 1953; Hodder, 1990; Renfrew and Bahn, 1996; Liu, 2004). Russian and earlier Soviet scholars have defined the Neolithic simply based on the first appearance of pottery (Chard, 1974; Kuzmin, 2003).

Due to the prevalence of Soviet and Russian research in Mongolia, the terms "Mesolithic" and "Neolithic" have been used in the Gobi Desert to differentiate sites with ceramics from those without ceramics. Since ceramic bearing sites are primarily found in distinct environmental contexts, the term Neolithic may improperly represent the actual chronological distribution of archaeological sites in the region (Janz, 2006). As such, categorizations based solely on occurrences of pottery are misleading and impede recognition of qualitative measurements by which to distinguish periodicity.

Based on its original use the term Neolithic is appropriately used to describe the New Stone Age of Mongolia, replete with polished stone tools, and other examples of technological development – small bifacially flaked points and a more varied tool kit. In order to promote consistency in terminology and recognition of contemporaneous shifts in human adaptation, the earliest post-LGM microblade-based assemblages in Northeast Asia should be referred to as *Epipalaeolithic*, regardless of the presence or absence of pottery. The period evidenced by a florescence of new flake tools, the more regular use of pottery, and a reliance on ground and polished stone technologies should be referred to as *Neolithic*. Finally, the following period is evidenced by incipient use and knowledge of copper and bronze working and can be referred to as the *Eneolithic* (currently referred to as Late Neolithic or Early Bronze Age). This system of nomenclature relies on a series of technological indicators other than pottery and is most appropriate for the developmental trajectory of Northeast Asia, as well as being more consistent with the original etymology of existing terminology.

Within this framework, it is possible to introduce local terminological variants for regional chronologies. In order to capture the Gobi Desert regional chronology more precisely, a local terminology is proposed here. Although the use of regional terminologies can be confusing due to differential recognition of archaeological cultures across international borders, the use of a local terminological framework allows for necessary distinctions between different subsistence economies or material cultures. Accordingly, I have sought to construct a clear and descriptive terminology for the Gobi Desert region by which we can define and categorize three chronologically distinct periods of related organizational strategies in the Gobi Desert region of Mongolia and China. Nomenclature for the three periods takes note of dune-field/wetland exploitation across the Gobi Desert and beyond, and represents a span of time stretching from the Late Epipalaeolithic to the Eneolithic: Oasis 1, spanning the Late Epipalaeolithic from 13.5 to 8.0 kya, this period represents incipient task-specific dune-field/wetland use; Oasis 2, coinciding with the Neolithic and dating from 8.0 to 5.0 kya, this is a period of intensive habitation of dune-field/wetland environments; and Oasis 3, spanning the Neolithic-to-Bronze Age transition or the Eneolithic, dating from 5.0 to 3.0 kya, this period is also represented by continued habitation of dune-field/wetland environments, and represents the transition from hunting and gathering to pastoralism. This terminology was designed to eventually be applied to other arid regions of Central Asia should it prove suitable.

3.2.2. Chronological variation in technology, subsistence, and land-use

3.2.2.1. Early Epipalaeolithic (Upper Palaeolithic/Late Palaeolothic) – 19.0 to 13.5k cal yr BP

The Early Epipalaeolithic is typified by the use of formal microlithic technology. Land-use seems to have been characterized by high mobility and utilization of a wide range of environments. In Mongolia, low density scatters of both chipped macrotools and rough microblade cores and flakes are thought to belong to this phase, more often referred to as the Late Palaeolithic (see Derevianko [Ed.], 2000: 263-271). The earliest post-LGM chronometric dates are 18.2k cal yr BP in northern Mongolia (Gladyshev et al., 2010) and 13.0k cal yr BP in the Gobi-Altai region (Derevianko et al., 2003). Although an overall lack of radiocarbon dates for Mongolian sites may contribute to a perceived lack of early post-LGM habitation, it is also possible that the region of modern Mongolia was very sparsely populated until the terminal Pleistocene or early Holocene to which the majority of microlithic sites appear to date.

Climate and subsistence

Post-LGM climate was highly variable in Northeast Asia, but showed increases in average annual precipitation and temperature. Summer monsoon circulation probably recommenced between 19.0-17.0k cal yr BP and lake levels stabilized across the region (Herzschuh and Liu, 2007; Wünnemann et al., 2007). Large ungulate populations may have declined during this period, as Pleistocene “megafauna” became extinct; however, there is now evidence that some large Pleistocene fauna like mammoth and ostrich survived into the terminal Pleistocene and early Holocene (Janz et al., 2009; Kurochkin et al., 2009; Kuzmin, 2010). Increased precipitation, enlarged desert oases, lakes, and stabilization of other diverse ecosystems are thought to have encouraged a more broad-spectrum subsistence, in concert with a decline of large game (Lu, 1999: 16-17; Bettinger et al., 2007).

Figure 3.2 Map of geographic locales mentioned in Chapter 3. Base map copyright of maps.com, used by permission.

The sporadic use of milling stones and pottery, florescence of microblade technology, and decline in the use of large points in various regions like China and Korea have been cited in support of this theory (Lu, 1998; Madsen and Elston, 2007; Seong, 2008; Elston et al., 2011). In the Upper Yenisei/Western Sayan Mountains region (see Figure 3.2) of southern Siberia zooarchaeological remains from Ui (Uy) I (see Figure 3.3), an LGM period habitation site, included remains of *Bos primigenius* (aurochs), *Equus hemionus* (Asiatic wild ass/onager), *Cervus elaphus* (red deer) and *Capra sibirica* (Siberian wild goat), while the similarly aged site of Tarachikha contained both large and small species such as *Mammuthus primigenius* (woolly mammoth), *Rangifer tarandus* (reindeer), *Ovis ammon* (Argali sheep), *Bison priscus* (steppe bison), *Alopex* sp. (fox), *Lagopus* sp. (grouse), *Marmota* sp. (marmot), and *Citellus* sp. (squirrel) (Markin, 1998). Early post-LGM period sites indicate a similar reliance on large game such as *Alces alces* (moose), aurochs, and *Equus ferus* (horse), but also contain grinding stones and a range of other resources such as eggs, *Gulo gulo* (wolverine), *Lepus* sp. (hare), fox, birds, and fish (Vasil'ev and Semenov, 1993). In North China, faunal remains from Xiaonanhai, dated to between about 15.7-12.8k cal yr BP (13,075 $\pm$ 500, 11,000 $\pm$ 500 BP), indicate continued exploitation of large-bodied species such as *Rhinoceros tichorhinus* (extinct rhinoceros), *Equus hemionus* (khulan), *Cervus canadensis* (elk or wapiti), and *Bubalus wansjocki* (extinct water buffalo) (Tang and Gai, 1986). During the LGM, edible plant species would have included mostly herbs and grasses with edible seeds (Lu, 1999). Post-LGM adaptations in North China are thought to include high mobility and varied land-use strategies that included dune-fields, wetlands, highland plateaux, and desert-steppes (Bettinger et al., 2007).

Post-LGM population expansion may have been facilitated by the florescence of microblade/core technology (Goebel, 2002; but see also Barton et al., 2007). Scattered evidence of microblade core technology has been found to pre-date 20.0 kya (see below), but these examples are rare and occur in lithic assemblages containing mostly large tools. Although the first evidence for the use of microblade cores appears just prior to 25.0k cal yr BP in Northeast Asia, it is not until after about 17.5k cal yr BP (15.0k cal yr BP) that microblade technology became widespread (Vasil'ev and Semenov, 1993; Chen, 2007; Kuzmin, 2007; Norton et al., 2007; Seong, 2008; Gladyshev, et al., 2010). Microblade core technology became a dominant core reduction technique in Northeast Asia by 15.4-11.5k cal yr BP (13.0-10.0k yr BP) and assemblages from this period are characterized by a diversity of microblade core types (Aikens and Akazawa, 1996; Ackerman, 2007; Elston et al., 1997; Lu, 1998; Xia et al., 2001; Cohen, 2003; Barton et al., 2007).

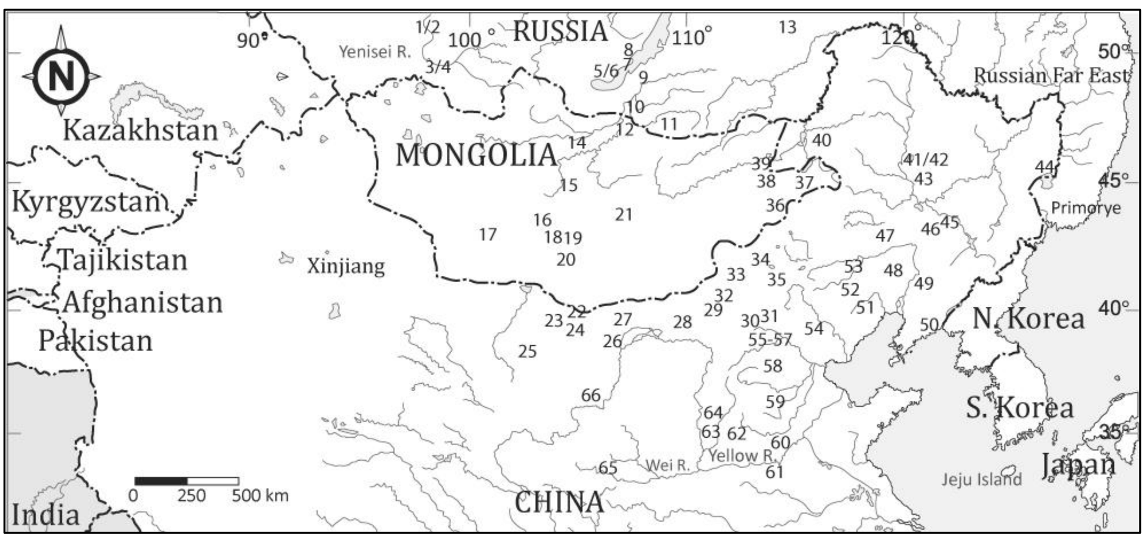

Figure 3.3 Map of archaeological sites mentioned in Chapter 3. Base map by maps.com. 1. Maina; 2. Ui; 3. Ust'-Khemchik; 4. Toora Dash; 5. Cheremushnik; 6. Ust'-Belaya; 7. Sagan-zaba; 8. Ulan Khada; 9. Oshkurovo; 10. Ust'-Kyakhta; 11. Studenoe; 12. Altan Bulag; 13. Ust'-Karenga; 14. Tolbor; 15. Moil'tyn am; 16. Orok Nor; 17. Chikhen Agui; 18. Barun Daban; 19. Ulan Nor Plain; 20. Shabarakh-usu; 21. Mandal Gobi/Ulan-khovor; 22. Yingen-khuduk; 23. Dottore-namak; 24. Ukh Tokhoi sites; 25. Mantissar sites; 26. Jabochin-khure; 27. Gashun Well; 28. Camp Ruined Lamasary (Site 11/11A); 29. Baron Shabaka sites (sites 19, 20, 21); 30. Jira Galuntu (Site 18); 31. Shara KataWell; 32. Spring Camp (Site 16); 33. Alkali Wells (Site 26); 34. Paoling Miao Southeast (Site 31); 35. Chilian Hotoga (Site 35); 36. Dulaani Gobi; 37. Tamsagbulag; 38. Khutyn-bulag; 39. Ovoot; 40. Hail'er; 41. Daxingtun; 42. Tengjiagang; 43. Ang'angxi; 44. Xinkailiu; 45. Zuojiashan; 46. Yaojingzi; 47. Fuhegoumen; 48. Chahai; 49. Xinle; 50. Houwa; 51. Xibajianfang; 52. Xinglongwa; 53. Zhaobaogou; 54. Menjiaquan; 55. Hutouliang; 56. Yujiagou; 57. Youmafang; 58. Nanzhuangtou; 59. Cishan; 60. Xiaonanhai; 61. Peiligang; 62. Xiachuan; 63. Chaisi; 64. Xueguan; 65. Dadiwan; 66. Pigeon Mountain Basin.

Early Epipalaeolithic technology in adjacent Northeast Asia

The archaeological record of Northeast Asia suggests regional continuity in lithic assemblages throughout the duration of the LGM and early post LGM. Microblade core reduction had been widely adopted at this time, but the use of expedient flake core and blade core reduction sequences was more common (Vasil'ev and Semenov, 1993; Markin, 1998; Lu, 1998; Norton et al., 2007; Sano, 2007; Ikawa-Smith, 2008; Chen, 2010). A trio of tool types – microblades, flake tools and heavy-duty tools – is identified with the LGM and early post-LGM, as recovered at Mengjiaquan in the North China Plain 20.9k cal yr BP (17,500 ± 250) (Lu, 1999). The pre-LGM period in Japan (Late Palaeolithic II) is characterized predominantly by the use of formal blade cores and retouched blade tools (Ikawa-Smith, 2008). During the LGM points, including backed points, were typical (Yuichiro, 2005), while later sites containing pottery (16.7-15.7k cal yr BP) are variously associated with microblade core technology, partially ground and chipped axe/adzes, large leaf-shaped points, gravers, scrapers and blades (Keally et al., 2003). In Korea, tanged points were common in pre-LGM and LGM assemblages, but became rare in the post-LGM period (Seong, 2007, 2008). At the pre-LGM Chaisi site (ca. 30.0k cal yr BP) in North China, microblade cores were associated with large tools such as choppers, scrapers and bolas, while post-LGM sites contained large cores, blade cores, microblade cores, unifacial points, small flake tools, and pebble tools like choppers, hammers, and chipped adzes (Chen and Wang, 1989; Lu, 1998).

Following the LGM core reduction strategies included many of the same elements found in preceding periods, but an increased focus on the use of microblade cores and a variety of new types are often noted. Several Japanese early post-LGM sites, dated to around 18.6k cal yr BP (15,470 ± 190), show a shift in microblade core types from sub-conical, to boat-shaped, to wedge-shaped (Sano, 2007). In Korea, wedge-shaped cores are considered to be the oldest type of microblade core technology, while smaller cores and more simplified reduction strategies are considered to be later developments (Norton et al., 2007). Chinese early post-LGM assemblages offer a contrast to the more common pattern of increasing variety in core forms. At the Xiachuan site (ca. 25.0-20.0k cal yr BP [21.0-16.5k BP]) microblade cores were mostly conical with a few wedge- and boat-shaped types (Tang and Gai, 1986; Chen and Wang, 1989; Lu, 1998; Tang, 2000; Chen, 2007), while the later Xueguan assemblage (16.5k cal yr BP [13,550 ± 150 BP]) primarily contained wedge-shaped microblade cores and only a few of the conical form (Lu, 1998). Early microblade core reduction techniques appear to have been more diverse in early North China sites (e.g., Xiachuan and similar undated assemblages from the lower Yellow River Valley – see Lu, 1998) than in other regions. The increasing frequency of microblade cores in post-LGM assemblages indicates a corresponding reliance on the use of microblade insets for organic hafts.

Large unifacial points are found in assemblages spanning the LGM and early post-LGM in several regions. The lack of reliable dates limits our interpretation of supra-regional patterns in the use of such points, but they are often associated with the LGM. At Xiachuan they are found with both microblade cores and backed knives made on blade tools (Lu, 1998). Points were similarly associated with microblade and blade industries at the pre-LGM Ui I in southern Siberia (Vasil’ev and Semenov, 1993). Large tanged points are indicative of late Pleistocene tool kits in Korea until the end of the LGM (Seong, 2007, 2008). Judging by the age of those sites, it is probable that large unifacial points are diagnostic of the LGM and very early post-LGM, but were not commonly used in later periods. Following the LGM, the increasing reliance on microblades as insets in composite points may be related to a decline in the use of unifacial points.

Microblade core technology

Methods of microblade core reduction in Northeast Asia developed over time and the earliest manifestation of the technology differs from later post-LGM developments. Despite the scarcity of reliable chronometric dates, several authors have attempted to use microblade core morphology and reduction sequences to create an artefact-based chronology within Northeast Asia (Tang and Gai, 1986; Chen and Wang, 1989; Seong, 1998). It is clear that wedge-shaped[8] microblade core technology is the most widespread in early assemblages, and the only type of microblade core present in pre- and early post-LGM Siberian and Mongolian assemblages (Vasil'ev and Semenov, 1993; Slobodin, 1999; Gladyshev et al., 2010).

Tang and Gai (1986) outline a progressive developmental technology for North China based on the relative frequency of certain cores types from directly and indirectly

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8 Unfortunately, the term "wedge-shaped" has been used to describe a morphology that is found supra-regionally during all time periods and can include several types of very different reduction strategies. Seong (1998) outlines several reduction strategies recognized by Japanese and Chinese archaeologists that can produce wedge-shaped cores (see also Morlan, 1976), but argues that analysis of lithic assemblages should focus on flexible typologies based on perform formation, platform preparation and blade production techniques. Pleistocene-type wedge-shaped cores made on heavily prepared nodules are herein referred to as "formal wedge-shaped cores."

dated archaeological sites (for alternate nomenclatures see Morlan, 1976; Seong, 1998). The earliest incarnation of microblade core technology in China was found at Xiachuan, where the most prevalent core forms were conical and boat-shaped. As described by Chen and Wang (1989), "conical cores" show variable shapes at discard. They are described as being made on small chunks with platforms trimmed from various angles. Cylindrical cores are similar, but with opposed platforms. Boat-shaped cores were similar to wedge-shaped, but were prepared from platform to distal end and lack an intentionally worked keel edge. The technique is reminiscent of the Horoka type from Hokkaido (Morlan, 1967; Seong, 1998).

Microblade cores from Xiachuan are considered to represent some of the most ancient examples of the technology in China, but the relative frequency of core types from the site is atypical of other LGM sites in Northeast Asia. In post-LGM Chinese sites, more formal wedge-shaped microblade cores are increasingly dominant, while conical cores are much less common or absent (see Chen and Wang, 1989). Conical cores are usually more common in Northeast Asian Holocene sites, where wedge-shaped cores are comparatively rare. Holocene wedge-shaped cores also vary in form from their Pleistocene predecessors. They are usually made on minimally prepared cobbles or rectangular nodules, and form thick-bodied performs with a keel edge in the back (Morlan, 1976; Chen and Wang, 1989). Aside from the keel, the exhausted form is quite similar to Xiachuan conical cores. Considering the range of other artefact types discovered at Xiachuan, including axes and grinding tools, the pre-LGM dates are extremely precocious.

Early Epipalaeolithic of Mongolia

In northern Mongolia, flake-based industries replaced blade-based ones around the same time that pressure flaked microblade cores were first used. Recent evidence from the open-air Tolbor sites suggests that this transition occurred by about 25.0k cal yr BP (Gladyshev et al., 2010). Pressure and percussion-flaked microcores became common during the post-LGM period, along with increasing numbers of microblades. Retouched points on flakes were also more common, a pattern that is repeated elsewhere in Northeast Asia. Little is known about the timing of this transition (Gladyshev et al., 2010).

Moil'tyn am is an important stratified site on the bank of the Okhotsk River near the ruins of the medieval Mongol city of Karakorum in central Mongolia. The site is undated, but lithic assemblages appear to date from the Middle Palaeolithic to Epipalaeolithic (Okladnikov, 1981). Layer 3 may correspond to the early Upper Palaeolithic (after Gladyshev et al., 2010) and is notable in the occurrence of subprismatic and irregularly shaped microcores with elongated flake scars reminiscent of microblade technology (Okladnikov, 1981: 289). Heavy-duty tools made on pebbles, prepared and expedient blade and flake cores, points and other retouched tools make up the majority of the finds. A prepared core strategy reminiscent of the Levallois technique is common. Pebble, flake and blade tools were found in Layer 2, but blades and elongated flakes are most characteristic.

Layer 1, which might be tentatively assigned to the Early Epipalaeolithic, indicates the continued use of heavy-duty pebble tools, along with more extensive retouch of flakes and a few true microblades and microblade cores. Microblade cores are mainly wedge-shaped and sub-conical, and are most consistent with forms described for the Xiachuan assemblage. The Dno Gobi (Дно Гоби[9]) locality, Sites 2 and 3 contain a range of tool types, including points, bifacially worked macrotools, flake tools and many blade and blade tools, as well as both conical and formal wedge-shaped cores (Okladnikov, 1986: 168, 200-201). Some elements of these sites appear to pre-date the LGM, but may date to as late as the early post-LGM.

Summary of Early Epipalaeolithic

Early Epipalaeolithic assemblages in Northeast Asia tend to focus on the production of large retouched flake and blade tools. Microblades were largely unretouched and were probably used primarily as knife blades or projectile inserts for organic hafts. Microblade cores were of a formal wedge-shaped variety throughout southern Siberia and northern Mongolia, while boat-shaped and conical cores were also used in northern China and in early post-LGM Japanese assemblages. Large unifacially retouched points are found in LGM and early post-LGM assemblages in some regions of Northeaast Asia, but do not appear to have been common throughout the Early Epipalaeolithic. Mongolian Early Epipalaeolithic assemblages are characterized by the use of both microblade core technology and retouched flake tools.

[9] For ease of recognition, names are given in Cyrillic when they are transliterated directly from the Russian or Mongolian literature and have not been previously used in English publications.

Considering the evidence from northern Mongolia and northern China, we expect that Early Epipalaeolithic lithic assemblages in the Gobi Desert would be typified by retouched flake tools, and both microblade and blade core technology. Large unifacial points could also be present in LGM or very early post-LGM assemblages. Microblade core technology might be represented by wedge-shaped, boat-shaped and conical core technology, with an emphasis on wedge- and boat-shaped forms. So far, no archaeological sites have been reliably dated to this period and none of the undated sites are typical of the Early Epipalaeolithic. Ostrich eggshell from the East Gobi has been dated to the Early Epipalaeolithic (see Appendix A.3), but the temporal association between dates and the artefacts is dubious. The region may have been quite sparsely populated during and immediately following the LGM, with increased population only in the terminal Pleistocene.

The tendency towards increased use of microblade core technology is typical of the Early Epipalaeolithic. A decline in the use of earlier lithic types like large unifacial points and, in northern Mongolia and Siberia, blade cores, is also notable within post-LGM tool kits. Technological shifts underlying changing subsistence strategies are not as clear as suggested for the Russian Far East and Japan by the use of pottery, but the more widespread use and importance of microblade core reduction sequences within Early Epipalaeolithic industries is an important characteristic that may reflect changes in early post-LGM foraging strategies. It has been suggested that the consistency with which microblade technology gradually became dominant over flake and blade tool technologies during and following the LGM, was related to the extremely cold seasonal temperatures and uneven distribution of resources that would have characterized the period in northern latitudes (e.g., Elston and Brantingham, 2002; Seong, 2007, 2008). As a reliable and efficient reduction strategy (*sensu* Elston and Brantingham, 2002), microblades could have served foragers as an important reliable hunting technology in circumstances where food resources were less reliable during the post-LGM period with fluctuating climatic conditions and increasing seasonality (Seong, 2007).

3.2.2.2. Late Epipalaeolithic/Oasis 1 (Mesolithic/Early Neolithic) – 13.5 to 8.0k cal yr BP

After about 13.5k cal yr BP a distinct shift organizational strategies, typified by diversification in subsistence and technology, occurs widely across Northeast Asia. A reliance on microblade core reduction strategies is representative of the Late Epipalaeolithic. Pottery becomes more widespread and is nearly ubiquitous by the end of the Late Epipalaeolithic. Regional developments in Northeast Asia appear to be more complex and diverse during this period. Stylistic and technological relationships between assemblages from the Gobi Desert and southern Siberia and northern China have been consistently emphasized in the archaeological literature and, along with their geographic proximity, make them important regions for contextualizing Mongolian and Gobi Desert post-LGM archaeology.

Climate and subsistence

The Late Epipalaeolithic began during a period of extreme low moisture availability corresponding to the Younger Dryas, lasting from 13.0 to 11.6 kya in monsoonal Central Asia and 12.0 to 10.0 kya on the Loess Plateau (Madsen et al., 1998; Herzschuh, 2006). The continuing post-LGM trend towards warmer, wetter conditions recommenced following the Younger Dryas with strong intensifications of both the Indian and Southeast Asian Monsoons at about 11.5k cal yr BP, along with an increase in seasonality that continued until after 9.6k cal yr BP (Herzschuh, 2006). Increases in monsoonal precipitation caused the boundary of arid lands in Northeast Asia to retreat dramatically (Starkel, 1998; Feng et al., 2007). Increased seasonality during the Late Epipalaeolithic may have limited the range of some species that were previously widespread. At the same time increased effective moisture would have resulted in the infilling of lake basins and river channels as well as the stabilization of alluvial and aeolian deposits formed during the LGM and terminal Pleistocene (see Owen et al., 1997; Hülle et al., 2009).

Archaeological faunal assemblages from the Late Epipalaeolithic are more varied than in the Early Epipalaeolithic, with a decreased emphasis on large-bodied game. The increasingly widespread use of pottery and grinding stones also indicates a shift in subsistence practices and land-use. In southern Siberia, faunal remains indicate that the exploitation of cervids and fish were increasingly important during the Late Epipalaeolithic (see Michael, 1984; Kirillov and Derevianko, 1998). Studenoe, a stratified site near the Mongolian border, exemplifies the transition in subsistence economy that occurred in much of Northeast Asia during the Late Epipalaeolithic. The site was used from about 21.6k cal yr BP to about 2.3k cal yr BP and was probably primarily inhabited throughout that time as a seasonal hunting camp (Buvit et al., 2003). Fauna from early layers (13.2-13.7k cal yr BP [11,300 $\pm$ 100 to 11,400 $\pm$ 200 BP, 11,400-11,800 years ago]) included forest, montane and steppe species such as *Cervus elaphus* (red deer), *Capreolus capreolus* (roe deer), *Poephagus baikalensis* (Baikal yak), Bovinae (bovines; aurochs or bison), and *Capra sibirica* (Siberian mountain goat) (Kirillov and Derevianko, 1998). Later Epipalaeolithic layers probably date until about 9.0k cal yr BP and contain mostly forest species such as *Alces alces* (moose), *Cervus elaphus* (red deer), *Capreolus capreolus* (roe deer), and fish species such as Siberian *elets*, *Lota lota* (burbot), and *Esox* sp. (pike) (Kirillov and Derevianko, 1998). The lowest cultural layer (XI) of the Ulan Khada site near Lake Baikal is thought to date to the very end of the Late Epipalaeolithic (Mesolithic). Here, the use of fishing equipment and seal bone (*Pusa sibirica*) further support the increasing importance of aquatic resources.

A different series of adaptations are represented by faunal assemblages from sites in North China. At Hutouliang the incorporation of small- to medium- bodied fauna – *Rana* sp. (frog), *Citellus citellus* (ground squirrel), *Cricetulus varians* (hamster), Vulpini (fox), *Sus scrofa* (wild boar), *Canis lupus* (wolf), *Cervus* sp. (deer), *Procapra picticaudata* (goa or Tibetan gazelle), *Gazella subgutturosa* (goitered gazelle) – into a diet already rich in large ungulate species such as *Equus hemionus* (khulan), *Equus przewalskyi* (wild horse), *Bos* sp. (cattle) suggests diversification of the existing diet (Gai and Wei, 1977; Chen and Wang, 1989; Lu, 1999). Faunal assemblage from the terminal Pleistocene to historic period site of Yujiagou (based on TL and ^{14}C, estimated to date from 13.7 to 2.1 ka), also in the Sanggan River region, contains an almost identical range of species but with a special focus on gazelle/antelope exploitation (Xia et al., 2001; Wu and Zhao, 2003). Possible early evidence of animal domestication also occurs during this period in the lake and marsh deposit of Nanzhuangtou (12.8-9.9k cal yr BP [10,815 ± 140 and 8800 ± 108 BP]) (Lu, 1999; Cohen, 2003). The site is thought to have been used for processing and cooking meat. Faunal remains included *Canis lupus* (wolf), *Sus scrofa* (wild boar or possibly domesticated pig), *Canis familiaris* (dog), *Gallus* sp. (possible domesticated fowl), and high frequencies of deer (*Cervus elaphus* [red deer], *Elaphurus davidianus* [Pere David's deer/Milu], *Capreolus capreolus* [roe deer], *Cervus nippon* [sika deer]) (Lu, 1999; Cohen, 2003). Fish, bird, soft-shelled turtle and shellfish remains were also recovered (Cohen, 2003; Wu and Zhao, 2003).

A change in the focus of subsistence is probably related to local shift in vegetation during the terminal Pleistocene, which would have influenced species composition (see Lu, 1999: 16-17). Megafauna and steppe species like mammoth, rhinoceros and equids were present in Early Epipalaeolithic sites in southern Siberia, but were probably no longer available in the more heavily forested terminal Pleistocene environments (Michael, 1984; Derevianko and Markin, 1998; Kuzmin, 2010). Hunters would have begun to target large- to medium-bodied cervids as an alternative. Small fur-bearing species appear to have been exploited prior to the LGM and in the Early Epipalaeolithic, but are less often noted in Late Epipalaeolithic faunal assemblages (see Vasil'ev and Semenov, 1993; Markin, 1998). Stratified sites in Siberia suggest that hunter-gatherers may have maintained a set pattern of land-use, but adjusted species selection according to local faunal diversity.

Likewise, data from North China indicate the continued use of steppe-dwelling ungulate species with the addition of small- and medium-bodied species from a variety of new environments like forests and marshlands. Foragers in the arid Gobi Desert and northwestern China (Bettinger et al., 2007) are expected to have relied on a comparable range of species from various environments, such as newly formed marshlands around stabilized lake and dune-fields. Thus, the Late Epipalaeolithic is suggested to have represented the incipient stages of an oasis adaptation that became central to Holocene human land-use in arid Northeast and Central Asia.

Late Epipalaeolithic technology in Northeast Asia

Microblade-based tool kits dominate Late Epipalaeolithic assemblages across Northeast Asia. Expedient flake technology continued to be used, but blade cores were no longer common in lithic assemblages. The importance of microblade technology coincides with an overall emphasis on the production of small flakes and tools and a corresponding decline in the use of macrotools. Pressure-flaking was a common method of retouch. Homogeneous cryptocrystalline stone such as jasper and chalcedony were most highly favoured and were probably more suited for producing the small formal microblade cores and finely retouched tools than more coarse-grained stone.

Assemblages from southern Siberia represent a series of technological changes that are broadly consistent with those in Mongolia. The Late Epipalaeolithic (locally referred to as the Mesolithic) of the Lake Baikal region is best known and is characterized by the increasing frequency of microblade cores and a diversity of microcore types, including less formal prismatic cores. Other markers of the period include the disappearance of prepared flake core technology ("Levallois"), declines in the number of large points, less varied scraper types, retouched microblades, and the occasional use of new technologies such as polished stone, bifacially worked tools, and fish hooks (see Michael, 1984; Kirillov and Derevianko, 1998). As in the rest of Northeast Asia, polished stone, pottery, and grinding stones became more common. The earliest evidence of pottery in the region comes from around Lake Baikal, where ceramics were found at several Late Epipalaeolithic sites[10]: Studenoe 1, layers 6 and 7; Ust'-Kyakhta; and Ust'-Karenga, Layer 7 (Kuzmin and Orlova, 2000). The first use of polished stone, especially in the manufacture of fishing gear, also dates to the end of the Late Epipalaeolithic.

The earliest stage of Late Epipalaeolithic technology is represented at Cheremushnik, where lithic assemblages indicate the continued use of Early Epipalaeolithic tool kits with the introduction of bifacially worked tools, projectile points ("arrowheads"), and axes (Michael, 1984). The stratified Oshkurovo site near Ulan-Ude is thought to date to between about 15.1-12.6k cal yr BP, the later layers exhibiting an increase in the number of worked small and medium sized pebbles, the addition of prismatic cores, and microblades with lateral retouch (Kirillov and Derevianko, 1998).

[10] All ceramic bearing sites are traditionally referred to as "Neolithic" in the Soviet/Russian literature. Such sites should be re-evaluated for consistency of technological associations and subsistence before being grouped with other Neolithic sites.

Upper layers of stratified assemblages from Ust'-Belaya post-date 10.1k cal y r BP (8960 $\pm$ 60 BP) and likewise indicate increasingly diverse microblade core forms, along with new technological developments like polished stone, small bifacial projectile points ("arrowpoints") and fishing hooks (Michael, 1984). Pre-dating 8.5k cal yr BP, the lowest level of Ulan Khada represents the Epipalaeolithic to Neolithic transition and indicates a heavy dependence on microblade core technology, fishing technology, polished adze/axes, and temporally diagnostic core tools from which burin spalls were taken to make "drills". Sinkers and blanks for hooks underlie evidence of the importance of fishing and a piece of seal bone indicates exploitation of the Baikal seal or *nerpa* (*Pusa sibirica*) (Khlobystin, 1969; Kuzmin and Orlova, 2000).

Lithic assemblages from the Late Epipalaeolithic of North China are similarly characterized by the increased use of microblade reduction strategies, but with the continued use of flake and heavy-duty tools. Wedge-shaped and boat-shaped microblade cores were dominant. The earliest type of formal wedge-shaped core is identified by the Hutouliang technique (Saikai/Fukui)[11]. Other wedge-shaped core types were also found in Late Epipalaeolithic sites along with boat-shaped and the more rare conical types. The He Tai technique (Yubetsu) may have developed in northern China following the Hutouliang type and was characterized by the preparation of a bifacial core, from which ski-shaped spalls were longitudinally detached to form a platform that was generally not rejuvenated during the process of reduction. The third variant was the Sanggan technique

[11] The technique is thought to have been represented in an early form at Xiachuan (25.0-20.0k cal yr BP) and then later at Hutouliang (12.9k cal yr BP). In this variant, the platform was shaped by transverse blows on a unifacially flaked blank, with microblades detached from one end of the platform (Tang and Gai, 1986).

(Oshoroko), where small spalls were removed from the tip of a bifacially prepared core to create a successively rejuvenated platform (for illustration, see Seong, 1998) (Tang and Gai, 1986). All three types were found at the Hutouliang localities, near the Sanggan River, Hebei Province[12].

New dates from Hutouliang suggest that pottery may have been used as early as 16.0k cal yr BP (13,080 ± 200) (Yasuda, 2002), but early pottery is more often recognized at Late Epipalaeolithic sites. Three Late Epipalaeolithic pottery sites are Yujiagou, Toumafang, and Nanzhuangtou. Pottery at Yujiagou, in the Hutouliang area of the Nihewan Basin, was associated with a thermoluminescence (TL) date of 11.6 ka (11,870 ± 1720) (Tang, 1997; Xia et al., 2001). East of Yujiagou, near Nihewan village, the Toumafang site has been dated to 8.3k cal yr BP (7530 ± 100 BP). Artefact assemblages include not only microblades and microblade cores, but small flaked tools, a chipped adze, pottery, grinding slab fragments, a few polished stone tools, and a large number of flaked and polished bone and antler tools (Lu, 1999). Likewise, the Nanzhuangtou site contains not only stone hammers and cores/flakes, but an array of new artefact types that are most often recognized in later periods, including variously decorated pottery shards (cord-marked, punctuate, and applied decorations), grinding stones, a roller or pestle, worked wood, a bone awl, and an antler drill (Lu, 1999; Cohen, 2003; Wu and Zhao, 2003). Interestingly, there are no microblades.

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[12] The best known date for the assemblages is 12.9k cal yr BP (or 12.5k cal yr BP based on 10,690 ± 210 in Lu, 1998, 1999), but more recent dates on pottery from Hutouliang indicate an even earlier age of about 16.0k cal yr BP (13,080 ± 200) for at least one of the sites (Yasuda, 2002).

Lithic assemblages in northwest China are distinct, but follow a similar pattern to that farther east. At Pigeon Mountain Basin in the Helan Shan foothills a milling stone was found above sediments dated to 13.5k cal yr BP (11,620 ± 70 BP) (Elston et al., 1997). Microlithic technology was also dominant after about 13.5k cal yr BP, corresponding with a decline in the use of macrotools (Bettinger et al., 2007). Retouched microblades occurred only in the later layers, dated to at least 11.7k cal yr BP (10,130 ± 70 BP), along with an "arrowpoint," which appears from the illustration to have been a small unifacially retouched flake (see Elston et al., 1997). Macrotools included gouges on cobbles, scrapers, flake tools, blade tools, spheroids, debitage, and roughly chipped Helan points resembling artefacts from Hutouliang, Xiachuan, and Xueguan (Elston et al., 1997). A shift in raw material preferences was also noted, in that the rise of microlithic technology appears to have corresponded with a shift from the use of quartzites and coarse-grained metavolcanics to crypocrystalline cherts and chalcedonies (Bettinger et al., 2007).

In Northeast China (Manchuria/Dongbei), the first use of microblade technology is later than in southern Siberia and North China. Few sites pre-date the Neolithic period, when evidence for sedentary habitation is found along with developed Neolithic stone tools and pottery. The two earliest post-LGM sites are Xibajianfang (Bajianfang), Liaoning Province, and Daxingtun, Heilongjiang Province. Xibajianfang contains mostly extant species with the exception of *Bos primigenius* (aurochs) and is thought to date to the terminal Pleistocene or early Holocene. There were small tools, but no microblades (Jia, 2007). At Daxingtun (13.7k cal yr BP [11,800 ± 150 BP]), only one prismatic microblade core and 14 truncated microblade fragments were reported (Lu, 1998) and the status of these artefacts as true microblades has been questioned (Jia, 2007). Small flakes, pebble tools, and microblades are thought to be typical of terminal Pleistocene assemblages, although the latter appear to have been less widely distributed. Direct percussion was used for detaching flakes, while indirect percussion was used for retouch. Flaked adzes, knives, and grinding slabs are not included until the early Holocene (Lu, 1998). As in southern Siberia, pottery was first introduced during the Late Epipalaeolithic and is associated with small tool/microlithic technology. Core typology appears to have been more diverse than in the Yellow River and North China Plain regions (Lu, 1998), which may be related to the use of less standardized core forms. Considering the late occurrence of microblade technology and the developed nature of its first appearance, it can be suggested that microblade technology diffused to Northeast China from neighbouring regions in the terminal Pleistocene.

Late Epipalaeolithic of Mongolia and Oasis 1 technology

Evidence of Late Epipalaeolithic occupation has been found throughout Mongolia, although chronological determinations have been based largely on typology rather than chronometric dating. As in Northeast China, there is a scarcity of Early Epipalaeolithic archaeological sites, but available dates indicate that Epipalaeolithic microblade core technology does pre-date developments farther east. The earliest dated post-LGM assemblage is from the Chikhen Agui cave site (13.4 to 8.7k cal yr BP [11,545 $\pm$ 75 to

7850 ± 100 BP]) (Derevianko et al., 2003). New radiocarbon dates on pottery also place the Shara KataWell site at the end of the Late Epipalaeolithic (9.6k cal yr BP, Table 3.1).

Other Mongolian Late Epipalaeolithic sites are recognized, but undated. Ostrich eggshell dates from Shabarakh-usu (Janz et al., 2009), Orok Nuur, Chilian Hotoga (Site 35), and Alkali Wells (Site 26) fall into the Late Epipalaeolithic, but ostrich eggshell dates are often problematic due to the use of sub-fossil shells. More probable Late Epipalaeolithic sites in Mongolia include Bygat-2 (possibly an early or transitional late Epipalaeolithic site, see Gladyshev, 1987), the lower levels of Dulaani gobi (Tseveendorj and Khosbayar, 1982), a slightly weathered artefact group from Ulan-khovor/Mandal Gobi (Govï) (Gábori, 1963; Kozłowski, 1972), Kerulen, Site 9 (Dorj, 1971: 29-30, 111), and Altan Bulag, Horizon I (Gábori, 1963).

Late Epipalaeolithic assemblages in Mongolia include highly developed microblade core technology based on a diverse array of core types, as evidenced by the Chikhen Agui assemblage (see Derevianko et al., 2003). Classic Epipalaeolithic wedge-shaped microblade cores typified by the Yubetsu (He Tao), Hutouliang (Saikai), and Togeshita (Yangyuan) techniques are not found in Late Epipalaeolithic assemblages, and wedge-shaped cores seem to conform more closely with the Yadegawa (Nodake) technique described by Seong (1998), where little specific platform preparation was conducted on the flat surface of the blanks. The technique employed might also be compared to that used in the manufacture of conical cores at Xiachuan. Notably, many of the Gobi Desert wedge-shaped cores are bifacially flaked on the opposite end of the flaking surface (or flute), allowing them to have been used as cutting tools (though many do not show clear evidence of usewear) (see Maringer, 1950; Morlan, 1976; Fairservis, 1993). The same technique is also evidenced at the probable Early Epipalaeolithic locality Dno Gobi, Sites 2 and 3 (Okladnikov, 1986), suggesting the long-term local utilization of both formally prepared wedge-shaped and flexible conical core reduction strategies in Gobi Desert assemblages.

The Shara KataWell site in the East Gobi yielded two cores, both of which are wedge-shaped. These specimens appear to have been made on flat cobbles of chalcedony with the exterior surface removed transversally from the sides and on the edges to create a rough D-shaped blank. Aside from the removal of short spalls, there was little or no platform preparation before microblades were detached from one end of the short axis. The technique bears similarities to the Togeshita (Yangyuan) technique reported from Hutouliang (Gai, 1984; Seong, 1998). Associated pottery (fibre-tempered with quartzite inclusions and light cord-marking) dates this site to about 9.5k cal yr BP. Reduction strategies and the more easterly locale of Shara KataWell may suggest technological influences from developed industries farther south.

Late Epipalaeolithic Mongolian assemblages are more typically characterized by smaller cores and less standardized platform preparation than other Northeast Asian Epipalaeolithic assemblages. Flexibility in manufacture appears to have been typical for later post-LGM Mongolian archaeological sites. The use of more flexible reduction strategies was probably aimed at exploiting a range of widely available, but differently shaped, raw material packages such as small cobbles of high quality stone characteristic of the Gobi Desert. The result is a wide diversity of core types. Such a situation is not unique, as assemblages in southern Siberia also seem to evidence a greater diversity of core forms by this time.

Finely retouched microblade tools also became common in the Late Epipalaeolithic. Microblades were not only used as inset blades in composite tools, but were retouched using indirect percussion to create multiple tools types. Assemblages recovered from Chikhen Agui Horizons 2 and 3 show that 26% and 18%, respectively, of all used and/or retouched flakes were made on microblades retouched using pressure-flaking techniques (Derevianko et al., 2003: Table 2). Microblades were retouched along one or more lateral edges or ends. Of the total artefacts from Horizon 2, unused microblades (< 10 mm wide) and bladelets (11-14 mm) made up 32% of the entire assemblage, while in underlying Horizon 3, unused microblades and bladelets made up 23% of the entire assemblage (Derevianko et al., 2003). While both layers indicate the regular use of microblades, the increased frequencies of both retouched and unretouched microblades in Horizon 2 underscores the growing importance of microblades within post-LGM tool kits. A greater reliance on microblade technology is in contrast to pre-LGM and Early Epipalaeolithic assemblages, which were based primarily on blade and large flake technology, including production from prepared Levallois-like cores.

Refinement of existing technological traditions and increasing reliance on microblade core reduction strategies at the end of the Mongolian Early Epipalaeolithic suggest continuity between those assemblages and the more widespread Late Epipalaeolithic sites. A refinement in existing methods of microblade core production is evident in Horizon I of Altan Bulag, in the Selenga River Basin of northern Mongolia (see Gábori, 1963: Planche III). A widespread pattern of increasing post-LGM microblade use, resulting in more efficient methods of manufacture, partially explains the technological similarities between Neolithic assemblages in the Gobi Desert and Lake Baikal region that have been widely noted in the literature on Mongolia and Northeast Asia (i.e., Gábori, 1963; Maringer, 1963; Chard, 1974). Due to the continuity of forest-steppe and river valleys south of the boreal forests between southern Siberia and Mongolia, a natural path of early expansion and later contact and trade may have existed between Siberia and northern Mongolia, possibly extending south across the open steppes and river valleys into the western Gobi Desert. Likewise, such contact between the more eastern parts of Mongolia and southern Siberia would explain similarities noted between those regions late in the Neolithic (Cybiktarov, 2002).

Summary of Late Epipalaeolithic developments and Gobi Desert Oasis 1

The term "Oasis 1" is used in this thesis to refer to the Late Epipalaeolithic. According to evidence from northwestern China, during this period dune fields began to be targeted as camp sites from which a range of ecozones could be exploited (Bettinger et al., 2007). Faunal remains consistently indicate the incorporation of medium- and small-bodied game, especially cervids. Although faunal assemblages are not as well studied in Northeast China, diversification of prey types seems to have been common across Northeast Asia as aquatic species and a wider range of mammalian fauna are recorded in many Late Epipalaeolithic sites. Evidence from Nanzhuangtou in northern China further suggests that wetland environments may have become important procurement locales during the Late Epipalaeolithic. Large game would have continued to be targeted and high residential mobility would have persisted. The persistent exploitation of larger game like equids in northern China is not surprising due to the relative prevalence of open steppe environments. It is proposed that the margins of sand dunes in proximity to upland regions were beginning to be important to foragers in arid northwest China at this time as they provided access to resources within both the dune-fields and sand-free piedmonts (Bettinger et al., 2007).

A similar pattern could be proposed for the Gobi Desert, based on environmental similarities. Possible Late Epipalaeolithic dune-field sites in basins or valleys include Shara Murun Crossing (Site 3) in the East Gobi, and in the Gobi-Altai Barongi Usu Valley, and Shabarakh-usu Site 2 components 2a and 2b (see Table 3.7). However, many Gobi Desert Oasis 1 sites were situated in high elevation environments, near springs or rivers (see Chapter 4). The lack of confirmed dune-field sites may be related to the difficulty in identifying and dating early aceramic sites, but might also represent a unique pattern of land-use focused on upland environments.

Based on the increased exploitation of cervids and fish in southern Siberia and the use of a more diverse array of small species in northern China, the Late Epipalaeolithic in Mongolia may also have been characterized by a reliance on medium- and small-bodied species. The grass seeds and a wealth of small-bodied animals at Chikhen Agui (though it is not clear if all the faunal remains can be associated with human activity), as well as the occasional use of pottery exemplified at Shara KataWell, may support such a model for the Gobi Desert. Unfortunately, comparative data for earlier sites is entirely lacking.

Technological trends during the Late Epipalaeolithic of Mongolia and the Gobi Desert are most consistent with those in southern Siberia and northwestern China. Microlithic tools, including retouched microblades, were more frequent than macrotools and were often shaped by pressure-flaking. Later Epipalaeolithic peoples tended to increasingly favour homogeneous cryptocrystalline stones (jasper and chalcedony were the most popular raw materials in the Gobi Desert) over coarser-grained materials such as siliceous sandstone, basalt and quartzites. By the end of the Late Epipalaeolithic, fibre-tempered cord-marked pottery had been incorporated into tool kits, though ceramics are still rare. Ostrich eggshell beads, which were also found in pre-LGM Northeast Asian sites, occur with increasing regularity during the Late Epipalaeolithic, including at Chikhen Agui, Yujiagou, Hutouliang, and other Nihewan Basin sites. Microblade core technology indicates a more varied and flexible approach to reduction strategies, frequently focused on prepared cores made from small nodules, and was organized around the exploitation of homogeneous raw materials producing reliable conchoidal fractures.

3.2.2.3. Neolithic/Oasis 2 (Early to Middle Neolithic) – 8.0 to 5.0k cal yr BP

The beginning of the Neolithic period in Northeast Asia, defined by widespread diversification of new lithic technologies, took place in the early Holocene. Approximately 8.0-5.0k cal yr BP is suggested as a broadly encompassing date for Oasis 2, or the early to middle Neolithic of Northeast Asia. The persistence of aceramic microlithic assemblages in the Gobi Desert has resulted in continued use of the term

"Mesolithic" for sites that are more closely allied to the broader trend in Neolithic technology, subsistence, and land-use. This includes specialized task sites outside of the base camps where ceramics were more commonly deposited. Due to our current reliance on relatively rare diagnostic technologies like pottery, grinding stones, and adze/axes, the introduction of a chronology able to distinguish the relative age of archaeological assemblages based on ubiquitous artefact types and specific elements of core reduction sequences is of central importance. Assigning known archaeological sites to a specific period is fundamental in identifying key shifts in land-use and patterns of resource exploitation.

Archaeological sites from the Neolithic are much more numerous across Northeast Asia and the comparative data are richer than for the preceding period. As outlined in Chapter 2, developments in subsistence and technology varied from region to region despite the general trend in diversification that sometimes included food production. Neolithic archaeological assemblages are more abundant in Mongolia than Epipalaeolithic sites. Many Neolithic sites are from the Gobi Desert and a dramatic increase in the number of sites may be related to increases in population density. Regional chronologies from the borderlands of northern China and southern Siberia will be used as a comparison, but primarily new radiocarbon dates from Gobi Desert sites will be used to identify local temporally diagnostic technologies.

Climate and subsistence

A period of high effective moisture associated with soil stabilization and higher vegetative biomass in arid environments took place in the early to middle Holocene and is known as the Holocene Climatic Optimum. Soil formation and the infilling of lakes are typical markers, but there is a great deal of regional diversity in both the timing of increased moisture and the environmental shifts that resulted. In the Gobi Desert, differences in the local dominance of circulation systems controlled temporal variability in Holocene climatic amelioration. Optimally moist conditions occurred variously between about 9.0 and 4.5k cal yr BP (Tarasov et al., 2000; Mischke et al., 2005; Jiang et al., 2006; Herzschuh, 2006; Rudaya et al., 2008). A widespread decline in precipitation and expansion of permafrost are evidence of climatic degradation that occurred across Northeast Asia between 5.8 and 4.5k cal yr BP (Starkel, 1998). All regions appear to have been effected by an overall decrease in effective moisture after ca. 3.0k cal yr BP (Herzschuh, 2006).

The Neolithic tends to be typified by the adoption of domesticated plant and animal species, and sedentary agricultural communities did emerge in North China and parts of Northeast China at this time. However, despite the prominent role of these new agricultural economies in studies of the Neolithic they are not typical in much of Northeast Asia. Hunter-gatherer groups continued to focus on wild resources. At the same time, the emergence or spread of new technologies like grinding stones, pottery, and specialized fishing gear often do suggest intensified exploitation of certain foods.

In the Lake Baikal region, hunter-gatherer economic strategies persisted into the Bronze Age and aside from dogs (Bazaliiskiy and Savelyev, 2003; Losey et al., 2011), plant and animal domesticates were not a regular component of economic strategies. One exception is the Sagan-Zaba site on the west coast of Lake Baikal, spanning the Mesolithic to Bronze Age, which is recorded as containing “frequent” remains of horse and sheep or goat (Weber et al., 1998). Fishing technology (composite fishing tools and harpoons) suggests the increasing importance of aquatic resources, while stable isotope studies indicate that ungulate meat continued to be of key importance in the diet throughout the Neolithic and Eneolithic (Weber et al., 1998; Weber and Bettinger, 2010). Faunal remains from sites in the Yenisei River region included red deer, Siberian goat and sheep, and molluscs (Vasil’ev and Semenov, 1993). Southern Siberia is typified by hunter-gatherer-fisher cultures. Domesticated species do not typically appear until about 5.5k cal yr BP in the Yenisei region and even later in the Lake Baikal region.

The Neolithic of Northeast Asia is best known by developments in the Central Plains and Yellow River Basin. Faunal remains from Nanzhuangtou suggest that domesticated animals may have already been adopted in some areas by the early Holocene. Bones of domesticated dog, pig, cow and possibly chicken from Peiligang culture sites (8.5-7.5k cal yr BP) attest to the role of animal husbandry in Early Neolithic economies (Underhill and Habu, 2006; Lu, 1999). The importance of millet agriculture during the Neolithic is evidenced by large scale storage of millet (*Panicum miliaceum*) dating to between 10.3-8.7k cal yr BP at Cishan in the North China Plain, provisioning of animals at Dadiwan by 7.9-7.2k cal yr BP, and indications of “slash-and-burn” cultivation beginning around 7.7 ka (Li et al., 2009; Lu et al., 2009; Barton et al., 2010). At the same time, a diverse array of floral and faunal remains from Cishan[13] and the slightly later Peiligang site indicates that hunted and gathered resources were still an important part of subsistence. By 5.0k cal yr BP, domesticated dogs, pigs, cows and sheep were all a part of many local agricultural economies, alongside cultivated millet, rice, soybeans and hemp (Crawford et al., 2005; Lee et al., 2007; Li et al., 2009).

Sedentism and cultivation also became common in Northeast China during the Early Neolithic, but such agricultural sites are mainly distributed over the alluvial plains of southern Northeast China and parts of Inner Mongolia. The earliest of these sites are Xinglongwa and Chahai, dated respectively to 8.1 and 7.8k cal yr BP (7240 $\pm$ 95 BP, 6925 $\pm$ 95 BP) (Guo, 1995a). No evidence of domesticated plants was recovered from these sites, but the site structure and tool kits indicate a reliance on cultivation and plant foods in conjunction with hunting (Guo, 1995a). Better evidence for millet domestication comes from Xinle I (Lowe Xinle), where village settlements in the Lower Liao River area were dated to 7.5-7.0k cal yr BP (6620 $\pm$ 150 to 6145 $\pm$ 120) (Jia, 2007). By the time of the Hongshan culture group at about 6.0-5.0 kya, agriculture included domesticated millet and pigs (Guo, 1995a). Faunal remains from Yaojingzi in Jilin Province (5.5k cal yr BP [4726 $\pm$ 79 BP]) included cattle, horse, and dog, and are taken as evidence of animal

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[13] Faunal remains from Cishan included *Ctenopharyngodon idellus* (grass carp), *Lamportula* sp. (mollusc), *Cuora* sp. (Asian box turtle; originally described in the literature as Emydidae, recent changes in taxonomy indicate that the genus of the animal referred to is probably *Cuora*), *Macaca mulatta* (rhesus monkey), *Meles meles* (badger), *Paguma larvata* (masked palm civet), *Panthera pardus* (leopard), *Sus scrofa* (wild boar), *Anser jabalis* (bean goose), *Gallus gallus* (fowl, possibly domesticated chicken), and several species of cervids (Lu, 1999). Plant remains included *Juglans regia* (common walnut), *Geetis bunseana* (hackberry seeds? – from Lu, 1999: 36, taxonomic designations are confused), and *Corylus leterapluylea* (hazelnut) (Lu, 1999).

husbandry (Liu, 1995). Highly ritualized behaviour is noted for this period. Many hunter-gatherer sites are still associated with the Neolithic period in Northeast China and are distributed primarily in the northernmost part of the region and on the steppe to the east of the Daxing'anling (Da Khinggan) mountains (Lu, 1998). The Xinkailiu site in Heilongjiang Province (6.2k cal yr BP [5430 $\pm$ 90 BP]) was associated with lake environments; fish storage pits and fishing tools, in conjunction with evidence of hunting, indicate a heavy reliance on fishing (Tan et al., 1995a; Lu, 1998).

The emergence of sedentary agricultural communities represents an important divergence from mobile hunter-gatherer subsistence economies, but dedicated hunter-gatherers were most common across Northeast Asia. Fishing, hunting, and gathering appear to have remained important throughout the Neolithic, with varying degrees of economic utility (Lu, 1998). No evidence of domesticated species has been recovered from Gobi Desert sites, though this may be due to poor preservation. The use of grinding stones and pottery has been cited as possible evidence for cultivation (see Chapter 2), but might also be related to the intensified processing of certain wild foods.

Neolithic technology in Northeast Asia

Although certain tool types associated with the Neolithic were used much earlier in some areas of Northeast Asia (see Chapter 2), it was not until about 9.0-8.0k cal yr BP that the use of pottery, polished stone, grinding stones, and bifacial flake technology became widespread. Regional differences in subsistence economies are notable during the Early

Neolithic and technological trajectories also begin to diverge more clearly during this time. Microblade technology continued to be important among hunter-gatherer groups, but was less dominant in the tool kits of sedentary agriculturalists.

Comparisons have been made most often between assemblages from Gobi Desert and the Lake Baikal region (Maringer, 1950; Okladnikov, 1962). Unfortunately, there are few studies of lithic chronology in the Lake Baikal region (see Weber, 1995). The stratified Ulan-Khada site provides some of the best data for building such a chronology and spans the terminal Late Epipalaeolithic to Eneolithic. The earliest dates on pottery from the Lake Baikal region come from this site and are dated to 8.5k cal yr BP (Kuzmin and Orlova, 2000). The “net-impressed” pottery is associated with small bifacial projectile points with straight bases, and new forms of composite fish hook shanks. “Pseudo wedge-shaped” and prismatic microblade cores, along with endscrapers on spalls, retouched microblades, and burins on microblades were found in all levels of the site. Polished stone appears earliest in the form of slate shanks for composite fishhooks and an adze, but is more common in younger layers (Goriunova and Khlobystin, 1991; Kuzmin and Orlova, 2000; Weber, 1995). By 5.0k cal yr BP, arrowshaft straighteners, bifacial knives and polished nephrite (jade) adze/axes were also present in the tool kit, along with a diversity of pottery types.

Due to a lack of information on lithic assemblages, ceramics have been considered the best markers to distinguish between the earlier Kitoi (8.8-6.9k cal yr BP) and the later Serovo/Glazkovo (6.2-3.0k cal yr BP). Early Kitoi pottery includes oval and mitre-shaped vessels with net impressions and later designs include cord-impressions near or below the rim and/or various incised lines forming geometric motifs. Serovo-Glazkovo period pottery exhibits greater variation in pottery styles, including: Ust'-Belaya, typified by simple oval pots with stab-and-drag and sometimes comb impressions; Posol'sk, typified by thick and straight-walled vessels with appliqué about 1-1.5 cm from the rim, featuring dentate impressions, stab-and-drag type lines, and often a series of small holes located above the appliqué; smooth-walled; cord-impressed decorations; and hatched decorations (Weber, 1995; McKenzie, 2009).

The Upper and Central Yenisei River region to the west of Lake Baikal is another area of cultural developments highly relevant to this discussion, though much less well understood. Neolithic components from stratified sites like Maina indicate the importance of microblade technology and include "double-platform," prismatic, and flat (or tabular) microblade cores (Vasil'ev and Semenov, 1993). Bifacial microlithic points are triangular with a concave base or a lateral notch, and there are also rhomboid and oval pieces. Bifacially flaked blades are interpreted as inserts for composite tools and are similar to Early Neolithic specimens from the Gobi Desert (see below). The Maina assemblage also included retouched microblades, burins, wedge-like tools, endscrapers, sidescrapers, retouched flakes, notched and denticulated pieces, and pebble tools (Vasil'ev and Semenov, 1993). The tool kit is consistent with other aceramic Neolithic archaeological sites in the region, including Ui II, Ust'-Khemchik 3, and Toora-Dash. Differences in assemblages included the occurrence at Ui II of a roughly flaked axe, wedge-shaped microblade cores, knives, and grinding stones. Triangular bifacial points with straight bases and conical microblade cores were found at Ust'-Khemchik 3.

Distinct artefact types from Toora-Dash include bifacial inserts on elongated flakes (lunate, rectangle, and trapeze shapes), arrowheads with concave bases, knives, and an antler adze.

Despite the absence of pottery at Early Neolithic sites in the Upper Yenisei River area, in the Central Yenisei region pottery appeared first near the beginning of the Early Neolithic (8.1-7.4k cal yr BP [7330 $\pm$ 35 BP, 6530 $\pm$ 60 BP]) (Kuzmin and Orlova, 2000). Pottery is thin-walled and tempered with sand and gravel. Rim fragments feature serrated impressions and a "belt of small pinholes" are often found on the upper side of the rim. "Back-stepped blade impressions" encircle vessels below the rim, with perpendicular lines coming from the lowest horizontal lines. These patterns have been compared to Posol'sk ceramics from the Lake Baikal region (McKenzie, 2009). Slightly later ceramics from various sites are more diverse and decorations include net impressions, cord impressions, oval stamps, horizontal rows of small oval serrated depressions, crescent impressions, zig-zag stamps, and punctate-comb zig-zag decorations (McKenzie, 2009). Later sites are extremely diverse and isolation of cultural complexes based on ceramics is problematic.

In northern China, regional tool kits reflect divergences in economic strategies represented by agriculturalists and hunter-gatherers. Microblade and flake technology are completely absent at Cishan, while chipped and/or polished axes comprise over 56% of the lithic assemblage (Lu, 1999). Spades are also common, along with grinding slabs/querns, rollers, hammers, chisels and anvils. Tools made from bone, antler, animal tooth, and shell are also present and include knives, chisels, drills, net shuttles, spades, needles, various ornaments, arrowheads for hunting, and harpoons for fishing. Simply shaped sand-tempered pottery vessels are typical. Most are roughly made, but finer vessels are also found. Tripod stands were used. Cord marking, comb impressions, and narrow bands of relief were common finishes (Lu, 1999). A similar lithic assemblage was found at Peiligang, but fully polished axes and spades are more common and there are lower frequencies of bone and antler tools. Quartzite and chert flake scrapers and points were also used (Lu, 1999). Microblade tools were used at Yujiagou, in the Nihewan Basin, as late as 2.1 ka, although frequencies declined steadily after about 11.6 ka (Xia et al., 2001). Neoliths (polished stone tools? – see Xia et al., 2001) appeared at about 8.7 ka and were most common between 6.6 and 2.1 ka. At Dadiwan, in northwestern China, microlithic technology was used by early millet-using hunter-gatherers, but is rare in later Neolithic agricultural sites (Bettinger et al., 2010b).

Similarly, microblades declined in quantity and variety throughout agricultural regions of Northeast China while polished stone and organic tools became more important (Lu, 1998). Lithic assemblages associated with sedentary communities are characterized by chipped and/or polished macrotools like hoes, spades, adze/axes, and grinding stones (querns and rollers), although microblades were used in composite tools (Guo, 1995a; Lu, 1998; Jia, 2007). Later Neolithic site groups like Zhaobaogou (6150 $\pm$ 85, 5980 $\pm$ 85), Lower Houwa (5600 $\pm$ 100 BP), and Fuhegoumen (4735 $\pm$ 100 BP) contain highly variable frequencies of microblades, but all indicate declining reliance on microblade technology (Guo, 1995a; Xu, 1995; Lu, 1998). Pottery was still handmade and sand-tempered pottery, but features a greater variety of surface designs. Cylindrical pots are the most common vessel type in both agricultural and hunter-gatherer sites (Guo, 1995a).

Groups more reliant on hunting and gathering focused more heavily on microblade technology (Lu, 1998). Although flake tools are much more common, microblades are numerous at such sites, and both boat-shaped and conical cores are recovered. Pressure flaking was heavily used for retouch and in the manufacture of arrowheads and spearheads made on flakes. Bone and antler tools are often found at Early Neolithic sites (Lu, 1998).

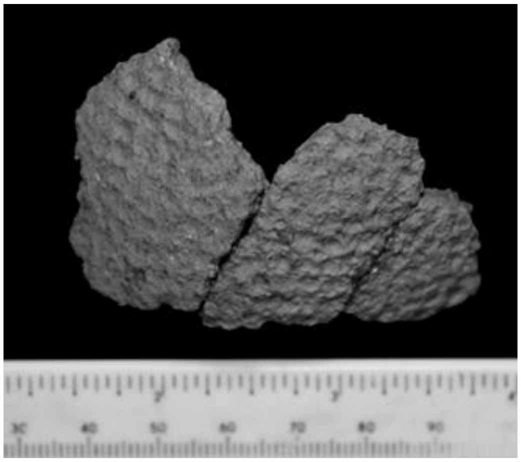
There are several key Neolithic hunter-gatherer sites in Northeast Asia. The terminal Epipalaeolithic or Early Neolithic assemblage from Tengjiagang in Heilongjiang Province (8.4k cal yr BP [7570 ± 85]) contains pottery, stone, bone and antler tools (Lu, 1998). Bone and antler tools make up about 30% of this assemblage. The Ang'angxi (Ang-ang-hsi) site group on the Song Nen Plain is closely allied with Gobi Desert assemblages. Located in a group of four sand dunes south of Wufu Station, the lithic assemblage is characterized by a diversity of unifacial points, large and small bifacial points, microblades for composite tools, scrapers and bifacial knives on blades (Chard, 1974: 106-107 [Figure 2.46]; Tan et al., 1995a: 132-135 [Figure 4.6]). Bone spearheads and knife blades were also found, and bone harpoons attest to the importance of fishing. High-fired pottery tempered with fine sand and some shell was mostly in the form of cylindrical vessels and was decorated with irregular shapes, incised lines, stab and drag lines, and fingernail marks (Tan et al., 1995a). At Xinkailiu, Heilongjiang Province (6.2k cal yr BP [5430 ± 90 BP]), tool kits and faunal remains indicate a heavy reliance on both fishing and hunting (Tan et al., 1995a; Lu, 1998). Small flake and microblade tools are most common and associated with polished axes, chisels, and grinding stones. Bifacially flaked projectile points are common and varied in character (Tan et al., 1995a).

Neolithic of the Gobi Desert and Oasis 2 technology

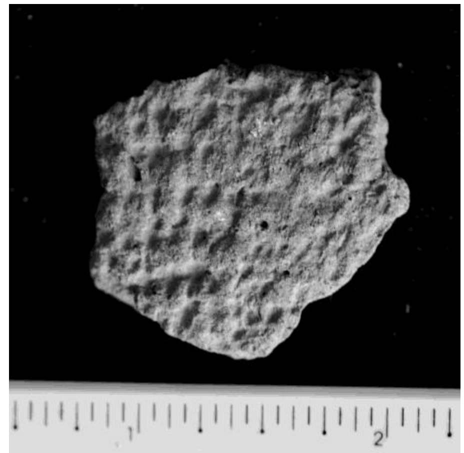
Prior to this study, there were no chronometric dates for the Early Neolithic of the Gobi Desert. Five archaeological assemblages are now dated to between 8.0-5.0k cal yr BP and assigned to the Neolithic or Oasis 2 (Table 3.1). All are from the Gobi Desert and include: Chilian Hotoga, Site 35 (7.6k cal yr BP [6728 $\pm$ 45 BP]), components of Baron Shabaka Well, Site 19 (6.8 and 6.4k cal yr BP [5954 $\pm$ 52 BP, 5609 $\pm$ 47 BP]) in the East Gobi; Ulan Nor Plain (5.8k cal yr BP [5116 $\pm$ 41 BP, 5061 $\pm$ 49 BP]) in the Gobi-Altai; and components of both Yingen-khuduk (5610 $\pm$ 370 ka), and Mantissar 12 (6460 $\pm$ 700 ka) in the Alashan Gobi.

The majority of Oasis 2 sites appear to have been longer term habitation sites with hearths. As at other Northeast Asian sites from this period, there are substantial additions to existing technology, including pottery, grinding stones, polished stone tools, and a proliferation of pressure-flaked points and bifaces. Most habitation sites contain pottery and chipped or lightly polished adze/axes. East Gobi sites are characterized by the use of large, formally-made grinding stones, but these artefacts are rare in more western Gobi Desert sites. Finely made points, presumably used as arrowheads, were found in all sites, including unifacially flaked microblade points from Chikhen Agui. Aside from the presence of small unifacial points at Chikhen Agui, Horizon 1 is relatively consistent with underlying horizons, although it may date to the early stages of Oasis 2 (after 8.7k cal yr BP) (Derevianko et al., 2008). This may be related to the task-specific nature of the site, but the impression of coherency could also result from a lack of stratigraphic integrity.

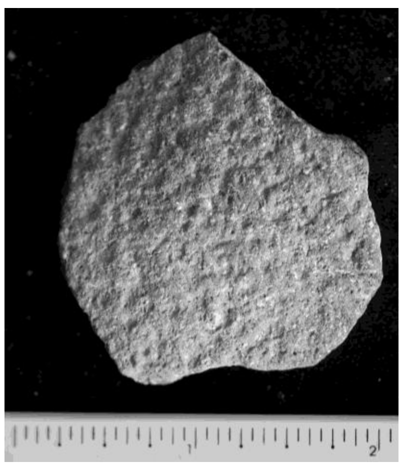
One difficulty in reconstructing an artefact-based chronology for Oasis 2 assemblages from museums is that Oasis 2 and Oasis 3 sites were often recovered from the same locality and collected as one group. Baron Shabaka Well, Yingen-khuduk, and Mantissar 12 all contain artefacts directly dated to both periods. The Chilian Hotoga and Ulan Nor Plain sites are more likely to represent coherent Oasis 2 assemblages (see Appendix B). Although historic pottery was included in the Ulan Nor Plain assemblage, this is not evidence of post-depositional intermingling of sediments, but rather a result of the collection by Nelson and Pond of artefacts scattered across the dune surface (Nelson, 1925; Pond, 1928, n.d.). It is common for the AMNH collections to include such artefacts (personal observation, August 2009).



a.



b.



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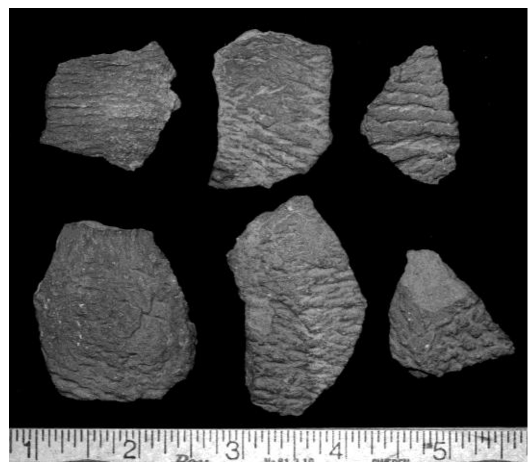


d.

Figure 3.4 Dated Oasis 2 pottery: a. “net-impressed” pottery from Yingen-khuduk, 5.6 ka; b. “net-impressed” pottery from Baron Shabaka, 6.4k cal yr BP; c. textile-impressed pottery from Chilian Hotoga, 7.6k cal yr BP; cord-impressed pottery from Mantissar 12, 6.5 ka.

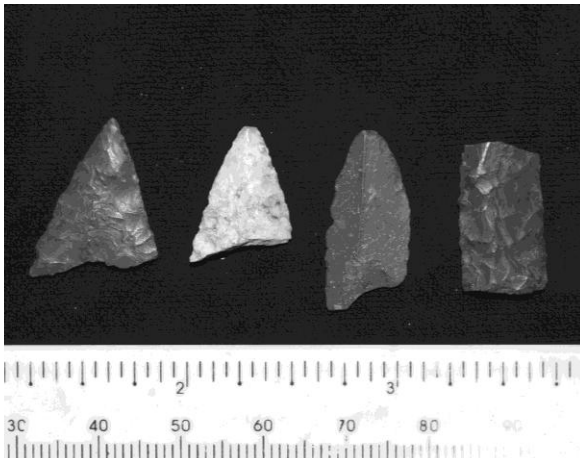
Dated decorated pottery shards are the best diagnostic artefact type. Samples from Yingen-khuduk (5.3-6.0 ka; UW2357, #K.13212: 123) and Baron Shabaka (6.4k cal yr BP; AA89885, #73/2229A) both bear a distinctive "net-impressed" surface design that can be considered characteristic of Oasis 2 (Figure 3.4a, b). Chilian Hotoga textile-impressed pottery, dated to 7.6k cal yr BP, is a coarse sand- and organic-tempered grey-ware blackened on the interior surface (Figure 3.4c). Oasis 2 pottery is typified by the use of heavy sand temper, thick walls, and a low-fired paste. The interior paste of most samples is blackened, which is typical of low-fired pottery with high organic content. The shard from Yingen-khuduk is exceptional in that the interior paste is not blackened. This is probably due to the fact that it was only tempered with sand rather than additional organics; the clay that was used might also have been less rich in organic matter. The lack of organic temper in Alashan Gobi pottery is typical of all periods. Some of the spongy-textured grey-ware from the East Gobi may also date to this early period (Figure 3.9). Pottery use became more common during Oasis 2 and is typified by "net-impressed," corded, or textile impressed low-fired grey or brown-ware.

Additional diagnostic artefacts can be recognized from sites that have been chronometrically dated or that contain pottery typical of Oasis 2. Unifacially retouched points made on microblades are found in several Neolithic sites in Northeast Asia and can be considered diagnostic of early Oasis 2 (Table 3.4). They are similar to some examples of perforators on microblades, but retouch on perforators is more localized on the distal end. Retouch on small unifacial points is more consistently executed and less steep than with the production of other microblade tools. Such artefacts were found in East Gobi sites and Horizon 1 of Chikhen Agui. According to the youngest accepted dates from Horizon 2 (8.7k cal yr BP; see Derevianko et al., 2008), Horizon 1 should post-date 8.7k cal yr BP (Derevianko et al., 2008). Such points are also found at Chilian Hotoga and Baron Shabaka, dating to 7.6k cal yr BP and 6.8k cal yr BP respectively. According to illustrations of typical assemblage artefact types, similar points were recovered in the Lower Liao River region of Northeast China from Xinle I (Lower Xinle) (7.5-7.0k cal yr BP [6620 ± 150 to 6145 ± 120]) and the similarly aged Zuojiashan I (Yaojingzi and Yuanbaogou) in the Changchun (Ji-Chang/Jilin-Chang) region of central Northeast China (Jia, 2007: 74-75, 125). Additional undated Neolithic sites also contain such points, including Haila'er and Ang'angxi (Chard, 1974: Figure 2.46). Based on the absence of unifacial points in later dated archaeological sites, it is reasonable to suggest that they are temporally constrained to approximately 8.0-6.5k cal yr BP.

Assemblages from eastern Mongolia collected by Mongolian and Soviet archaeologists also indicate the widespread use of unifacial points in the eastern regions. Examples of such finds include surface assemblages from Dornogovi aimag (or Eastern Gobi province) (Dorj, 1971: 170), surface assemblages from Sükhbaatar aimag (Dorj, 1971: 156), the Khutyn-bulag (Хуйтэн-Булаг) lake site (Dorj, 1971: 39-40, 136), and at Locale 9 (Стоянка 9) (including shouldered points) (Dorj, 1971: 29-30; 111). Based on Dorj's (1971) descriptions and illustrations, such sites probably date to about 8.0-6.5 kya. The upper layers of Dulaani Gobi (Дулааны Гобь), Dornogovi aimag, contained both unifacial and bifacial points and may be attributed to about 7.5-6.5 kya (see Tseveendorj and Khosbayar, 1982). I suggest that Munkh-tolgoi (Мунх-толгой) also dates to about

7.5-6.5 kya (Dorj, 1971: 30-31, 112-113). The Ovoot (Овоот) assemblage, excavated from a sand deposit on the Kerulen River near Ovoot Mountains, contains pottery, bone harpoons, and composite hafts. Based on the frequency of retouched microblades and the early forms of pressure and rough bifacial flaking on macrotools, the site probably dates to the Epipalaeolithic-to-Neolithic transition (Dorj, 1971: 33-36, 119-125).

In the East Gobi, unifacial micropoints were recovered at Jira Galuntu (Site 18) (Figure 3.5b, c), Baron Shabaka Well (Site 19), and Baron Shabaka South (Site 21) (Figure 3.5d). Chilian Hotoga (Site 35) also contained a retouched microblade that was probably used as a hafted projectile, but it is associated with bifacial flake points and is not finely finished (Figure 3.5a). Some unifacial points from Jira Galuntu were shouldered (Figure 3.5b), which is also observed in Zuojiashan I assemblage unifacial points (Jia, 2007: 125). Similar artefacts are depicted for Lake Baikal (Trans-Baikal) region sites (Chard 1974: 86 [Figure 2.27]). Shouldered points are a distinctive trait of the Early Neolithic in southern Siberian, including the Maina site, attributed to the early Holocene climatic optimum (Vasil'ev and Semenov, 1993: Figure 3). The presence of unifacial points at Chikhen Agui indicates that the technology was distributed across the Gobi Desert region, although possibly more common in Eastern Mongolia and Northeast China (Table 3.4).



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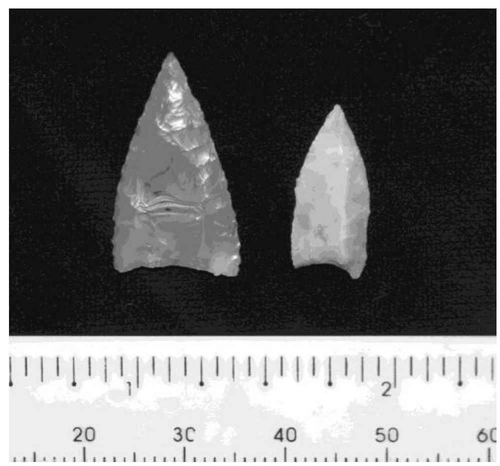

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Figure 3.5 Unifacial and bifacial points from Oasis 2 sites: a. Chilian Hotoga, bifaces and uniface (second from right); b. Jira Galuntu, unifacially retouched shouldered microblade points; c. Jira Galuntu, unifacially retouched flakes and microblade segment (middle); d. Baron Shabaka South, bifacial and unifacial points.

Region	Site Name	Chronometric dates	Unifacial points	Bifacial points	Shouldered points
East Gobi	Baron Shabaka	6.8, 6.4 kya	yes	yes	no
	Baron Shabaka South	N/A	yes	yes	no
	Chilian Hotoga	7.6 kya	yes	yes	no
	Jira Galuntu	N/A	yes	yes	yes
	Dulaani gobi, upper layers	N/A	yes	yes	N/A
	Dornogovi aimag (surface)	N/A	yes	yes	N/A
Gobi-Altai	Chikhen Agui	After 8.7 kya	yes	no	no
East Mongolia	Sükhbaatar aimag (surface)	N/A	yes	yes	N/A
	Khutyn-bulag	N/A	yes	yes	N/A
	Locale 9	N/A	yes	no	yes
	Munkh-tolgoi	N/A	yes	yes	N/A
Northeast China	Xinle I	7.5-7.0 kya	yes	N/A	N/A
	Zuojiashan I	N/A	yes	N/A	yes
	Haila'er	N/A	yes	yes	N/A
	Ang'anxi	N/A	yes	yes	N/A

Table 3.4 Summary of sites containing small unifacial points in the Gobi Desert, East Mongolia, and Northeast China.

The method of manufacturing of small bifacial points may have been derived from techniques used to retouch microblades, particularly the manufacture of unificial points. Narrow bodied bifacially flaked points have been found associated with unifacial points at Jira Galuntu, Baron Shabaka Well, Baron Shabaka South (Figure 3.5d) and Chilian Hotoga, possibly indicating that bifacial points were derived from experiments in forming points from minimally retouched blades and flakes. Bifacial points from Baron Shabaka South appear to have a slightly concave base and occasional light fluting (see Figure 3.5d). Small bifacial blades are probably contemporaneous with bifacial points, both having been recovered from the Chilian Hotoga Well site (Figure 3.5a). Bifacially flaked points and blade-like pieces were recovered from the upper levels of Maina in the

Upper Yensei region (Vasil'ev and Semenov, 1993: Figure 3). This assemblage was excavated from a "buried double soil" that was ascribed to the optimal early Holocene phase. Small bifacial points date to as early as 8.5k cal yr BP in the Lake Baikal region, but the use of bifacial techniques for the manufacture of both points, blades and knives was more widespread in this region of southern Siberia sometime after 7.2k cal yr BP (6310 ± 70; see Kuzmin and Orlova, 2000; Weber, 1995). According to data from the Chilian Hotoga Well assemblage, bifacial pressure-flaking appears to have been used in the Gobi Desert by at least 7.6 kya.

Dated Oasis 2 assemblages, along with the Jira Galuntu and Baron Shabaka South sites, are detailed in Appendix B. These site assemblages indicate a number of characteristics that distinguish them from the Late Epipalaeolithic/Oasis 1. Formal grinding stones are one of the most notable technological developments in this period, particularly in the East Gobi, and are consistent with similar technologies in northern China. Likewise, partially polished stone adze/axes are found in East Gobi sites.

As discussed above, unifacial blade and bifacial flake points are a hallmark of the Early Neolithic across the Gobi Desert and eastern Mongolia. Pressure-flaked microtools are a hallmark of the Mongolian Neolithic and can be used to distinguish Neolithic from Epipalaeolithic sites. A range of bifacial flaking techniques was employed in the manufacture of microblade cores, chipped macrotools like adzes and axes, and fine bifacially pressure-flaked points, blades, and knives. Small chipped adzes are also representative of Oasis 2 and were often made on high quality cryptocrystalline stones (Figure 3.6). Semi-lunar knives originate during Oasis 2, as evidenced at Baron Shabaka

Well and Ulan Nor Plain. Bifacial flaking was also used in the preparation of wedge-shaped microblade cores, which are characterized by a knife-like edge opposite the flaking face.

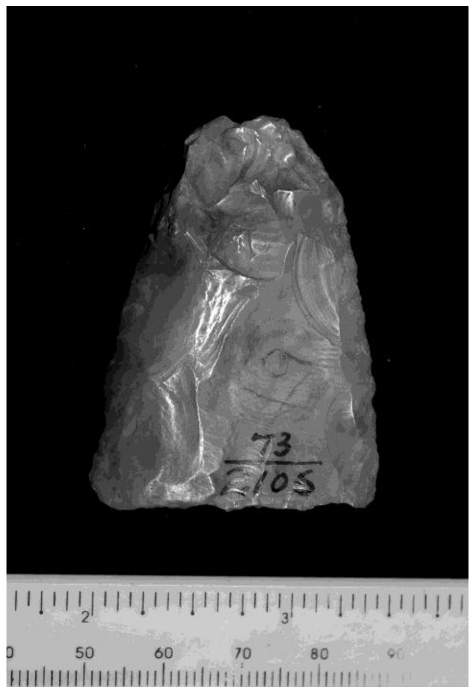


Figure 3.6 Small chipped adze from Baron Shabaka Well, on high quality jasper.

Microblade core manufacture during Oasis 2 continues to be characterized by flexibility and a number of cores forms are recognized. Many microblade cores do not fall into distinctive shapes and were classified during data collection as “unknown” or “informal”. More carefully executed and heavily reduced cores are less common, but generally fall into three categories: wedge-shaped, conical, and cylindrical. Conical and cylindrical types sometimes have a wedge-shaped back, which would have facilitated core reduction if used to grip the core in a vice. A wedge-shaped back might also have been useful as a multipurpose tool. The Epipalaeolithic layers at Chikhen Agui contain well-made and heavily used microblade cores, though they tend to be blockier and squatter than the slender cylindrical and conical cores typical of later periods.

Numerous test pieces from the Ulan Nor Plain site help to construct the primary method of microblade core preparation at the site (see Figure 3.12). A platform was first prepared on a small, roughly oval cobble by removing one narrow end. A rough wedge or U-shape was then formed by transverse or sometimes longitudinal chipping from the edges or platform. Microblades were sometimes struck from one of the wide, flat faces of the core, but more often from one narrow edge, progressing around onto the adjacent sides. The narrow edge was sometimes bifacially prepared, as evidenced by test pieces and numerous “keel flakes.” The exact method of core preparation appears to have been primarily determined by the shape, cortical structure, and striking quality of the raw material. Simple elongated flakes were also struck from cores prepared in this way. The edge opposite the surface of microblade removals was often bifacially flaked into a knife-like edge, which was probably related the process of core reduction (Flenniken, 1987; Tabarev, 1997), but could also have been used as a tool (Morlan, 1976).

The most heavily reduced cores generally tended to take a conical or cylindrical form (the latter was usually formed by the use of two opposing striking platforms). There are many examples of intermediate specimens discarded at the transition from wedge-shaped to small conical core. Other heavily reduced cores retained the wedge-shaped back at discard and were most heavily reduced from the narrow face. Flexibility of core form throughout the artefact's use life indicates a variability in core reduction strategies that was probably partially controlled by the original nodule shape and size. The lack of formal core preparation prior to microblade removal probably contributed to different choices during the reduction sequence based on variation in the location and nature of remaining cortical surfaces and evolving core shape.

Other significant core types include expedient cores, biface cores, and informal blade/bladelet/elongated flake cores. Some cores are also classified as "core tools" and these are informal, amorphous cores with evidence of use and/or retouch and numerous flake removal scars that do not intentionally contribute to overall core morphology. Expedient cores are amorphous cores with numerous flake removal scars and no distinct platform. Biface cores are also found in Oasis 2 sites and are typically thick bifaces covered in rounded, rather than elongate, flake scars. They are often U-shaped. When evidence of use and/or retouch suggests that the cores were used as tools, they are classified as "biface core tools". Biface cores and biface core tools are less common than microblade cores. The category of "informal blade/bladelet/elongated flake cores" is used to classify cores with a roughly prepared platform, and elongate flake scars, indicating the removal of elongate flakes wider than microblades. Such cores are present in the majority of Gobi Desert assemblages, including those from Epipalaeolithic sites.

Near the end of Oasis 2 the use of high quality jaspers probably became more widespread. As exemplified at Chikhen Agui, raw materials were locally obtained in the Late Epipalaeolithic. More selective use of various high quality cryptocrystalline stones in the manufacture of unifacial and bifacial points, bifacial knives and some heavily reduced microblade cores suggests that high quality raw materials were procured for the production of certain tool types, even if they were not local. Since knowledge of raw material sources is scanty, it is currently not possible to define "local" and "exotic" (but see Kulik et al., 2006 for the Gobi-Altai region). Petrographic studies of lithic assemblages and raw material sources would greatly improve our knowledge of land-use and possibility of trade-routes from source locales like the Arts Bogd-Ulan Nor Plain and the Ukh-tokhoi/Khara Dzag plateaux regions.

Summary of Neolithic developments and Gobi Desert Oasis 2

One of the most commonly cited inferences about Neolithic Gobi Desert peoples is that they were engaged in some form of incipient agriculture during the middle Holocene (e.g. Cybiktarov, 2002). Although the dates of millet domestication in Northeast Asia make it possible that Gobi Desert people were familiar with such developments, the contents of Gobi Desert archaeological assemblages do not support the conclusion that Gobi Desert peoples were agriculturalists. In the western Gobi Desert, grinding stones are rare in both Oasis 2 and Oasis 3 assemblages. More extensive use of grinding stones in the East Gobi is suggestive, but aside from one possible "hoe-like tool" at Baron Shabaka Well there is little evidence of the digging and sowing tools, or storage facilities characteristic in North and Northeast China agricultural sites. Evidence of permanent settlements, subterranean houses, and the small villages typical of early sedentary agriculturalists is likewise missing. Hunter-gatherers may have heavily exploited wild grass seeds and/or tubers in the dune field/wetland environments where grinding stones are found. They might also have aided in the abundance of seasonal resources by scattering seed. But there is currently no convincing evidence of full-fledged agricultural endeavours in the Gobi Desert proper.

Likewise, there is little of evidence for domesticated animals during the Mongolian Neolithic; however, domesticated dogs were probably widespread amongst hunter-gatherers in Northeast Asia by the beginning of the Neolithic and it is possible that they were used by hunter-gatherers in Mongolia. Other domesticated species like pigs, cows, and sheep were all present in the Early Neolithic of North China. Chickens may also have been kept. Pigs and chickens are not adapted to high residential mobility and are unlikely to have been adopted by Gobi Desert groups. The Tamsagbulag site in eastern Mongolia is thought to represent an economy reliant on hunting, fishing, gathering, but complemented by millet cultivation and cattle husbandry as early as 6.5 kya (Derevianko and Dorj, 1992; Séfériadès, 2006). Both the dates and evidence for domestication are provisional and must be investigated further. Middle Holocene plant and animal domestication in eastern Mongolia would suggest continuity with contemporaneous economic developments in neighbouring Northeast China.

Tools characteristic of Oasis 2 are summarized in Table 3.6 and include large formal grinding stones, polished stone, chipped and/or partially polished adze/axes, pressure-flaked unifacial microblade points, and a variety of bifacial tools such as small pressure-flaked points, knives and blades. Microblade cores include wedge-shaped, conical, and cylindrical types. Biface cores are also typical of Oasis 2. While expedient flake cores and amorphous flakes were found in Oasis 2 assemblages, many tools were still based on microblades. The most notable exception is the production of microlithic endscrapers, which were often made on thick semi-circular flakes or microblade core platform reduction spalls (i.e., thumbnail scrapers). Bifacial preparation on flakes and microblades was also important. By the end of Oasis 2, lithic assemblages were typified by microblade cores, tools on microblades, and a range of bifacially flaked tools manufactured on high quality cryptocrystalline stone. Pottery use was more widespread than during Oasis 1 and was characterized by the use of low-fired brown-wares with simple surface treatments (Table 3.5).

The environmental distribution of Gobi Desert sites is discussed in more detail in Chapter 4; however, all dated Oasis 2 sites are associated with dune-field environments near streams or former lakes. According to site distribution and the proliferation of grinding technology and pottery, it is probable that Oasis 2 represents the first intensive use of dune-field resources. Faunal remains from Chilian Hotoga indicate the utilization of a range of resources that included both small- and large-bodied animals, dune-field/wetland (e.g., bird, frog), and steppic species (e.g., equids). Gazelle remains are common in many sites from North China and we can predict that they were also regular prey for Gobi Desert inhabitants. Grinding stones suggest the processing of small plants like grass seeds and/or tubers. The appearance of less portable tools like grinding stones, pottery, and large adze/axes suggests a shift in residential mobility, perhaps related to both increased investment in dune field/wetland resources and decreased seasonal mobility. The absence of permanent dwellings indicates a continuance of relatively high residential mobility.

Timing in the introduction of Neolithic tool kits is similar across Northeast Asia. Between 9.0-8.0k cal yr BP, the use of pottery, polished stone, grinding stones, and bifacial flake technology became widespread. It has long been observed that assemblages from southern Siberia, much of Northeast China, and Mongolia bear remarkable similarities in material culture, particularly in the development of bifacial flake technology and the early diversification of microblade core types. The occurrence of broadly similar developments in material cultures, despite highly variable environmental conditions, makes this situation particularly interesting. Although the idea that the Gobi Desert was peopled by migrations from the Lake Baikal region is untenable based on differences in pottery chronologies and subsistence patterns, the Early Neolithic of the Gobi Desert suggests a much closer circle of interaction with and influence from northern and eastern cultures than with southern agricultural neighbours of the Yellow River Valley.

3.2.2.4. Eneolithic/Oasis 3 (Late Neolithic/Early Bronze Age) – 5.0 to 3.0k cal yr BP

The Late Neolithic, Eneolithic, or Early Bronze Age in Northeast Asia is here dated to the period between about 5.0 to 3.0k cal yr BP. Technology and land-use is more consistent with the preceding period than during the Epipalaeolithic-to-Neolithic transition. However, changes in social networks and economic endeavours are represented by subtle shifts in surviving material culture, and mark a divergence that often prefigured later historic economies in the area. By 5.0 kya, pastoralism was widespread across the Eurasian steppe. Many domesticated animals and crops of Western Asian origin were already being incorporated into Northeast Asian subsistence strategies (see Chapter 2). In many cases, the geographic domains of historic pastoralist and agriculturalist societies were already clearly defined by 3.0 kya, although hunting and gathering still contributed to economic activities.

Despite the shorter length of time encompassed by Oasis 3, evidence of human activity is more visible than in earlier periods. This situation is not restricted to the Gobi Desert. One need only make a brief survey of regional literatures in order to see that our knowledge of this period is much more detailed than for the preceding one due to a greater number of identified and excavated sites (e.g., Svyatko et al., 2009). Increased site visibility in the Gobi Desert, particularly in the Alashan Gobi and the Gobi-Altai, might reflect either a peak in population density or a shift in residential mobility that affected site distribution and visibility.

However, the difficulty in distinguishing late Oasis 2 from Oasis 3 assemblages might also contribute to a perceived overabundance of Oasis 3 sites. In order to gain a better understanding of shifts in Holocene land-use, clear chronological markers must be established. Distinct differences between Oasis 1 and Oasis 2 assemblages make it fairly simple to separate Epipalaeolithic from Neolithic sites, but fewer diagnostic markers distinguish early from late Neolithic assemblages. Primary chronological markers like polished stone, chipped adze/axes, formal grinding stones, and bifacial points were all introduced early in the Neolithic and may have been used until the end of the Eneolithic.

Increasing regionalization during the Eneolithic hinders inferences about technological change based on comparative assemblages from neighbouring regions. Gobi Desert material culture has been compared to that of contemporary groups in Central Asia, the Lake Baikal region of southern Siberia, northwestern China, and the rest of Northeast Asia (Maringer, 1950; Formozov, 1961; Larichev, 1962; Okladnikov, 1962; Derevianko and Dorj, 1992). Little evidence of influence in material culture is recognized from the Central Plains and Lower Yellow River Valley, where the trend towards tool kits focused on polished stone and bone tools continued from the early Neolithic. Despite occasional similarities to assemblages from other regions, Gobi Desert lithics and ceramics are distinct and well-represented in dated assemblages. As such, the focus of this section is to identify evidence for temporal markers within local assemblages, drawing comparisons to neighbouring regions only when most applicable. Chronological interpretations are based on new dates and detailed site descriptions.

Climate and subsistence

The Eneolithic broadly coincides with the end of the Holocene warm/wet phase. Due to differences in the dominance of various circulation systems across the Gobi Desert, the three target regions (i.e., East Gobi, Gobi-Altai, Alashan Gobi) were affected differently by Holocene trends in precipitation and effective moisture. Despite a general pattern of increasing aridity, all regions maintained higher effective moisture than prevails today. There is evidence for the expansion of arid steppe environments after 6.3k cal yr BP in the East Gobi, and more widespread aridification between 4.5-2.9k cal yr BP (Herzschuh, 2006). Beginning around 5.2k cal yr BP, aridity increases in the Gobi-Altai and intensifies after 4.0k cal yr BP (Starkel, 1998; Tarasov et al., 2000). In the Alashan Gobi, desert expansion recommenced after about 4.0k cal yr BP, but local vegetation may not have been strongly affected in areas of increased moisture availability (e.g., around lakes and rivers) until after about 3.2k cal yr BP (Herzscuh et al., 2004; Mischke et al., 2005). An overall decrease in mean effective moisture after 3.0k cal yr BP is apparent across the entire Gobi Desert (Herzschuh, 2006).

The economic strategies and material culture in neighbouring regions were much different than in the Early Neolithic. The Eurasian Bronze Age began between 5.5-5.0 kya, when nomadic pastoralist communities began to replace sedentary settlements. By 5.0 kya, heavy wheeled carts and wagons pulled by oxen were used throughout the Eurasian steppe and large scale wool production was practiced in the Middle East (Kohl, 2007). By between 5.5-5.0 kya, the use of cattle and/or sheep was firmly established in agricultural regions of North China and Northeast China.

By the middle of the Eneolithic, a suite of both West and East Asian domesticates would have been familiar to many inhabitants of northern China and southern Siberia. Beginning around 4.5 kya, various established agricultural communities along the Yellow River and its tributaries were growing crops like soybean, adzuki bean, hemp, Chinese cabbage, buckwheat, canola/rapeseed, and wheat (Crawford et al., 2005; Lee et al., 2007; Li et al., 2009). Rice was cultivated as far north as Korea sometime between 5.0 and 3.5 kya. Camels were bred and used by Andronovo peoples in Xinjiang by about 4.0 kya (Kuzmina and Mallory, 2007: 252). Some of the first secure evidences of possible horse domestication in Northeast Asia come from Qijia sites in northwest China and date to about 3.7 kya (Yuan and Flad, 2005). The presence of painted pottery in sites from the Alashan Gobi suggests contact between Gobi Desert groups and neighbouring agropastoralists who had domesticated herd animals such as cattle, sheep, and horses.

From about 4.5 to 3.0k cal yr BP, nomadic pastoralist peoples who inhabited the mountain-steppe zone just west of the Gobi Desert are archaeologically recognized by their use of domestic animals, metallurgy, elaborate burial complexes, and rock art. The period between 3.5 and 3.0 kya probably marked the true decline of Neolithic hunter-gatherer societies and the rise of nomadic pastoralist economies, as pastoralism reached its height across Northeast Asia between 3.2 and 3.0 kya (see Chapter 2). Agriculture had also intensified in Northeast China and Korea, where sedentary communities cultivated millet, rice, wheat, barley, and sorghum. In northern Mongolia, Bronze Age ritual and burial monuments based on the intensive ritual use of horses have been dated to between about 3.2-2.8k cal yr BP (Fitzhugh, 2009).

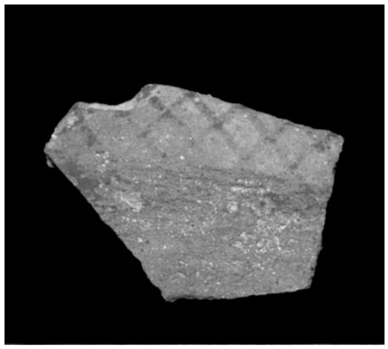
Based on the continuity of lithic assemblages during this period, there is little evidence to contradict the continuance of hunter-gatherer subsistence strategies in the Gobi Desert. Occupation of dune-field/wetland sites remains extensive and indicates the importance of associated resources. A decline in formal grinding technology is notable. Different methods of use or a focus on those species requiring less extensive technological investment is more likely related to this shift in technology than the decreased importance of plant foods. A change in residential mobility and the need for more portable tool kits might also have contributed to such a trend. Likewise, an increase in the diversity and abundance of pottery could be indicative of either a shift in processing methods (i.e., boiling instead of grinding), or a new investment in decorative elements less related to basic subsistence. More detailed analyses of possible shifts in land-use and subsistence during Oasis 3 are contained in chapters 4 and 6.

Eneolithic of the Gobi Desert and Oasis 3 technology

The majority of dated Oasis 3 sites are from the Gobi-Altai and the Alashan Gobi (see Figure 3.1). There are five archaeological sites dated to between 5.0-3.0k cal yr BP and assigned to the Eneolithic or Oasis 3, including: components of Baron Shabaka Well, Site 19 (3.3k cal yr BP [3115 ± 47 BP]) in the East Gobi; Shabarakh-usu 1 (4.9k cal yr BP [4308 ± 40 BP]), Shabarakh-usu 4 (4.0k cal yr BP [3680 ± 76 BP]), Shabarakh-usu 10 (3.9k cal yr BP [3595 ± 41 BP], 3.5k cal yr BP [3246 ± 39 BP]), in the Gobi Altai; and Jabochin-khure (3500 ± 300 ka), Gashun Well (3.6k cal yr BP [3385 ± 40 BP]), components of Yingen-khuduk (3910 ± 300 ka, 3910 ± 230 ka), and components of Mantissar 12 (3840 ± 340 ka), in the Alashan Gobi. Several Oasis 3 assemblages are considered temporally coherent and offer clear examples of typical tool kits. Detailed descriptions of dated sites are offered in Appendix B.

One of the most important post-LGM localities in the Gobi Desert is Shabarakh-usu. Many separate sites were collected from the same locality during the 1925 Central Asiatic Expedition. However, unlike at similar localities such as Yingen-khuduk and Baron Shabaka Well, each assemblage was separately curated at the AMNH and fully described by Nelson in his field notes (1925). For this reason, sites at the Shabarakh-usu locality were most heavily sampled for chronometric dating. All the sites from this group have been dated to the Oasis 3 phase, but two distinct periods of Oasis 3 habitation are represented (see Figure 3.1). Shabarakh-usu 1 is dated to the Oasis 2-Oasis 3 transition (4.9k cal yr BP [4308 ± 40 BP]), while the two remaining sites span the period from about 4.0-3.5k cal yr BP. Despite low carbon yields for Shabarakh-usu 4, the date produced for this site (4.0k cal yr BP [3680 ± 76 BP]) was similar to that from the surface of Shabarakh-usu 10 (3.9k cal yr BP [3595 ± 41 BP]).

Differences between Oasis 2 and Oasis 3 assemblages are present in both the ceramic and lithic components, although changes in ceramic technology are most recognizable. Ceramics are more common than in Oasis 2 and more intensive manufacturing processes were involved in the production of certain pottery types. High-fired ceramics began to be produced. Homogeneous red-ware, including painted pottery (Figure 3.7), from the Alashan Gobi and Baron Shabaka Well in the East Gobi appear to have been fired at temperatures suggestive of formal kiln firing. Low-fired ceramics were still regularly used. In addition to the brown and grey-wares typical of Oasis 2, red and reddish-brown-wares become common and may indicate the effects of higher firing temperatures on local clays.



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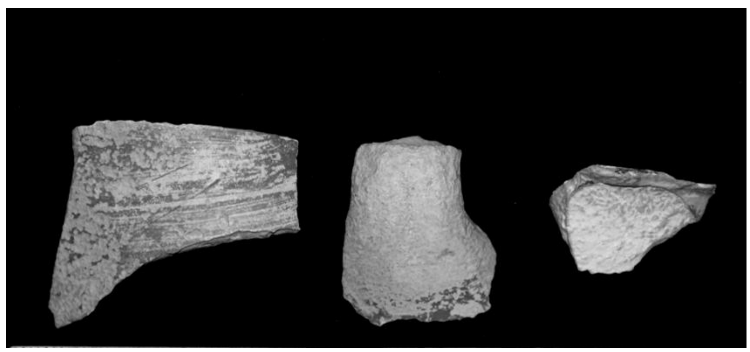


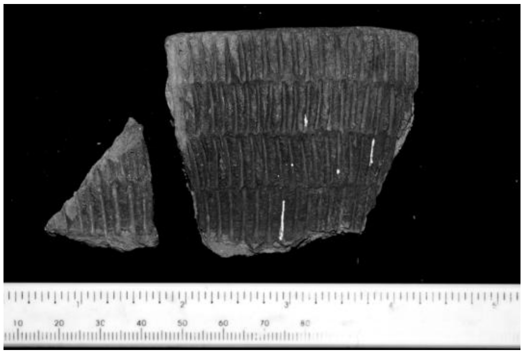
d.

Figure 3.7 Painted pottery from the Gurnai Depression. From sites: a. Mantissar 8, K. 13294:1; b. Mantissar 12, K. 13298: 1-4; c. Mantissar 7, K. 13293: 2; and d. Mantissar 12, K. 13298: 5.

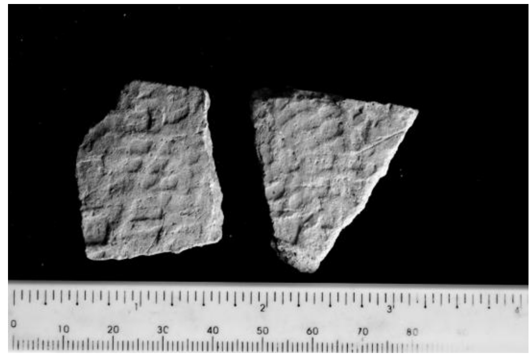
A greater diversity of surface treatments is recognized from Oasis 3 assemblages (see Figure 3.8, Table 3.5). Common surface finishes include string-paddled, incised geometric designs, stamps (including a shard from Baron Shabaka Well that was impressed using a roller stamp with evenly spaced rows of square punctates or “toothed” impressions Figure 3.8e), channelled ware, moulded rims, and raised clay bands that were moulded or incised. The majority of pottery from Shabarakh-usu 1 was string-paddled, but there is also evidence of moulded rims and incised geometric patterns. Shabarakh-usu 4 and Shabarakh-usu 10 both contain a wide range of other diagnostic of Oasis 3 pottery types (see Appendix B). Handles and miniature lugs are new features that are found at both early and late Oasis 3 sites. A variety of vessel shapes are noted (see Table 3.5), although comparative data on Oasis 2 vessel shapes is lacking. One partially reconstructed string-paddled bowl from Gashun Well is dated to 3.6k cal yr BP, but flat-bottomed pots appear to have been widely used. Cylindrical flat-bottomed vessels were found in East Gobi sites.

Oasis 1	Oasis 2	Oasis 3	Metal Ages
<u>Firing</u> low <u>Temper</u> coarse sand and organic temper <u>Finish</u> thin cord markings <u>Form</u> unknown	<u>Firing</u> low <u>Temper</u> sand and organic temper fine sand temper coarse sand temper <u>Finish</u> Net-impressed Textile Cord markings <u>Form</u> straight-walled unknown	<u>Firing</u> low high <u>Temper</u> none sand and organic fibre sand mica or nacre <u>Finish</u> Paddled (string/cord) Geometric-incised Channelled Painted Smeared basket Burnished “Toothed” roller stamp Raised/incised clay bands Moulded rim <u>Form</u> Straight-walled flat-bottomed cylindrical globular bowls handles lugs	<u>Firing</u> low high <u>Temper</u> sand sand and fibre unknown <u>Finish</u> Stamped Moulded rim Raised clay bands unknown <u>Form</u> unknown

Table 3.5 Characteristics of pottery associated with each period. Based on direct dates and associated assemblages.



a.



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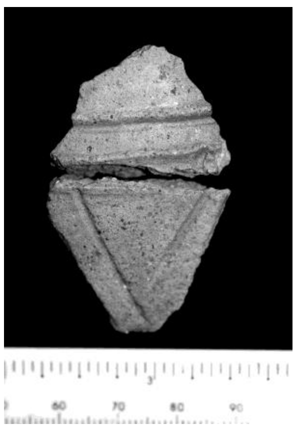

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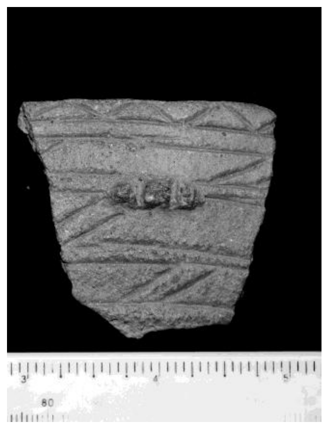

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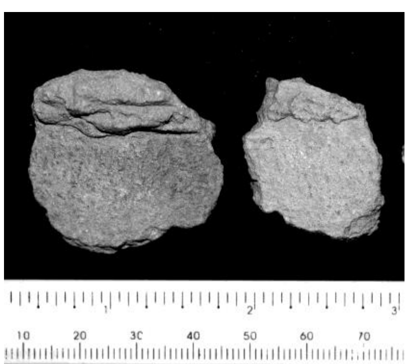


f.

g.

h.

Figure 3.8 Examples of Oasis 3 pottery from dated sites: a. channelled-ware, Shabarakh-usu 10; b. "checker-stamped", Shabarakh-usu 10; c. "geometric-incised", Yingen-khuduk; d. "geometric-incised", surface collection of Shabarakh-usu 1 and 2; e. roller-stamped punctate design, Baron Shabaka Well; f. incised raised clay band, Shabarakh-usu 1; g. incised raised band, Shabarakh-usu 10; and h. moulded rim, Yingen-khuduk.

There appears to have been little change in the types of temper used; sand or a combination of sand and organic temper is most common. As observed for Oasis 2 sites (see above), regional variation in temper types continues during Oasis 3. Sand-temper is most common and is sometimes mixed with organics, shell, or unidentified mediums. The majority of shards from the Alashan are heavily tempered with sand, though grain-size varies. Evidence of organic temper is rare at Alashan sites. Untempered-wares are more common here than in the rest of the Gobi Desert. Many East Gobi ceramics are distinct from those in western Gobi Desert sites. One common tempering medium in the East Gobi occurs only occasionally in pottery from the Gobi-Altai or the Alashan; it is a shiny material that might be mica or nacre ("mother-of-pearl"). Another distinct type of temper common in East Gobi sites (16% of shards from Baron Shabaka Well) is unidentified; when broken, the interior paste is characterized by a spongy, porous texture that is usually blackened (Figure 3.9). Some sort of organic temper is suggested. Inclusions of mica/nacre are usually associated with this type of fabric. Similar specimens were also recovered with less frequency from Gobi-Altai sites.

While pottery manufacture appears to have been more important during Oasis 3, the use of large grinding tools declined. Large, formal grinding stones are most common in the East Gobi at Oasis 2 sites. Such tools are rare farther west and there little evidence for use of the ground pestles (one exception is a possible fragmentary specimen from Abdertungtei in the Alashan Gobi; see Maringer, 1950: Plate XXXIX), rollers, and saddle querns that have been found in East Gobi sites. Heavier and more formal types of grinding equipment from western sites include large, rather flat hand stones with one angled edge from Abderungtei (K. 13209: 139), Yingen-khuduk, and Ulan Nor Plain, and a large, flat grinding slab from the Shabarakh-usu (Bayan-dzak) collections housed at the Institute of Archaeology, Mongolian Academy of Science. Oasis 3 assemblages sometimes include grinding stones or “rubbing” stones (see Fairservis, 1993), but they are smaller and presumably more portable.

Figure 3.9 Example of “spongy-textured” paste common in East Gobi sites.

Lithic assemblages represent a clear continuation of flintknapping techniques with only minor variations. Microblades are frequently retouched into perforators and other tools. Endscrapers on microblades are rare in Oasis 2 sites, but more common during Oasis 3. Drills with expanded bases made on microblades are a new artefact type.

Although adze/axes were identified in Oasis 2 sites, fully polished specimens are rarer and associated with Oasis 3 habitations. Chipped adze/axes are found in sites from all regions beginning in Oasis 2, but seem to be more widespread during the later phase.

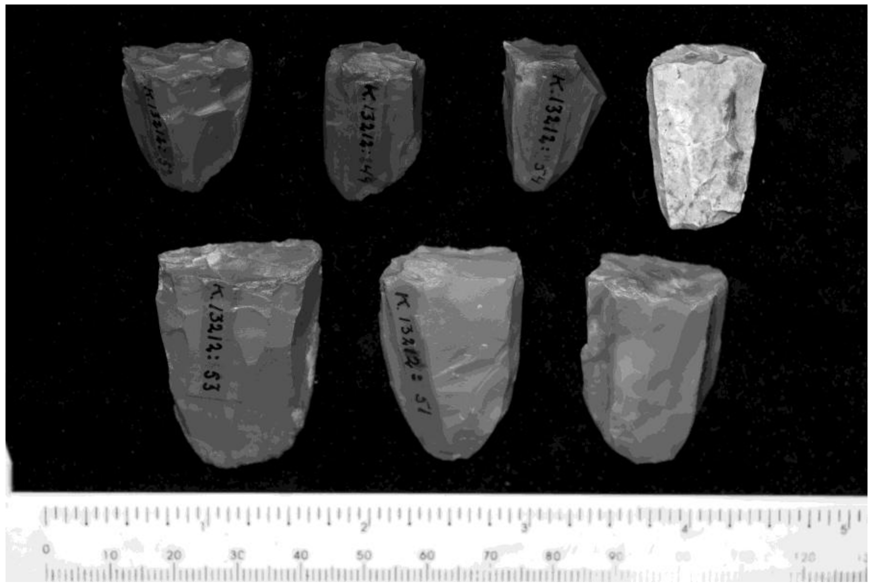
Larger knife blades were also added to the tool kit (Figure 3.10). In comparison with smaller Oasis 2 bifacial blades, the longer size, curved shape, and single rounded end of Oasis 3 specimens suggest that these artefacts were intended to function as full-size hafted blades. Such tools are also recognized in upper levels of Ulan-khada in the Lake Baikal region, dating to 4.0k cal yr BP or slightly later (Khlobystin, 1969; Goriunova and Khlobystin, 1991). The earliest example of curved knife blades comes from Ulan Nor Plain, dated to about 5.8k cal yr BP. New types of bifacial projectile points were also introduced and included forms with stemmed and convex bases (Figure 3.11). Such projectile points were found at the following sites: Camp Ruined Lamasery Obo (Site 11/11A), Baron Shabaka West (Site 20), and Paoling Miao Southeast (Site 31), in the East Gobi; Shabarakh-usu 1 and Shabarakh-usu 2, in the Gobi-Altai; and Mantissar 7 (K. 13293), in the Gurnai Depression of the Alashan Gobi. The extensive use of bifacially flaked tools is typical of late Oasis 2 and Oasis 3 assemblages, and they appear to have played an increasingly important role in tool kits throughout the Neolithic and Eneolithic.

Figure 3.10 Example of large curved bifacial blade from Shabarakh-usu 4.

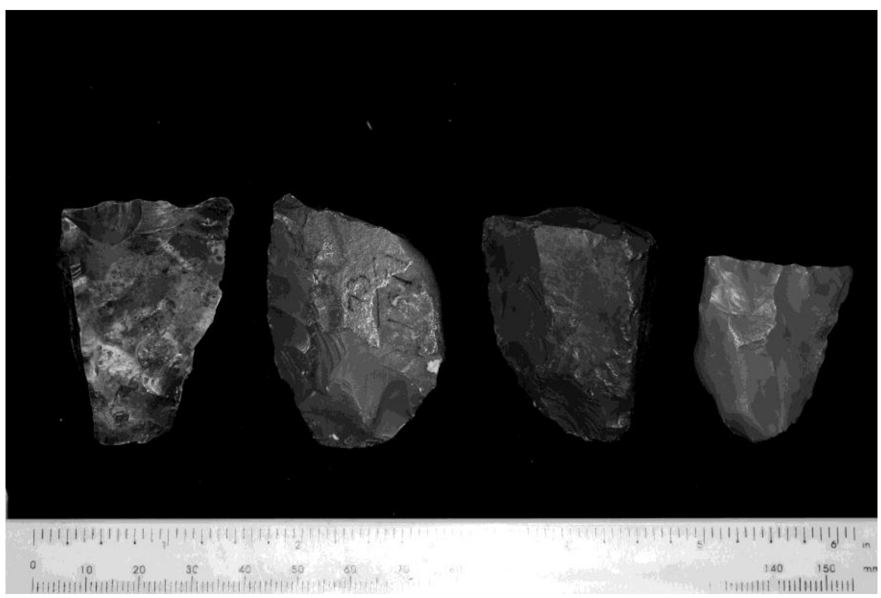
Figure 3.11 Examples of Oasis 3-type bifaces from Shabarakh-usu 2. On the right are examples of biface blades, including one small, but slightly curved specimen and one specimen typical of Oasis 2 “bifacial inset blades.”

Microblade core reduction strategies underwent subtle regional shifts during Oasis 3. Wedge-shaped cores are less common and conical and cylindrical forms are dominant. Notably, wedge-shaped cores are found more regularly in Alashan Gobi sites during this period than in the East Gobi or Gobi-Altai. Cylindrical cores are sometimes characterized by use of opposing ends as striking platforms. Numerous stubby cylindrical cores indicate heavy reduction by successive platform rejuvenation. Such core types are less common during Oasis 3 in the East Gobi than in the Gobi-Altai and the Alashan Gobi. In the western Gobi Desert barrel-shaped cores, or massive cylindrical microblade cores, are probably diagnostic of the Oasis 3 period, though such cores were present during Oasis 2 in East Gobi sites.

A series of partially prepared microblade cores from Yingen-khuduk indicates the use of roughly cylindrical preforms with a heavily prepared platform (Figure 3.12a). Cortex removal and nodule shaping on the Yingen-khuduk specimens appears to focus on the production of thick, round preforms with a predetermined cylindrical form that is divergent from the flatter morphology exemplified at Ulan Nor Plain (Figure 3.12b). At Ulan Nor Plain, preforms were made on flat nodules or nodules with one side removed for thinning. One or more of the sides were retouched in order to create a wedge. The two reduction strategies are not necessarily temporally distinct, since cores produced from both types of preforms are present in the assemblages, but rather represent different strategies favouring either the production of cylindrical or wedge-shaped cores.



a.



b.

Figure 3.12 Microblade core preforms from Yingen-khuduk (a) and Ulan Nor Plain (b).

Summary Eneolithic developments and Gobi Desert Oasis 3

Many Oasis 3 archaeological sites have been dated to between 4.0-3.5 kya, the period immediately preceding the archaeologically visible rise of nomadic pastoralism. According to existing research, the Neolithic-to-Bronze Age transition or the early Bronze Age in Mongolia is thought to have taken place between about 4.0-3.0 kya. The characterization by Soviet and Mongolian archaeologists of tool kits from this period indicates the continued use of flake tools and microblade inserts along with an increase in bifacially retouched tools such as finely pressure-flaked projectile points. These earlier observations are consistent with those recorded here. In contrast, the Eneolithic upper levels of the Yenesei River region site Toora-Dash indicate the continued use of flake technology, but an absence of arrowheads and bifacial inserts (Vasil'ev and Semenov, 1993).

Soviet literature suggests that animal husbandry and plant cultivation were of some importance to local economies in the steppe and forest zones of eastern Mongolia, but no concrete evidence of domestication has been recognized in the Gobi Desert. Evidence of agriculture includes hoe-like implements and ring-shaped "counter-weights," which are thought to be indicative of low-level agricultural production (Cybiktarov, 2002). Several tools from the Baron Shabaka Well locality might be similarly categorized (see Appendix B), but are inconclusive evidence of cultivation. Based on excavations at Tamsagbulag and other archaeological sites, it has also been proposed that the Neolithic-to-Bronze Age transition was typified by more temporary campsites than in earlier phases of the Neolithic (Sériadès, 2006). Thus far, all post-glacial Gobi Desert archaeological sites suggest high residential mobility and there is little evidence of permanent or semi-permanent occupations. The possibility of higher residential mobility at this time contradicts the likelihood of agricultural production, which is typically associated with increased sedentism. Examples of probable spindle whorls might similarly be taken as evidence of the use of spun wool, but are not dated could have served for spinning other types of fibres, such as bast.

Copper smelting is indicated by pieces of slag and a few metal artefacts from sites in Siberia and along the border of Mongolia. In the Lake Baikal region of southern Siberia, copper and/or bronze artefacts first appear during the Glazkovo period (5.2-3.4k cal yr BP after Weber and Bettinger, 2010). Limited evidence of smelting suggests low-level local production in the forest region of northeastern Mongolia (Cybiktarov, 2002; Sériadès, 2006). Several microlithic assemblages from the Gobi Desert contain evidence of copper or bronze slag. Dottore-namak (K. 13248) is one such site in the Alashan Gobi, but ceramics were dated to about 2.5 ka (3540 $\pm$ 1060 ka, 2740 $\pm$ 200 ka) (Table 3.1), indicating that the assemblage dates to the late Bronze Age or early Iron Age.

Oasis 3 represents a period of continued intensive occupation of dune-field/wetland environments in the Gobi Desert. Extensive remains in the dune-field marshland environment of the Gurnai Depression (Maringer, 1950: 151-163) exemplify the importance of such habitats to Gobi Desert groups in this later phase. Hunting and gathering were most certainly the basis of local economies. Although fishing is of particular importance in much of Northeast Asia, Gobi Desert tool kits show little evidence of intensive fish exploitation. Expedition field notes make frequent references to the diversity of bird life in the Gobi Desert, particularly around lakes, and birds may have been an important food source. Plant foods would have been especially abundant in dune-field/wetland environments and would continue to have been important during this time. Some sites were found in steppe environments, suggesting that hunters continued to take advantage of abundant wild ungulate herds like gazelle, horse, and khulan.

A possible shift in the relative importance of formal grinding technology is represented by the use of smaller informal grinding tools and “rubbing stones” in Gobi-Altai and some East Gobi Oasis 3 sites. All types of grinding stones are rare in the Alashan Gobi. Larger grinding tools may have continued to be used in Oasis 3 sites from the East Gobi, but they are rare and may have been derived by later inhabitants from Oasis 2 occupations. Decreased investment in milling technology suggests a shift in the use and processing of local plant foods. A desire for more lightweight grinding stones is implied and is intriguing when combined with an increased investment in pottery production. While enhanced portability is suggested by the adoption of more lightweight technology, the more frequent use of pottery could be considered contradictory. Nevertheless, pottery is not as heavy as grinding stones, and can be attached to thongs for transport. Unlike large grinding stones, ceramic vessels are frequently used in mobile societies (Hoopes, 1995; Bollong et al., 1997; Pavlů, 1997; Bright and Ugan, 1999; Rice, 1999; Eerkens et al., 2002). At the same time, the use of high-fired and more decorative pottery (e.g., stamped, painted, incised designs rather than simple paddled pots) indicates that some vessels were probably manufactured with the intention of longer-term curation.

Grinding stones are usually assumed to indicate the production of flour, which hunter-gatherers could then mix with grease and other foods and store for delayed consumption (for examples see Manne, 2012). In other cases, grinding stones are thought to have been related to macerating foods for supplemental feeding or weaning of infants (Hillman, 1989). Many ethnographic cases of pottery use among hunter-gatherers indicate that the technology was frequently used to prepare stews (Bollong et al., 1997; Eerkens, 2004; Malainey et al., 1999; Mercader et al., 2000; Pratt, 1989), the broth of which can also provide substantial nourishment for feeding infants. Storage of dried seeds or plants might be an alternate function of curated pottery vessels, which is a possibility that can be explored partially through studies of usewear (i.e., relative frequency of evidence for cooking or lack thereof on shards). A shifting emphasis between these two technologies may suggest different trends in the relative importance of food processing and/or transport methods.

The exploitation of ostrich eggshell for beads seems to have flourished during Oasis 3. Many dune-field sites from this period contain older eggshell scavenged for the manufacture of beads. Heightened evidence for the production of ostrich eggshell beads along with marked diversity in ceramic styles shows the increased importance of ornamental elements.

Oasis 3 is broadly characterized by increased investment in the manufacture of pottery vessels and adze/axes, decreased investment in formal grinding technology, and a greater variety of bifacially flaked tools.

3.2.3. Estimates of ages for undated sites

Chronometric dates on pottery and associated artefacts have been used to identify several key diagnostic artefact types and technological trends for each period. These findings are summarized below in Table 3.6. Diagnostic pottery types are summarized above in Table 3.5. In order to make a more reliable assessment of land-use and mobility from the Epipalaeolithic to Eneolithic, it is important to determine the relative age of as many sites as possible. By using initial findings based on chronometric dates, a number of undated sites can be assigned a relative age. Expanding the site sample size for each period will also contribute to preliminary assumptions about artefact chronology.

Estimated ages are assigned based on data collected during analysis of collections and are limited primarily to those sites for which detailed quantitative and qualitative data was obtained. The majority of data is presented in the form of tables in order to ease presentation of extensive data. Table 3.7 lists sites for which data was collected in 2008 and 2009, with limited representation of sites analyzed in 2004. Estimated ages are based on the presence of diagnostic artefacts (e.g., unifacial points, biface blades, small chipped adze/axes, polished adze/axes, distinct pottery types) or the relative frequency of certain artefact types (e.g., wedge-shaped cores, cylindrical/conical cores, endscrapers on microblades, adze/axes). Artefact lists for each site are published in Maringer (1950) and Fairservis (1993). The distribution of artefact types in each assemblage was a key consideration in establishing a relative age for each site (see Appendix C); however, the use of photographic images was also extremely important and allowed for the recognition of less easily quantified traits.

Pre-LGM Palaeolithic	Early Epipalaeolithic	Oasis 1/ Late Epipalaeolithic	Oasis 2	Oasis 3	Metal Ages
Large pebble tools Cores “Levallois” type Blade Microblade (rare) Flake Microblade cores Pressure-flaked Sub-prismatic Flake tools Elongated flakes Various retouched	Large pebble tools Bone/antler tools Cores “Levallois” type (rare) Blade Microblade Flake Microblade cores Boat-shaped Wedge-shaped Conical? Flake tools Sidescrapers Endscrapers Large unifacial points Various retouched	Large and small pebble tools Informal grinding stones Pottery Bone/antler tools Cores Microblade Flake Microblade cores Boat-shaped Wedge-shaped Conical Cylindrical Microblade tools Insets Various retouched Flake tools Endscrapers Various retouched	Large formal tools Formal grinding stones Pottery Bone/antler Cores Microblade Biface Flake Microblade cores Wedge-shaped Conical Cylindrical Microblade tools Unifacial points Perforators Awls Various retouched Flake tools Bifacial points Endscrapers Perforators Bifaces Projectile points Shouldered points Large points Inset blades (parallel-sided) Large knives Large tools Adze/axes (ground, edge-ground,chipped, micro) “Hoes”	Large formal tools Informal grinding stones Pottery Bone/antler Cores Microblade Biface Flake Microblade cores Wedge-shaped Conical Cylindrical Barrel Microblade tools Endscrapers Perforators Expanded base drills Flake tools Bifacial points Endscrapers Perforators Various retouched Bifaces Projectile points (straight, stemmed, convex, fish-tailed bases) Blade knives Large tools Adze/axes (polished, edge-ground,chipped) Grooved slabs	Slag Bronze projectiles Pottery Cores Microblade Flake Microblade cores Conical Cylindrical Flake tools Various retouched

Table 3.6 Summary of artefact chronologies. Based on dated assemblages and comparative regional data.

It is difficult to distinguish Oasis 2 from Oasis 3 sites in the absence of diagnostic pottery types. Pottery is mostly found in sites near dune-fields and larger water sources, making it necessary to use other types of artefacts to recognize different phases within Neolithic/Eneolithic assemblages. Several Oasis 3 chronological markers have already been noted in the discussion of dated Gobi Desert assemblages: expanded base drills, curved bifacial blade knives, projectile points with stemmed, fish-tail and convex bases, barrel-shaped cores, endscrapers on microblades or elongated flakes, and finely polished adze/axes. Some of these artefact types (including endscrapers on microblades) have been found in limited numbers in late Oasis 2 sites, but are primarily restricted to Oasis 3 sites. The association of several kinds of Oasis 3-type artefacts is most definitive of age. Whenever possible, estimating the approximate age of a site was more reliant on the range of associated artefacts, rather than one or two diagnostics (see Appendix C).

EAST GOBI			
SITE	ENVIRONMENT	PERIOD	QUALIFICATIONS
SKW	Mountains/river	Oasis 1	Dates
3	Dunes/valley/river/badlands	Oasis 1	Core/scraper types, large flakes, microblades, thick bifacial knife
6D	Hillslope/river	Oasis 1	Core/scraper types
7	Hillside/river	Oasis 3	Backed microblades, cowrie, pottery
9	Mesa/river	unknown	1 core preform only
9B	Hilltop	Palaeolithic?	Debitage, rough macrotool
9C	Base hill/river	Oasis 2 or 3	Scraper types
9D	Hills	Oasis 2 or 3	Partially retouched point, scrapers
10/10A/10B/10C	Hills/stream	Oasis 2 or 3	Mixed sites, few diagnostics, biface fragments
11/11A	Knoll/dune/stream	Oasis 3	Mixed?, core types, biface types
12	Plains/stream	Oasis 2	Mixed?, core/scraper types, material
12/12A/12B	Mountains/stream/some on plains (12)	Epi/Palaeolithic, Oasis 2	Mixed, core/scraper types, material, debitage
13	Mountains/stream	Late Oasis 2?	Core/scraper types, raw materials
13A	Mountains/stream	Oasis 2 or 3	Core/scraper types, biface, material
14	Mountains/stream	Oasis 1	Core/scraper types, raw materials
15	Hill at head of wash	Oasis 2	Biface, core/scraper types, material
18	Dune/basin/lake	Early Oasis 2	Unifacial points, grinding stones, polished stone, pottery; also Historic
19	Dune/basin/lake	Oasis 2, Oasis 3	Dates
20	Valley/dunes/lake	Oasis 2 and/or 3	Pottery, bifaces, drill, grinding stones, core and scraper types
20A	Dune/basin/lake	Various	Mixed
21	Hillside/dunes/lake	Early Oasis 2	Unifacial points, cores, grinding stones, chipped adze/axes
23/23A	Mesa/river	Oasis 3	Pottery, grinding stones, material
28	Hillside/lake/sand	Oasis 3	Macrotools, bifaces, material, cores
29	Valley slope/sand	Late Oasis 2 or early Oasis 3	Core/scraper types, bifaces, drills, polished macrotool, raw materials
30/30A	Valley bottom/river	Late Oasis 3	Macrotool, grinding stone, core/scraper, bifaces, possibly mixed
31	Valley/dune/river	Late Oasis 2 and early Oasis 3	Mixed, core/scraper types, macrotools, bifaces, grinding stones
34	Mesa /lake	Oasis 3?	Based on chalcedony biface blanks
35	Dune/basin/lake	Early Oasis 2	Dates
36	Dune/basin/lake	Oasis 1	Microcore/scraper types/material

Table 3.7a Age estimates for studied archaeological sites, East Gobi. SKW = Shara KataWell.

GOBI-ALTAI			
SITE	ENVIRONMENT	PERIOD	QUALIFICATIONS
CM	Mesa/stream	Epipalaeolithic and Oasis 3	Differences in surface abrasion, core/scraper types, debitage
GBW	Basin/well	Early Oasis 2	Pottery, cores, mortar
BUV	Mtn valley/dunes	Oasis 1?	Core/scraper types, weathering
DH	Foothills/well	Palaeolithic	Debitage, large flakes
UNP	Dune/basin/stream	Late Oasis 2 and some Oasis 3?	Dates, some pottery types might be Oasis 3, curved biface; also Historic
JW	Dune/basin/stream	Early Oasis 2	Bifaces, core/scraper types
JW s-s	Dune/basin/stream	Late Oasis 2	Bifaces, core/scraper types/material
SG	Foothills	Epipalaeolithic	Core/scraper types, no microblades
AB	Foothills/spring	Oasis 2	Biface, core/scraper types, blade tools
KhO	Mountain meadow/streams	Metal Ages?	Raw material, core/scraper types, presence of Metal Age monuments
BD	Dune/basin/lakes	Oasis 2 and Oasis 3	Core/scraper types, pottery, polished macrotool; also Metal or Historic
ON	Plains/dune/lake	Oasis 2 and 3	Pottery, core/scraper types; Historic
SC	Plains/stream	Oasis 3	Core/scraper types
Su 1	Dune/basin/lake	Early Oasis 3	Dates
Su 1A	Dune/basin/lake	Oasis 2	Pottery, core/scraper types
Su 2	Dune/basin/lake	Early Oasis 3	Pottery, macrotools, biface types
Su 2a	Dune/basin/lake	Epipalaeolithic or Oasis 1	Raw material, core types, microblades
Su 2b	Dune/basin/lake	Oasis 1	Core types, eggshell – 9.4k cal yr BP
Su 4	Dune/basin/lake	Oasis 3	Dates and comparison to Su 10
Su 7	Dune/basin/lake	Early Oasis 3	Core/scraper/biface types, pottery, shouldered drills and perforators
Su 8	Dune/basin/lake	Late Oasis 2	Pottery, bifaces
Su 10	Dune/basin/lake	Oasis 3	Dates
Su 11	Dune/basin/lake	Late Oasis 2	Bifaces, raw material
Su 13	Dune/basin/lake	Oasis 3	Pottery, bifaces, drills

Table 3.7b Age estimates for studied archaeological sites, Gobi-Altai. Shabarakh-usu sites 2, 8, 11 and 13 were analyzed in 2004 (Janz, 2006) and quantitative data is not as comprehensive, although additional photographs were taken in 2008. CM = Cemetery Mesa, GBW = Gashuin Bologai Well, BUV = Barongi Usu Valley, DH = Dubshi Hills, UNP = Ulan Nor Plain, JW = Jichirun Wells, JW s-s = sub-surface component of Jichirun Wells, SG = Sairim Gashato, AB = Artsa Bogdo, KhO = Khunkhur Ola, BD = Barun Daban, ON = Orok Nor.

ALASHAN			
SITE	ENVIRONMENT	PERIOD	QUALIFICATIONS
176	Dune/lake	Oasis 3	Pottery, core types, scraper types, partially polished axe
179	Dune/lake	Oasis 3	Pottery like 176
183	Plains/dunes	Oasis 3	Painted pottery, polished axe, cores
186	Plains/dunes	Oasis 2?	Large microblades, scraper types
188	Plains/basin	unknown	Microblade debitage and large flakes/cobbles
202	Plains/basin	Epipalaeolithic?	See 204, intrusive pottery?
203	Plains/basin	Oasis 3	Dates
204	Plains/basin	Epipalaeolithic	Macrotools, few microlithics, no microblades
207	Sand/basin/well	Oasis 3	Dates
208	Dune/basin/river	Oasis 3	Bifaces, macrotools, core types
209	Basin/stream/well	Oasis 3	Biface/pottery types
210	Basin/stream/well	Oasis 3	Biface/pottery types
212	Dune/lake	Oasis 2 and 3	Dates
213	Dune/basin	Oasis 2	Partially polished axe, various cores
216	Foothill/spring	Oasis 3	Core types, scraper types, bifaces –drills?
218	Mountain/stream	Oasis 3	Core types, scraper types, biface fragment
219	Mountains	Palaeolithic	Scraper on macroflake
220	Mountain/stream	Oasis 2	Inset blade knife, “stray finds” = mixed?
222	Mountain/well	Oasis 3	Biface frag., scraper types, biface core
223	Mountain/well	Late Oasis 2 or Early Oasis 3	Spearpoint, bifaces, core/scraper types, pottery
226	Valley/river	Oasis 1	Core types
229	Valley/river/sand	unknown	Odd undiagnostic macrotool or core tool
230	Mountain/cave	Oasis 3	Pottery, chalcedony bead making, one scraper on microlithic flake
231	Mountain/river	Oasis 2	Large bifaces, blade core, late core types
237	Valley/river/sand	Palaeolithic	Core types, lack of microliths
240	Hill plains	Oasis 3	Spindlewhorls, pottery, polished axe, grooved slab (also grinding stone)
241	Hills/swamp	Oasis 2?	Core types, chipped adze/axes
247	Dune/basin	Oasis 2	Core types, scraper types, drills, bifaces
248	Dune/basin/spring	Metal Ages	Dates
251	Plains/sand	unknown	1 scraper only
258	Basin/lake/sand	Oasis 2 or 3	1 cylindrical core only
259	Basin/lake/sand	Oasis 2?	Aceramic, biface types, hoe-like tools, awl, unifacial perforator, adze/axe types
277	Dune/lake	Oasis 3?	Slag, pottery, scraper types, Metal Age?
280	Dune/lake	Oasis 3	Painted pottery
287	Dune/wetland	Oasis 3?	Pottery, cores, scraper types, Metal Age?
289	Dune/wetland	Oasis 3	Pottery, biface

Table 3.7c Age estimates for studied archaeological sites, Alashan Gobi.

		ALASHAN	(continued)
SITE	ENVIRONMENT	PERIOD	QUALIFICATIONS
290	Dune/wetland	Oasis 3	Pottery, core/scraper types, bifaces, polished stone frag., turquoise frag., drills
293	Dune/wetland	Oasis 3	Painted pottery, biface, drill, core/scrapers
294	Dune/wetland	Oasis 3	Painted pottery, cylindrical core
296	Dune/wetland	Oasis 3	Painted pottery
298	Dune/wetland	Oasis 2 and Oasis 3	Dates
303	Dune/wetland	Oasis 3	Scraper types
307	Dune/wetland	Oasis 3?	Slag, pottery, core/scraper types, mixed
311	Dune/wetland	Oasis 3	Scraper types
316	Dune/wetland	Oasis 3	Similar raw materials to other sites
321	Plains	Early Oasis 2	Core/scraper types, blade knife, adze/axe
322	Plains/spring	Palaeolithic	Large flake tools, thumbnail scrapers (intrusive?)
323	Mountain/spring	Epipalaeolithic	Core/scraper types, blade
324	Mountain/spring	unknown	1 amorphous core on cobble

Table 3.7c (continued) Age estimates for studied archaeological sites, Alashan Gobi. Sites 209, 210, 240, 241, 280, 289, and 296 were not analyzed, but assigned to a period based on presence of diagnostic artefacts. Shara-khulus (K. 13241) also includes the fragment of a pottery spindlewhorl, which were also recovered from Altat (K. 13240).

One challenge with respect to East Gobi archaeological sites was the presence of formal grinding stones. In general, formal, often finely polished pestles and rollers are characteristic of Oasis 2 assemblages like Chilian Hotoga and Baron Shabaka Well. The occasional occurrence of such artefacts in sites with a typical range of Oasis 3 core, scraper, and biface types is problematic. While the presence of grinding stones is rare in the Alashan Gobi, most Oasis 3 sites in both the East Gobi and the Gobi-Altai contain only small grinding slabs or what are sometimes referred to in AMNH catalogues as “rubbing stones”. Use of formalized grinding stones may have continued in the East Gobi during Oasis 3, or they may have been scavenged from Oasis 2 sites as is done by modern herders (see Pond, n.d.: 90-91). Baron Shabaka West (Site 20) is the best example of this situation, where large formal grinding stones are associated with Oasis 3 style pottery (i.e., pottery with rolled cord finish, and high-fired stamped grey-ware similar to that dated to 3.3k cal yr BP from Baron Shabaka), a blade knife, an expanded base drill, and core/scraper types. While the grinding stones may have been scavenged or artefacts from two different periods of occupation mixed, the most important point is that the presence of formal grinding stones does not definitively distinguish an Oasis 2 period occupation.

Despite the difficulty in properly assigning sites to a particular period or phase, temporal associations between certain artefact types were strengthened in the process. Considering assemblage inventories, quantitative data, and photographic images from numerous sites allowed for more comprehensive recognition of possible diagnostic traits in lithic assemblages. Just as expanded base drills are associated with dated Oasis 3 sites, artefact associations within additional undated sites suggested that fully retouched awls (recognized by long triangular shape as illustrated in Maringer, 1950: Plate XXIX, 14) are more closely related to late Oasis 2 occupations. Large thin bifacial flake knives are similarly assigned to Oasis 2, as are the largest formal tools like “hoes” or the massive pick found at Baron Shabaka Well (see Appendix B). An abundance of bifacial tools are more often associated with Oasis 3. While bifaces began to be used during Oasis 2, small bifacial projectile points are most common in Oasis 3 assemblages. Intensive production of small bifacial points, as exemplified by Shabarakh-usu 7 and 11 (see Fairservis, 1993; Janz, 2006), is associated with Oasis 3. Bifacial points appear to be less common in late Oasis 3 sites and are so far absent in sites dated to the Metal Ages.

Use of a limited range of high quality raw materials is also characteristic of Oasis 2 and early Oasis 3 assemblages. The increasing reliance on a select range of homogeneous cryptocrystalline raw materials began in the late Epipalaeolithic and is a trend that has been noted at Chikhen Agui (Derevianko et al., 2003). A limited selection of reliably high quality raw materials is particularly noticeable in the Gobi-Altai, where homogeneous cryptocrystalline stone is easily obtainable. At the same time, many microlithic assemblages across Mongolia contain artefacts made on red or purple jasper characteristic of the Gobi-Altai region (Joshua Wright, personal communication, May 2011). Assemblages characterized by the use of more roughly flaked projectile points on a range of local, less homogeneous crytocrystallines, including chalcedony pebbles, may date to the end of Oasis 3. Chalcedony appears to have been preferred for the manufacture of small bifacial tools, and the increased predominance of those tools may be reflected in a decline reliance on exotic jaspers. These preliminary observations must be tested through the analysis of raw material frequencies amongst the debitage of directly and indirectly dated sites, but this data was not collected in the course of my study. A better understanding of tool stone distributions across the Gobi Desert is necessary.

In some instances, sites can be identified only as Oasis 2/Oasis 3. Late Oasis 2 sites (e.g., the late Oasis 2 site of Ulan Nor Plain, which contains blade knives and endscrapers on microblades/elongated flakes; see Appendix B), and early Oasis 3 sites (e.g., Shabarakh-usu 1; see Appendix B) are most difficult to distinguish. Late Oasis 2 assemblages show the initial incorporation of Oasis 3-type technologies. Assigning a relative age to smaller assemblages is most problematic because they often appear to have been related to raw material procurement or short-term task sites where finished diagnostic artefacts, including cores, were rarely discarded. The situation is especially notable in the East Gobi. Late Oasis 2 and early Oasis 3 assemblages are recognized by the use of only a few high quality raw materials, as opposed to a wider range of local, often poor quality stones. The consistent focus on high quality raw materials at type sites like Baron Shabaka Well and Yingen-khuduk support this categorization. Core reduction strategies were also considered and artefacts like keel flakes indicate increased core preparation typical of Oasis 1 and 2.

Future refinements of Neolithic/Eneolithic artefact chronologies will allow for more precise categorizations, but similarities in artefact types across Oasis 2/Oasis 3 are a reminder that although period designations are useful for grouping like sites they are incapable of capturing the transitional nature of local technological change. A designation of “late Oasis 2 or early Oasis 3” encompasses the period between 6.0-4.0k cal yr BP. After this, only slight shifts in technological strategies appear to have occurred, including a decline in the frequency of finely finished projectile points, more regular use adze/axes, another increase in the variety and relative frequency of pottery, and a decline in the importance of high quality exotic stone. A decline in the relative importance of microblade production might also have occurred, but the possibility should be explored in more detail when additional late Oasis 3 sites have been dated.

Several other significant observations should be made:

a. Pottery first appears in Oasis 1 sites, but is not common until Oasis 3.

b. Wedge-shaped cores appear to be more typical of Oasis 1 and 2 assemblages in the East Gobi and the Gobi-Altai, but are more representative of late Oasis 2 and/or early Oasis 3 assemblages in the Alashan Gobi.

c. Alashan Gobi occupations are notable for the high frequency of macrotools or large formal tools such as adzes, axes, gouges, and chisels. Currently, sites with large, thin bifaces and awls are assigned primarily to Oasis 2. Most of these sites are aceramic, even the large lakeshore site of Gashun-nor (K. 13259).

d. Two types of Oasis 3 sites are distinguishable – those with few microblades and lower quality raw materials, and those with more microblades and high quality raw materials. It is difficult to assess whether this is related to chronology or simply due to situational constraints. For example, highly localized raw material constraints such as those related to seasonal mobility could have created such a pattern. Oasis 2 sites do often contain very finely finished projectile points and microblade tools, along with more uniform and slender microblades made on a narrow range of raw materials. However, the later Oasis 3 site of Gashun Well (3.4k cal yr BP) shows the continued use of high quality raw materials and intensive microblades manufacture. Additional research on this issue is required.

e. Ta Sur Heigh (Site 7) in the East Gobi contains evidence for the use of exotic cowry (Cypraeidae) shells, which are also found in Neolithic and Early Bronze Age sites in northern China and are associated with long distance trade (Peng and Zhu, 1995). Other cowry finds in the East Gobi are not as clearly associated with Neolithic/Eneolithic habitation sites. Pottery and stone tool types from Ta Sur Heigh are consistent with other Oasis 3 assemblages. Northwest China is identified as the main centre of cowry use and cowries have been associated with Majiayao (~5.3-4.0 kya) cultural sites. More tentative data had also suggested that their use in burial contexts may date to the Early Neolithic in North China (Peng and Zhu, 1995). By about 4.0 kya, cowries had begun to spread east, being used at lower Xiajiadian sites around the Yanshan Mountains and in eastern Inner Mongolia. Cowry use was most widespread between about 3.6-2.6 kya. The association of cowries with Oasis 3 occupations is chronologically appropriate and indicates relationships with contemporaneous Neolithic cultures and some access to Western-Eastern trade goods.

Based on direct dates and periodization of additional sites, the following set of chronological indicators is proposed for the Gobi Desert:

1. Early Epipalaeolithic, 19.0-13.5k cal yr BP – There is no clear evidence of archaeological sites from this time period in the Gobi Desert, although some possible examples have been noted. Judging from trends in neighbouring regions, we can expect that lithic assemblages were focused on the production of large unifacially retouched flake and blade tools. If microblade technology was present, it can be expected that microblade flakes were largely unretouched and used as inserts for organic hafts. Microblade core forms differed between southern Siberia/northern Mongolia and northern China; therefore, we cannot predict which forms would have been adopted in various Gobi Desert target regions.
2. Oasis 1 or Late Epipalaeolithic, 13.5-8.0k cal yr BP – Microlithic tools largely replaced flake and blade tools and were sometimes retouched using pressure-flaking. Fibre-tempered cord-marked pottery was adopted by 9.5k cal yr BP in the East Gobi. Ostrich eggshell bead production becomes more common. Microblade core technology frequently focused on prepared cores made from smaller nodules and organized around the exploitation of cryptocrystalline stones producing reliable conchoidal fractures. By the end this phase, cryptocrystalline stone was favoured for knapping over coarser-grained materials like siliceous sandstone, basalt and quartzite.

3. Oasis 2 or Neolithic, 8.0-5.0k cal yr BP – New technologies like formal grinding stones, chipped and/or ground adze/axes and bifacially flaked tools were added to microlithic assemblages. Pottery became increasingly common. String-paddled, net-impressed and undecorated plain-wares are most typical. The production of microblades is the dominant reduction strategy, but formal biface cores and expedient flake cores were also used. Unifacial projectile points made on microblades are typical of early Oasis 2, with bifacial forms emerging slightly later. Small endscrapers were made on thick semi-circular flakes or microblade core platform reduction spalls. Elongated endscrapers (tongue-shaped) on bladelets (10-14 mm in width) are occasionally recovered, especially in the Alashan Gobi. Endscrapers on amorphous flakes are most common. Beginning around 6.0k cal yr BP, there was a diversification of bifacially flaked tools types. Large, thin bifaces are also associated with the late Oasis 2 phase and may have served as large knives. Late Oasis 2 assemblages are also characterized by a trend towards the use of a few select high quality raw materials.
4. Oasis 3 or Eneolithic, 5.0-3.0k cal yr BP – Pottery use was more extensive during the final stage of the Neolithic. Both low- and high-fired ceramics are found and the variety of treatments includes geometric-incised, channelled, moulded rims, and raised clay bands. Handles and miniature lugs were used. Red and reddish-brown-wares are common. Lithic assemblages are similar to those of late Oasis 2, but new tool types include fully polished adze/axes, expanded base drills, and projectile points with stemmed, fish-tail, and convex bases. Small informal

grinding stones are more typical of Oasis 3 than the large formal types used during Oasis 2 (primarily in the East Gobi). Wedge-shaped cores are less common in the East Gobi and the Gobi-Altai and more common in the Alashan Gobi. Barrel-shaped cores are typical of tools kits in Alashan Gobi and the Gobi-Altai.

3.3. Discussion

Chronometric dates on several post-LGM archaeological sites from three Gobi Desert regions provide a starting point from which to begin ordering numerous existing microlithic assemblages. For early periods a comparison with technological developments elsewhere in Northeast Asia is instructive. These comparisons illustrate not only larger trends in technology, but also in economic developments. The temporal continuity of widespread shifts in technology also suggests some level of interconnectedness amongst hunter-gatherers in mainland Northeast Asia. As population, or at least the visibility of archaeological sites, increased during the Early Holocene, technological assemblages are more regionally divergent and stylistic comparisons between regions are much less useful.

By the Late Neolithic or Eneolithic, the widespread rise of sedentism and production economies based on the exploitation of domesticated plants and animals contrast markedly with evidence of mobile foraging economies in the Gobi Desert. However, mobile foraging economies without evidence of domesticated plants and animals persisted in many other parts of Northeast Asia, including the Lake Baikal region and much of the higher latitude far eastern regions of Russia and Northeast China. The use of microblade and biface technology flourished in many of these regions, as it did in the Gobi Desert, though in diverse forms. The technological diversity that emerged during the Neolithic might be associated with increasingly localized interaction spheres and group identification, as geographically discontinuous developments punctuated a previously more homogeneous economic landscape (e.g., compare the archaeological records of the Minusinsk Basin and the Lake Baikal region, or the Central Plains and Northeast China, during the Late Epipalaeolithic and the early Bronze Age).

The artefact-based chronology that is presented here represents a preliminary method of classification for the Gobi Desert based on current knowledge of assemblage composition and diagnostics. Future excavation and chronometric dating will allow for a more refined understanding of chronology, including relative dependence on various raw material types, changes in microblade core reduction sequences, and trends in biface production. Distinct technological continuity between the late Oasis 2 and early Oasis 3 phases is notable and it is hoped that the relationship between these two phases will be more clearly elucidated by future research.

CHAPTER 4 – PREHISTORIC HUMAN LAND-USE IN THE GOBI DESERT

The goal of this study is to not only to build a preliminary technological chronology, but to elaborate temporal and spatial characteristics of land-use in the Gobi Desert during the terminal Pleistocene to late middle Holocene in order to better understand modes of subsistence and settlement prior to the emergence of nomadic pastoralism. I have used chronometric dating and an artefact-based chronology to assign approximate ages to almost 100 archaeological sites (Table 3.7) from three environmentally distinct regions of the Gobi Desert. Reconstructions of land-use in this chapter are based on information from original site descriptions (i.e., environment, topography, assemblage composition) and quantitative analysis of lithic assemblages. Since each of the three regions is environmentally distinct, they will be considered separately in order to account for possible differences in land-use related to variable resource distribution, and the timing of climate-mediated environmental shifts (see Chapter 5).

Examination of shifts in organizational strategies begins with a series of hypotheses about expected changes in land-use based on current knowledge of post-LGM archaeology in the Gobi Desert and other parts of Northeast Asia, as outlined in Chapter 2. The following hypotheses are based on previous interpretations of Gobi Desert archaeology as well as the new chronometric dates detailed in Chapter 3.

1. By 13.5k cal yr BP, post-LGM climatic amelioration had allowed highly mobile desert-adapted hunter-gatherers to expand across the Gobi Desert,

exploiting a wide range of environments, including dune-fields. A period of increased aridity and resulting resource stress during the terminal Pleistocene and early Holocene may have encouraged the introduction of more specialized processing technologies like grinding stones and pottery for extracting additional nutrients from arid-adapted plant species like grass seeds (Bettinger et al., 2007; Elston et al., 2011). Residential mobility was high and organized in a circulating pattern more typical of Binford's (1980) foraging system.

2. Optimally warm and moist conditions following 8.0k cal yr BP led to the stabilization of dune-fields and the creation of diverse new habitats around rivers, lakes and larger interdunal marshes. Since local hunter-gatherers had begun using dune-field environments in previous periods, the new abundance of resources, along with the infilling of associated depressions, rivers and lake basins led to more regular and/or prolonged occupation of such environments. Hunter-gatherers continued to exploit a variety of environments using a radiating pattern of land-use similar to a collector system (Binford, 1980), with longer term seasonal base camps centred on dune-field environments.
3. After about 5.0k cal yr BP, widespread deterioration of steppe environments and the contraction of lakes and wetlands outside of dune-fields encouraged hunter-gatherers to intensify seasonal use of dune-field/wetland environments, which were oases of productivity. Diminished returns encouraged hunter-gatherers to make more frequent moves, resulting in the geographic expansion of smaller field camps and task sites. Herd animals were first incorporated

into the hunter-gatherer system at this time, providing new resources for subsistence and raw materials.

This chapter uses quantitative lithic analysis of assemblages assigned in the previous chapter to the Late Epipalaeolithic (Oasis 1), Neolithic (Oasis 2), and Eneolithic (Oasis 3) in order to test the proposed patterns of land-use. In the following chapter, local and supra-regional palaeoenvironmental data is synthesized in order to contextualize reconstructions of land-use with notable shifts in local effective moisture, vegetation, and hydrology. According to the resulting data, each hypothesis is reassessed in the concluding chapter.

4.1. Analysis of land-use

Human exploitation of various ecozones is expected to have shifted with post-LGM environmental change. Key ecozones would have become more or less productive in meeting the needs of local hunter-gatherers. The internally-drained basin-range and steppe topography of the Gobi Desert is expected to have provided discontinuous access to patchy resources, particularly when increased precipitation resulted in the capture of moisture from run-off within lowland basins, supporting the formation of lakes and denser vegetation. Lowland basins, open desert or desert-steppes, and mountainous highlands would have offered a range of seasonal resources. Wide swaths of low elevation land covered by dune-fields interspersed with wetlands and small lakes must have supported higher plant and animal diversity and productivity (Nicholas, 1998).

Ungulate populations noted by expedition scientists and explorers in the early 20th century (Allen, 1938) should have been more numerous under less arid conditions and would have provided more reliable access to large- and medium-bodied prey than in modern times. Numerous accounts of seasonally abundant avian fauna also suggest a former richness in small game (Nelson, 1925; Pond, n.d.; Hedin, 1943).

Raw material resources, particularly high quality tool stone, would also have had important affects on land-use preferences and overall mobility. However, very little is known about the distribution of such resources in the Gobi Desert. According to expedition archaeologists the richest sources of raw materials in the western study areas were in the Arts Bogd-Ulan Nor Plains (Gobi-Altai) and the Ukh-Tokhoi/Khara Dzag plateaux region (Alashan Gobi) (Nelson, 1925; Maringer, 1950; Fairservis, 1993; see also Kulik et al., 2006). Pond (n.d.) also notes the presence of silicified volcanic ash and chalcedony sources in the Southwest subregion of the East Gobi (see Figure 1.2), but the extent of these resources is not clear. Some inferences about the availability of lithic raw material can be based on regional variability in frequencies of primary reduction and relative nodule size, inferred from percentage of remnant cortex and core volume. A more reliable assessment of the influence of raw material availability upon lithic assemblage variability will only be possible, however, with additional research on material sources.

Differences in subsistence and settlement can be inferred for each phase by examining the distribution of archaeological sites within each target region during each time period (Oasis 1, 2, and 3). Palaeoenvironmental data can then contribute to our understanding of resource availability. Large-scale changes in land-use across the Gobi Desert can also be recognized. Lithic assemblage composition and lithic reduction strategies are used to assess relative levels of residential mobility between regions and time periods. Formal cores and tools tend to be associated with situations of high residential mobility and raw material conservation, while informal cores and tools are more common in situations of decreased mobility. Examining qualitative and quantitative differences between lithic assemblages will allow us to ascertain whether certain environments with large site assemblages were associated with longer term occupations, or whether they were simply frequently reoccupied. While all environments might yield proof of human habitation and exploitation, the goal is to recognize changes in their function and relative importance throughout time.

4.1.1. Categorization of sites and environments

In addition to period assignments, each archaeological assemblage is categorized according to relative assemblage size and environmental context. Artefact assemblage composition and the dominant modes of lithic reduction are used as evidence for site function and relative duration of occupation. The relative density of each site is based on orders of magnitude for artefact counts (< 10, 11 to 100, 101 to 1000, 1001 to 5000, > 5000). This approach is considered a more reliable estimate of site size due to variation in surface collection methods. Interpretations of raw material use are based on core dimensions, relative percentage of remnant cortical surface, reduction strategies, and extent and intensity of retouch. Resulting interpretations of relative length of occupation within different ecozones can then be used to interpret overall mobility and aspects of subsistence.

Based on knowledge of Gobi Desert landforms and previous interpretations of land-use in arid Northwest China (e.g., Bettinger et al., 2007) we should expect significant variation in the use of five distinct terrains: dune-field, lake, steppe, mid-elevation (e.g., mesas, hillslopes, plateaux), and mountainous terrain. Four separate environmental factors should be important in delineating ecozone categories based on variation in modern floral and faunal distribution: elevation, topography, water source, and presence/absence of sand or dune-fields (Allen, 1938; Jigjidsuren and Johnson, 2003; Batsaikhan et al., 2010). Data on elevation (metres a.s.l.) was sometimes recorded in field journals, but I more often estimated elevation by locating each archaeological site on expedition base maps (Hill, n.d.; Hill and Roberts, n.d.; Roberts et al., n.d.;) and recent topographic maps (Army Map Services, Corps of Engineers, U.S. Army, Washington, D.C., 1949, 1950, 1954; Norin, 1978; Bureau of Geological Investigation, Geological Survey of Mongolia, 2003a, 2003b, 2003c, 2003d) according to site names and descriptions (Nelson, 1925; Pond, 1928, n.d.; Maringer, 1950). Expedition maps were all at the 1:200,000 scale. Regional maps were at the 1:500,000 scale for the Gobi-Altai region, at a 1:1,000,000 scale for the Alashan Gobi and East Gobi (Norin and Montell, 1969), and at the 1:500,000 for the Gurnai Depression (Norin, 1978).

I derived information about topography, water sources, and presence or absence of sand primarily from site descriptions, complemented by cartographic data where site descriptions are lacking. For greater accuracy, information on nearby water sources was referenced with maps, since changes in the surficial hydrology of the study area have been dramatic over the past 3000 years. Many sites were recorded as being discovered near wells, but maps clarify the hydrological context by indicating the proximity of “intermittent streams” or drainage channels. In such circumstances, the site is considered to be found near a stream. Wetlands and lakes were grouped together since the distinction may have been less relevant in wetter periods where what are today wetlands or marshes would have been extant lakes. Moreover, wetland/marsh margins of lake habitats were probably just as, or more, important to hunter-gatherers as the lakes themselves. Table 4.1 outlines the categories used for classifying various localities.

Parameter	Categorization groupings				
Elevation metres a.s.l.	1 = < 1000	2 = 1000-1200	3 = 1201-1400	4 = > 1400	
Topography	1 = basin (basin/ valley)	2 = steppe (plains/basin plains)	3 = promontory (mesa/hillslope/ hilltop/foothills)	4 = upland (mountains/ foothills)	
Water source	none	well/spring	river/stream	lake/wetland	
Sand	1 = none	2 = present			
Site size # artefacts	1 = < 10	2 = 10-100	3 = 101-1000	4 = 1001-5000	5 = > 5000

Table 4.1 List of categories used for analysis of site context.

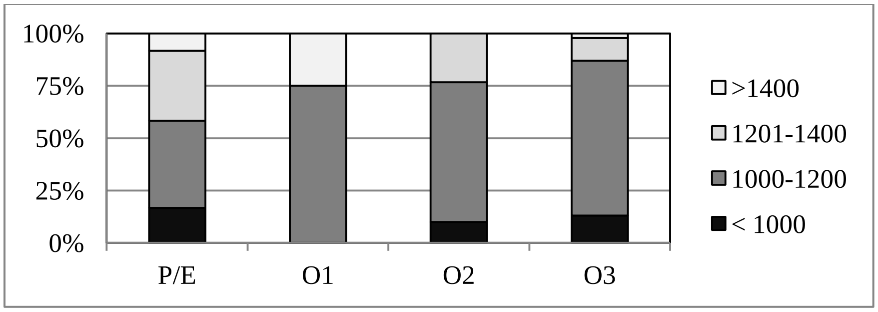
In order to determine which environmental parameters were most relevant to archaeological locations, Pearson's chi-square was used to evaluate the natural juxtaposition of environmental parameters (Table 4.2). The relationships between water source and both elevations and topography were difficult to test due to low cell counts, but individual cells showed a strong significance between the association of rivers and streams and camps in upland locales (especially 1201-1400 m a.s.l. and mountainous terrain), while camps in basins or valley lowlands suggested significant association with lakes and/or wetlands. Sites associated with sand dunes showed a strong correlation with basin/valleys, lake/wetlands, and elevations between 1000 and 1200 m a.s.l. ($p = < 0.0001$). These relationships are not surprising considering natural geological processes; however, the distribution of sites within a specific intersection of environmental zones is worth noting.

ELEVATION/ WATER Count Expected	< 1000	1000-1200	1201-1400	> 1400
None	5 1.9	8 10.3	2 2.6	1 1.7
Well/spring	2 1.2	5 6.4	1 1.6	2 0.7
River/stream	4 4.2	17 23.2	10 5.9	5 2.6
Lake/wetland	2 5.7	41 31.0	5 7.8	0 3.5
TOPOGRAPHY/ WATER	Basin/valley	Steppe	Promontory	Upland
None	7 9.9	5 2.4	2 2.0	3 2.7
Well/spring	3 6.4	4 1.6	0 1.3	4 1.8
River/stream	14 20.9	3 5.1	8 4.2	11 5.8
Lake/wetland	41 27.9	4 6.9	3 5.6	0 7.7
ELEVATION/ SAND	< 1000	1000-1200	1201-1400	> 1400
No sand	5 5.5	21 30.3	13 7.7	8 3.4
Sand	8 7.4	50 40.7	5 10.3	0 4.6
TOPOGRAPHY/ SAND	Basin/valley	Steppe	Promontory	Upland
No sand	10 27.9	11 6.9	9 5.6	18 7.7
Sand	55 37.1	5 9.1	4 7.4	0 10.3
WATER/ SAND	None	Well/spring	River/stream	Lake/wetland
No sand	10 7.3	9 4.7	26 15.4	3 20.6
Sand	7 9.7	2 6.3	10 20.6	45 27.4

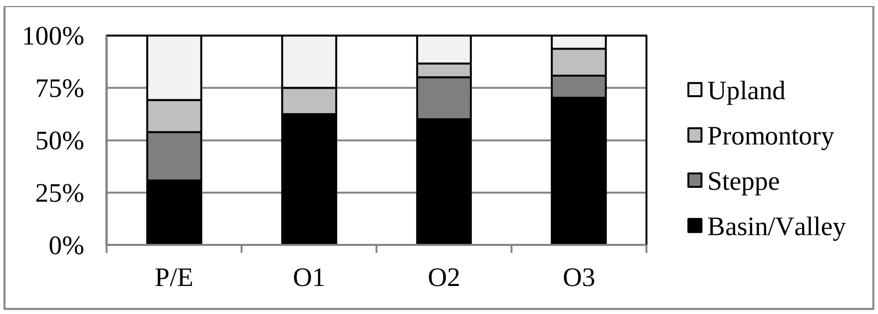
Table 4.2 Relationship between environmental parameters, showing natural juxtaposition of variables. Elevation/water: $X^2 = 26.04$, $p = 0.0020$. Topography/water: $X^2 = 40.88$, $p = <0.0001$. Elevation/sand: $X^2 = 22.24$, $p = <0.0001$. Topography/sand: $X^2 = 52.10$, $p = <0.0001$. Water/sand: $X^2 = 47.53$, $p = <0.0001$.

Due to the low number of Palaeolithic and Epipalaeolithic sites and a sample biased (either through collection practises or natural occurrence) towards sites in lowland dune-field environments, individual cell counts are too low to test the significance of distribution; however, visual consideration of sites according to period (i.e., Palaeolithic/Early Epipalaeolithic, Oasis 1, Oasis 2, and Oasis 3) suggests that certain environmental zones were probably favoured during different periods (Figure 4.1, Table 4.3). Oasis 1, Oasis 2, and Oasis 3 sites show a strong distribution at elevations between 1000-1200 m a.s.l. High elevation sites (> 1400 m a.s.l.) are most rare. Distribution of sites according to elevation is probably closely related to natural local topography and collection biases – the majority of landmass in the Gobi Desert rests at elevations of between 1000 and 1200 m a.s.l. and high elevation locales were not as extensively explored during collecting expeditions. Despite this probable bias, individual cell counts in Table 4.3 show that Palaeolithic/Epipalaeolithic sites are more commonly associated with elevations between 1201 and 1400 m a.s.l. than would be expected for a random sample.

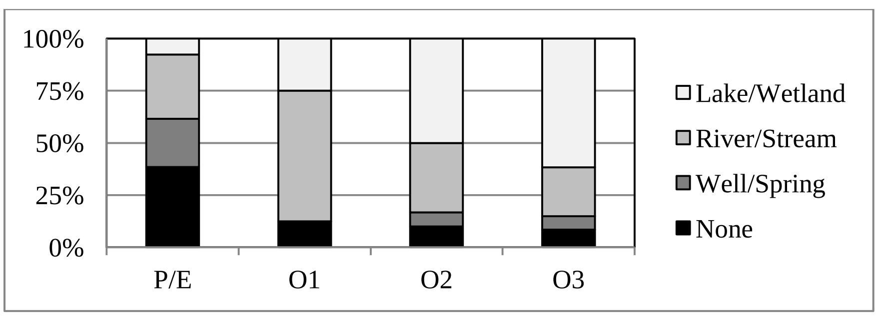
Considering the lack of sites at elevations above 1400 m a.s.l., and the potential for an underrepresentation of sites at elevations above 1200 m a.s.l., topographic parameters are considered to be more informative (i.e., basin/valley, steppe, promontory, upland). An entire range of topographic environments were exploited during all periods, but Oasis 1, 2 and 3 sites were most common in basins, depressions, or valleys (Figure 4.1, Table 4.3).



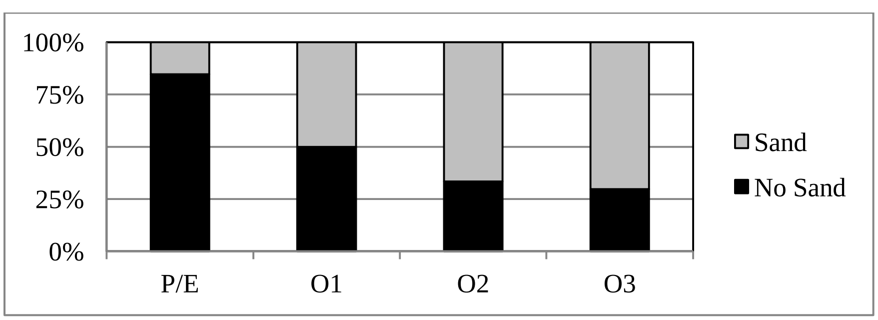
a.



b.



c.



d.

Figure 4.1 Distribution of Gobi Desert sites according to each environmental parameter: a) elevation; b) topography; c) water source; d) sand. Palaeolithic/Early Epipalaeolithic, N= 13; Oasis 1, N = 8; Oasis 2, N= 30; Oasis 3, N = 47.

ELEVATION	Palaeolithic/ Epipalaeolithic	Oasis 1	Oasis 2	Oasis 3
< 1000	2 1.4	0 0.9	3 3.4	6 5.3
1000-1200	5 8.1	6 5.4	20 20.3	34 31.1
1201-1400	4 2.0	0 1.3	7 5.0	5 7.7
> 1400	1 0.5	2 0.3	5 7.7	1 1.9
TOPOGRAPHY				
Basin/valley	4 8.0	5 4.9	18 18.4	33 28.8
Steppe	3 1.9	0 1.1	6 4.3	5 6.7
Promontory	2 1.5	1 0.9	2 3.4	6 5.3
Mountains	4 1.8	2 1.1	4 4.0	3 6.2
WATER SOURCE				
none	5 1.7	1 1.1	3 4.0	4 6.2
Well/spring	3 1.1	0 0.6	2 2.4	3 3.8
River/stream	4 4.0	5 2.4	10 9.2	11 14.4
Lake/wetland	1 6.2	2 3.8	15 14.4	29 22.5
SAND				
absent	11 5.2	4 3.2	10 11.9	14 18.7
present	2 7.8	4 4.8	20 18.1	33 28.3

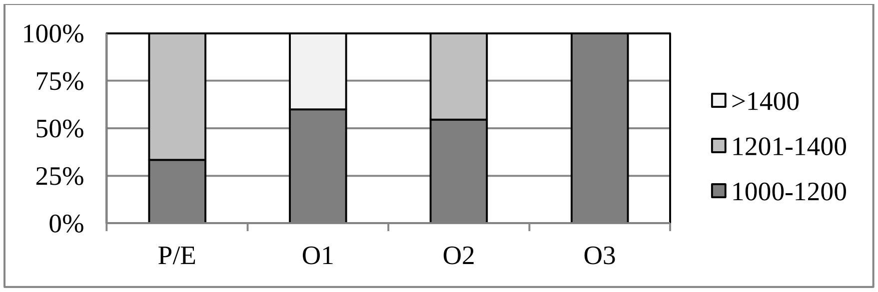
Table 4.3 Actual and expected distribution of sites according to each environmental parameter. Elevation: $X^2 = 18.47$, $p = 0.0301$. Topography: $X^2 = 11.95$, $p = 0.2163$. Water source: $X^2 = 22.41$, $p = 0.0077$. Sand: $X^2 = 13.74$, $p = 0.0033$.

One of the most distinct patterns is found for water sources. Palaeolithic and Epipalaeolithic sites are almost entirely absent from wetland/lake environments, while Oasis 2 and Oasis 3 sites cluster around major water sources (river/stream, wetland/lake). Oasis 1 sites are most common around rivers or streams, while Oasis 3 sites are most commonly found around lakes or wetlands. Oasis 2 sites are primarily distributed near rivers/streams and wetland/lakes.

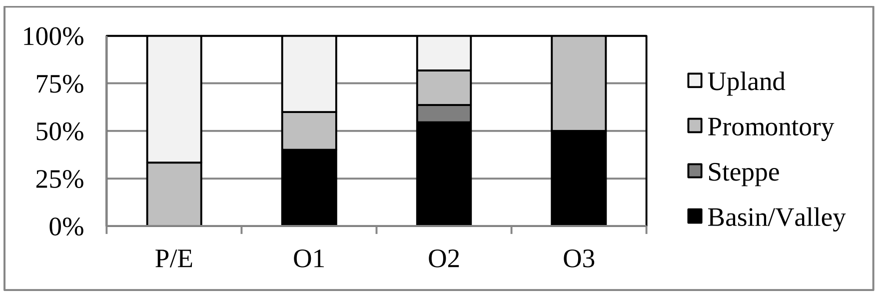
Other notable patterns include the association of Palaeolithic and Early Epipalaeolithic sites with elevations between 1201-1400 m a.s.l. and upland topography, the association of Oasis 3 sites with basin/valley topography, and the preferential association of Oasis 3 sites with sandy environments. Dune-fields appear to have been important to Gobi Desert groups during Oasis 2 (20 out of 30 sites) and Oasis 3 (33 out of 47 sites), but are underrepresented in earlier periods. While cell counts indicate significant associations with basin/valleys, lake/wetlands, and sand only in Oasis 3, the numbers suggest that such environments were avoided in early periods and that habitation became progressively more common beginning in Oasis 1. Stabilization of dune-fields activated during the LGM was probably not complete until after the Younger Dryas and early Holocene (Grunert and Lehmkuhl, 2004). Prior to the stabilization of dune-field environments in the early Holocene, they would not have offered rich ecosystems for foraging. Similarly, the wetland habitats that were apparently favoured in later periods may not have been well-established and productive until Oasis 2.

Site distribution according to period can also be investigated for each of the three regions. Figures 4.2-4.4 indicate consistency in site distribution between the three target regions. The East Gobi group (Figure 4.2) is notable in that Oasis 3 sites are equally distributed between basin/valley and promontory locales. This contradicts the general finding that lowland environments were uniformly favoured during both Oasis 2 and Oasis 3. East Gobi sites are also distributed mostly around rivers or streams, including about 50% of Oasis 2 and Oasis 3 sites. This condition may be attributed to either increased archaeological survey in 1928 around large rivers such as the Shara Murun and its tributaries, or to local hydrology, which is characterized by many rivers and drainage channels bounded by marshes and wetlands.

The Gobi-Altai group (Figure 4.3) shows a relatively high frequency of Palaeolithic/Early Epipalaeolithic (~25%) sites around lakes – a situation entirely lacking in other regions. The apparent distribution of these early sites around lakes might be due to more intensive sampling of dune-field/lake sites in the Gobi-Altai, where several distinct sites were recorded from the same locality. Better integrity of individual Shabarakh-usu sites might also contribute to enhanced recognition of early sites. In the East Gobi and Alashan Gobi, distinct sites were not maintained during collection, which confuses the recognition of early components. As noted in Appendix B, some artefacts from the Baron Shabaka Well locality in the East Gobi are most typical of the Epipalaeolithic, but the lack of site structure limits interpretation. Excavation of sub-dune layers around dune-field/wetland sites is probably needed in order to better assess this circumstance.



a.



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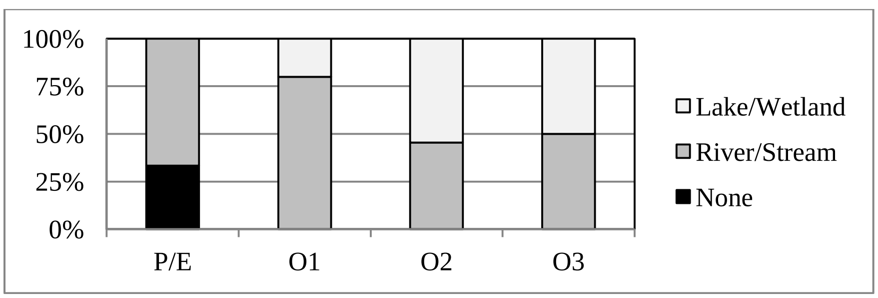

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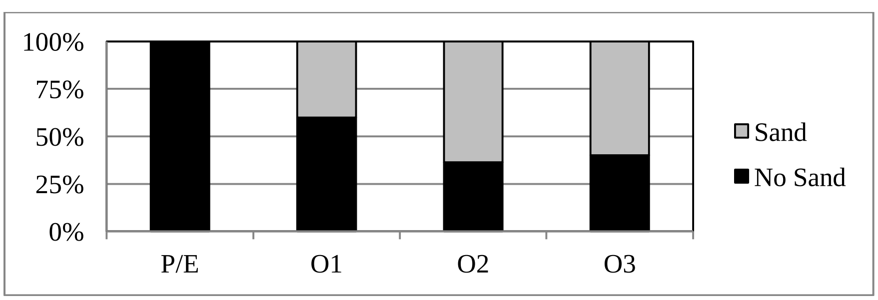
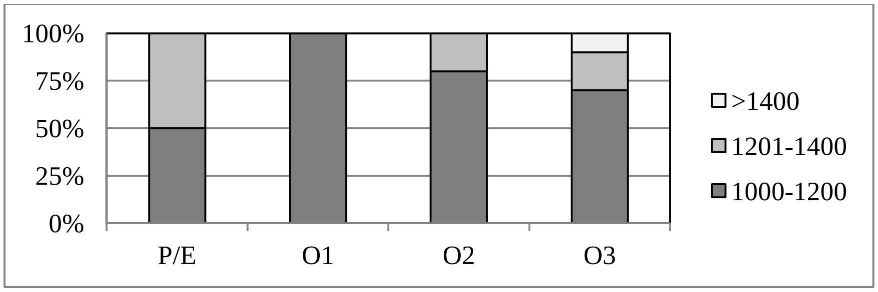


d.

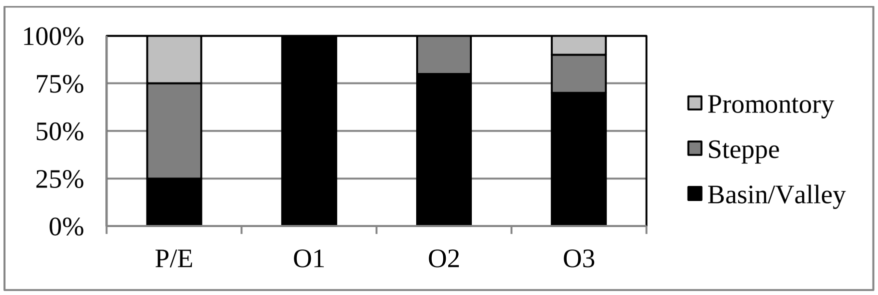
Figure 4.2 Distribution of East Gobi sites according to each environmental parameter: a) elevation; b) topography; c) water source; d) sand. Palaeolithic/Early Epipalaeolithic, N = 3; Oasis 1, N = 5; Oasis 2, N = 11; Oasis 3, N = 10.

ELEVATION	Palaeolithic/ Epipalaeolithic	Oasis 1	Oasis 2	Oasis 3
1000-1200	1 2.1	3 3.4	6 7.6	10 6.9
1201-1400	2 0.7	0 1.2	5 2.6	0 2.4
> 1400	0 0.2	2 0.3	0 0.8	0 0.7
TOPOGRAPHY				
Basin/valley	0 1.3	2 2.2	6 4.9	5 4.5
Steppe	0 0.1	0 0.2	1 0.4	0 0.3
Promontory	1 0.9	1 1.5	2 3.4	5 3.1
Mountains	2 0.6	2 1.0	2 2.3	0 2.1
WATER SOURCE				
none	1 0.1	0 0.2	0 0.4	0 0.3
River/stream	2 1.6	4 2.8	5 6.1	5 5.5
Lake/wetland	0 1.2	1 2.1	6 4.5	5 4.1
SAND				
absent	3 1.4	3 2.4	4 5.3	4 4.8
present	0 1.5	2 2.6	7 5.7	6 5.2

Table 4.4 Actual and expected distribution of sites in the East Gobi according to each environmental parameter. Elevation: $X^2 = 19.88$, $p = 0.0029$. Topography: $X^2 = 11.31$, $p = 0.2549$. Water source: $X^2 = 11.97$, $p = 0.0627$. Sand: $X^2 = 4.39$, $p = 0.2224$.



a.



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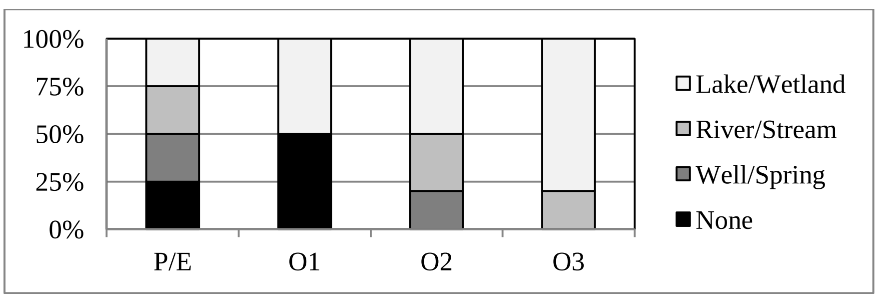
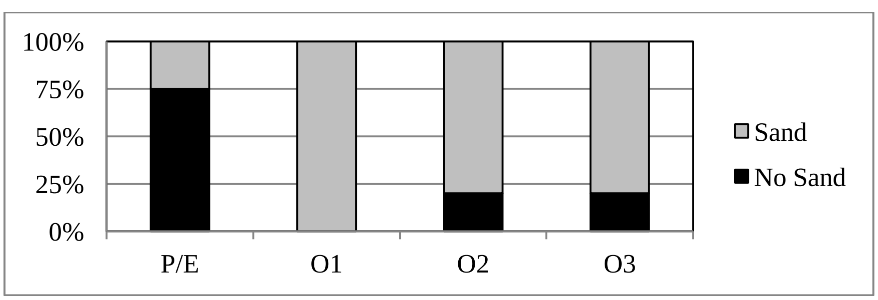


c.

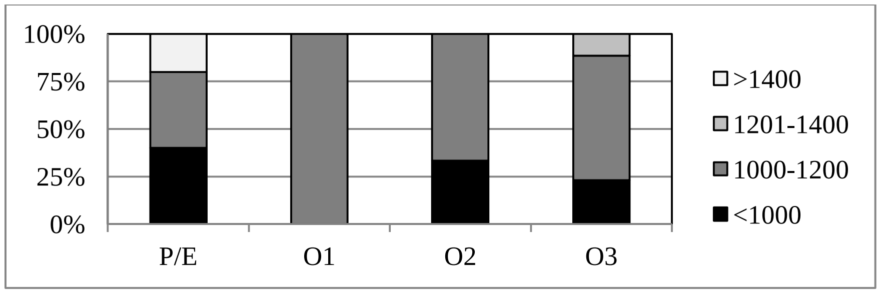


d.

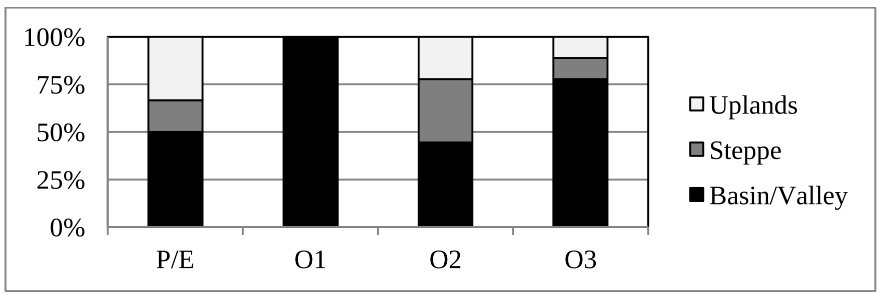
Figure 4.3 Distribution of Gobi-Altai sites according to each environmental parameter: a) elevation; b) topography; c) water source; d) sand. Palaeolithic/Early Epipalaeolithic, N = 4; Oasis 1, N = 2; Oasis 2, N = 10; Oasis 3, N = 10.

ELEVATION	Palaeolithic/ Epipalaeolithic	Oasis 1	Oasis 2	Oasis 3
1000-1200	2 2.9	2 1.5	8 7.3	7 7.3
1201-1400	2 0.9	0 0.5	2 2.3	2 2.3
> 1400	0 0.1	0 0.1	0 0.4	1 0.4
TOPOGRAPHY				
Basin/valley	1 2.8	2 1.4	8 6.9	7 6.9
Steppe	2 0.9	0 0.5	2 2.3	2 2.3
Promontory	1 0.3	0 0.1	0 0.8	1 0.8
WATER SOURCE				
None	1 0.3	1 0.1	0 0.8	0 0.8
Well/spring	1 0.5	0 0.2	2 1.1	0 1.1
River/stream	1 0.9	0 0.5	3 2.3	2 2.3
Lake/wetland	1 2.3	1 1.1	5 5.8	8 5.8
SAND				
absent	3 1.1	0 0.5	2 2.7	2 2.7
present	1 2.9	2 1.5	8 7.3	8 7.3

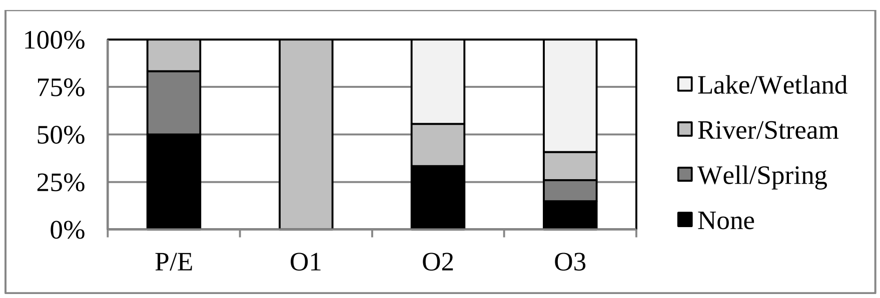
Table 4.5 Actual and expected distribution of sites in the Gobi-Altai according to each environmental parameter. Elevation: $X^2 = 3.97$, $p = 0.6810$. Topography: $X^2 = 5.92$, $p = 0.4320$. Water source: $X^2 = 12.83$, $p = 0.1706$. Sand: $X^2 = 5.92$, $p = 0.1154$.



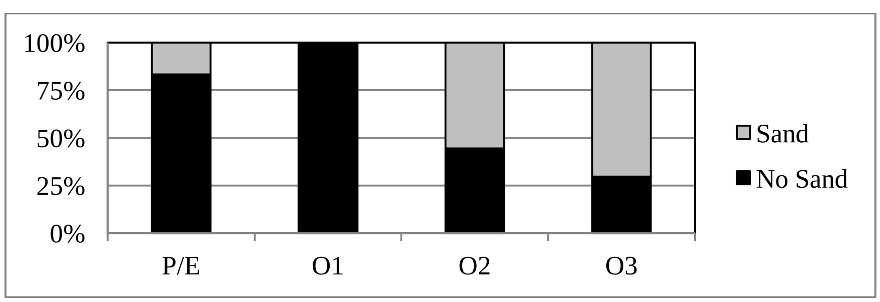
a.



b.



c.



d.

Figure 4.4 Distribution of Alashan Gobi sites according to each environmental parameter: a) elevation; b) topography; c) water source; d) sand. Palaeolithic/Early Epipalaeolithic, N = 6; Oasis 1, N = 1; Oasis 2, N = 9; Oasis 3, N = 27.

ELEVATION	Palaeolithic/ Epipalaeolithic	Oasis 1	Oasis 2	Oasis 3
< 1000	2 1.3	0 0.3	3 2.4	6 7.0
1000-1200	2 3.2	1 0.6	6 5.7	17 16.5
1201-1400	0 0.4	0 0.1	0 0.7	3 1.9
> 1400	1 0.1	0 0.0	0 0.2	0 0.6
TOPOGRAPHY				
Basin/valley	3 4.0	1 0.7	4 6.1	21 18.2
Steppe	1 1.0	0 0.2	3 1.5	3 4.4
Mountains	2 1.0	0 0.2	2 1.5	3 4.4
WATER SOURCE				
none	3 1.4	0 0.2	3 2.1	4 6.3
Well/spring	2 0.7	0 0.1	0 1.0	3 3.1
River/stream	1 1.1	1 0.2	2 1.7	4 5.0
Lake/wetland	0 2.8	0 0.5	4 4.2	16 12.5
SAND				
absent	5 2.5	1 0.4	4 3.8	8 11.3
present	1 3.5	0 0.6	5 5.2	19 15.7

Table 4.6 Actual and expected distribution of sites in the Alashan Gobi according to each environmental parameter. Elevation: $X^2 = 10.48$, $p = 0.3134$. Topography: $X^2 = 5.65$, $p = 0.4637$. Water source: $X^2 = 14.95$, $p = 0.0923$. Sand: $X^2 = 7.31$, $p = 0.0625$.

In the Alashan Gobi (Figure 4.4), Oasis 3 sites are most common around lakes or wetlands, but appear to have been more evenly distributed across different types of water sources than in other regions. The majority of Oasis 2 and Oasis 3 sites from mountainous terrain or elevations over 1400 m a.s.l. were from the Ukh-tokhoi/Khara-dzag plateaux region of the Alashan Gobi. Most of these sites are attributed to Oasis 3. Occupations identifiable as Oasis 2 or only Neolithic/Eneolithic (Oasis 2 or Oasis 3) were also recovered from mountainous terrain in the East Gobi, but these sites appear to have been related to raw material procurement. Only one site in the Gobi-Altai, associated with Oasis 3, was collected at an elevation of more than 1400 m a.s.l.

Broadly similar trends in the distribution of sites during different periods are characteristic of the Gobi Desert, despite above noted divergences between regions. The most notable trend is the use of dune-fields and lake/wetland environments during Oasis 2 and Oasis 3. It is probable that the abundance of Oasis 2 and Oasis 3 sites within dune-field/wetland environments is related to factors other than sampling bias. Dune-field/wetland environments are closely linked with topography and elevation; based on the distribution of sites within various topographic, hydrological, and depositional environments, five distinct ecozones can be distinguished: 1) lowland dune-field/wetland (lowland [< 1200 m a.s.l.] dune accumulations around rivers, marshes and lakes); 2) lowland river (sites situated on plains or wide valleys near rivers); 3) lowland dry (lowland sites with spring/well or no clear source of water); 4) upland (sites on mesas, mountains or other higher elevation regions near major water source); and 5) upland dry (upland [> 1200 m a.s.l.] sites with no apparent nearby water source or a minor water source such as a spring or well[14]).

Figures 4.5 and 4.6 illustrate the distribution of sites for each region and for the Gobi Desert as a whole. Distribution of sites across ecozones in the entire Gobi Desert sample further supports the trends noted above. Individual counts are too low for some variables to permit the use of chi-square, but the cell counts suggest a high probability that the distribution of sites is not a random effect of sampling (Table 4.7).

Several trends in land-use can be identified. The lack of early sites in dune-field/wetland environments is consistent for all regions. Although dune-field/wetlands appear to have been favoured, a range of environments were exploited during Oasis 2 and Oasis 3. Ecozones without access to major water sources appear to have been avoided during Oasis 1 (coinciding with the Younger Dryas; see Madsen et al., 1998), though the small sample size may contribute to this effect. According to site distribution, the use of high elevation (> 1200 m a.s.l.) or upland environments appears to have continued as an important component of Oasis 1 organizational strategies. Most clearly, the distribution of Gobi Desert sites indicates a gradual trend towards increasing exploitation of sandy lowland environments around major water sources, most of which would have been surrounded by marshland. While the increasing use of dune-field/wetland environments is evident in this sample, it is not clear how the use of other environments may have changed with time as new resources and technologies were incorporated into subsistence

[14] Although springs probably functioned in earlier periods, and wells may have been dug into former springs, these sources are considered in a different category because they provide water but none of the floral, faunal or material resources typically associated with major bodies of water.

strategies. Recognizing differences in how various ecozones were used will further enhance our understanding of changes in land-use over time. Appendix D lists the ecozone grouping of each studied site.

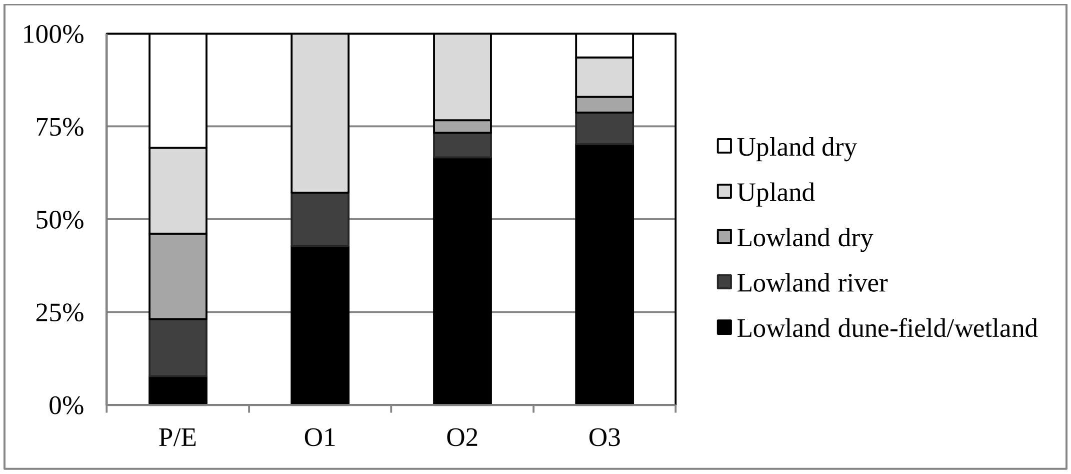


Figure 4.5 Distribution of Gobi Desert sites according to ecozone. Palaeolithic/Early Epipalaeolithic, N = 13; Oasis 1, N = 7; Oasis 2, N = 30; Oasis 3, N = 47).

Ecozone	Palaeolithic/ Epipalaeolithic	Oasis 1	Oasis 2	Oasis 3
Lowland dune-field/wetland	1 7.7	4 4.7	20 17.8	33 27.8
Lowland river	2 1.2	1 0.6	2 2.8	4 4.4
Lowland dry	3 0.8	0 0.4	1 1.8	2 2.9
Upland	3 2.4	3 1.3	7 5.6	5 8.7
Upland dry	4 0.9	0 0.5	0 2.2	3 3.4

Table 4.7 Actual and expected distribution of Gobi Desert sites according to each ecozone. $X^2 = 32.544$, $p = 0.0011$.

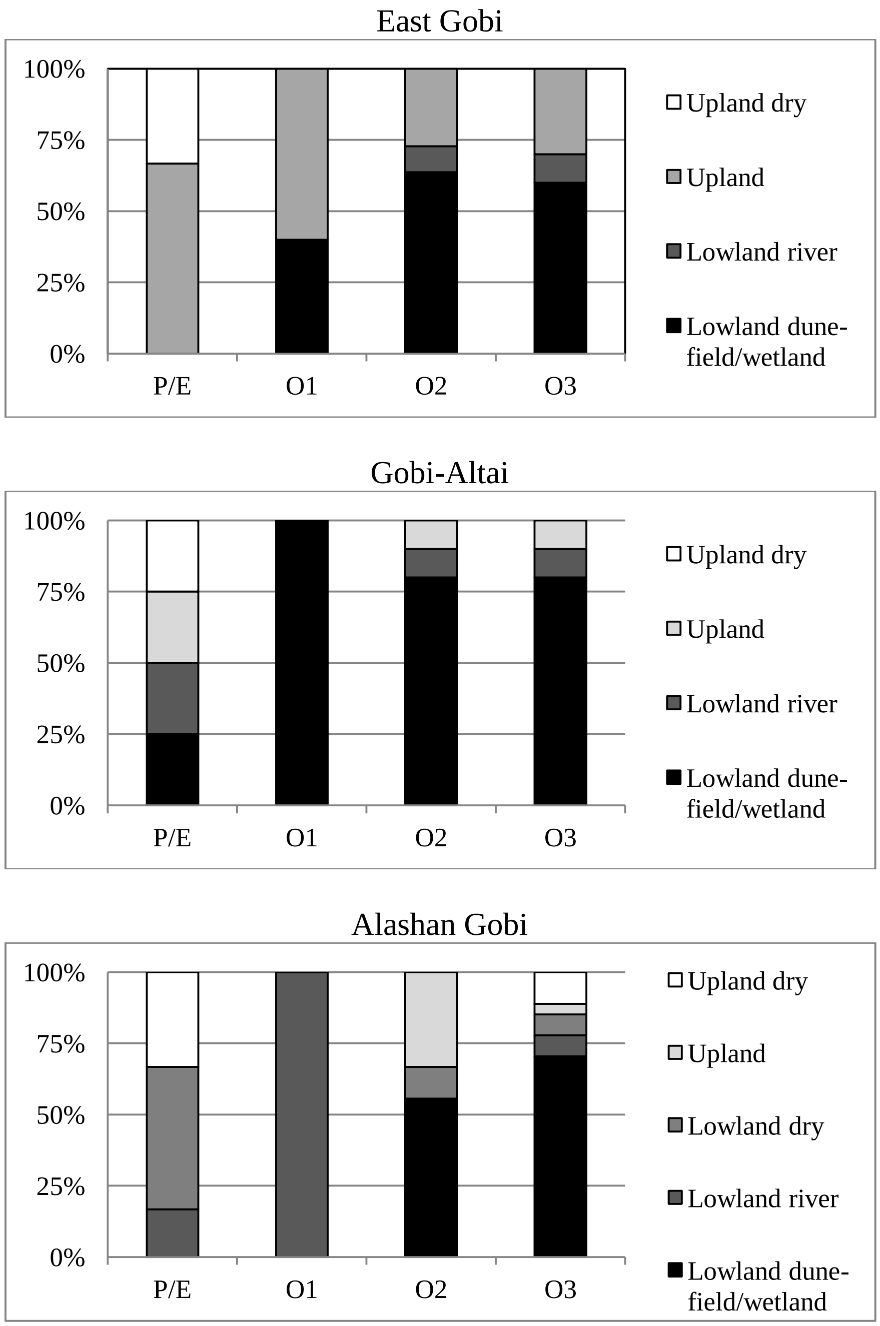


Figure 4.6 Distribution of sites in each target region according to ecozone. East Gobi: Palaeolithic/Early Epipalaeolithic, N = 3; Oasis 1, N = 5; Oasis 2, N = 11; Oasis 3, N = 10. Gobi-Altai: Palaeolithic/Early Epipalaeolithic, N = 4; Oasis 1, N = 2; Oasis 2, N = 10; Oasis 3, N = 10. Alashan Gobi: Palaeolithic/Early Epipalaeolithic, N = 6; Oasis 1, N = 1; Oasis 2, N = 9; Oasis 3, N = 27.

East Gobi

Ecozone	Palaeolithic/ Epipalaeolithic	Oasis 1	Oasis 2	Oasis 3
Lowland dune-field/wetland	0 1.5	2 2.6	7 5.7	6 5.2
Lowland river	0 0.2	0 0.3	1 0.8	1 0.7
Upland	2 1.1	3 1.9	3 4.2	3 3.8
Upland dry	1 0.1	0 0.2	0 0. 4	0 0.3

$X^2 = 13.34$, $p = 0.1476$

Gobi-Altai

Ecozone	Palaeolithic/ Epipalaeolithic	Oasis 1	Oasis 2	Oasis 3
Lowland dune-field/wetland	1 2.9	2 1.5	8 7.3	8 7.3
Lowland river	1 0.5	0 0.2	1 1.1	1 1.1
Upland	1 0.5	0 0.2	1 1.1	1 1.1
Upland dry	1 0.1	0 0.1	0 0.4	0 0.4

$X^2 = 8.90$, $p = 0.4470$

Alashan Gobi

Ecozone	Palaeolithic/ Epipalaeolithic	Oasis 1	Oasis 2	Oasis 3
Lowland dune-field/wetland	0 3.3	0 0.6	5 5.0	19 15.1
Lowland river	1 0.6	1 0.1	0 0.8	2 2.5
Lowland dry	3 0.8	0 0.1	1 1.2	2 3.8
Upland	0 0.6	0 0.1	3 0.8	1 2.5
Upland dry	2 0.7	0 0.1	0 1.0	3 3.1

$X^2 = 32.42$, $p = 0.0012$

Table 4.8 Actual and expected distribution of sites in each region according to ecozone.

4.1.2. Assemblage composition

Variation in assemblage composition can help decipher the use of different ecozones in which sites were found. A variety of information can suggest site function. Relative site size and assemblage composition are the most important data used for this purpose. Artefact assemblage composition, based on the presence or absence of certain artefact types, gives a general sense of tasks carried out at each site, as well as an overall impression of technological organization within the broader organizational strategy. Aspects of subsistence practices, residential mobility, transport limitations, scheduling, perceived risk, and raw material availability all contribute in different ways to the composition of tools kits (Binford, 1979; Torrence, 1983; Bleed, 1986; Parry and Kelly, 1987; Nelson, 1991; Bousman, 1993; Kuhn, 1994; 1995; Bamforth and Bleed, 1997). Specialized technologies are especially useful for the recognition of particular activities within each environment.

Misrepresentation of site function can occur due to factors such as differences in the rates of discard, variation in occupation span, and post-depositional collection of artefacts for reuse, or as souvenirs (Schiffer, 1987: 47-50; 114-119). Rare artefacts that are very sensitive to site function and chronology, such as decorated pottery, and finished tools such as projectile points, are those most frequently collected by archaeologists in past decades (Schiffer, 1987: 116). Comparisons between large sites where researchers were only able to recover and curate a small incomplete sample, and very small sites from which an entire assemblage could be collected, are expected to be especially problematic. In the Gobi Desert, as Pond (n.d.) observed, it is probable that grinding stones were often scavenged over the millennia. The practice of scavenging heavy ground stone tools for reuse may have increased with the introduction of animals for transport (see Schiffer, 1987: 114).

Differences in depositional contexts and collection practices can influence interpretations of intra-assemblage variability. Due to the possibility of such biases, site categorizations are based on presence/absence rather than artefact counts. However, I believe the same indices, such as the ratio of formal to informal cores in each assemblage, is less biased by collection practices. High variation among sites, including a suggestive pattern of high levels of expedient technologies in the larger assemblages (see section 4.1.3) suggests that collection biases were minimal. Variation due to collection biases is also expected to be more significant in comparisions between regions than in comparisons within them. Assemblages within each region were collected, if not by the same researcher, by the same expedition group and are expected to be relatively internally cohesive.

High density of occupation debris within Gobi Desert dune-field/wetland environments are a key characteristic of the Neolithic/Eneolithic archaeological record. However, it is not known if these occupations resulted from relatively long term habitation in this particular environment or from successive short-term reoccupations. Discrete sites or artefact clusters were clearly noted at Shabarakh-usu and Baron Shabaka Well (Nelson, 1925; Pond, n.d.; Fairservis, 1993; Janz, 2006). Such clusters could have resulted from sequential reoccupations or from the activities of contemporaneous task groups associated with a single longer term occupation site. Identifiable differences in site function are expected to exist between ecozones, with the use of certain environments changing over time. The increased focus on dune-field/wetlands during Oasis 2 anticipates distinct differences in site function during that period when compared to earlier Oasis 1 occupations.

4.1.2.1. Concepts and methods

Two types of archetypical hunter-gatherer settlement systems were used by Binford (1980) to represent extremes on a continuum of residential mobility strategies. Situating Gobi Desert groups along this continuum is helpful in understanding these arid lands high-latitude hunter-gatherers. At either end of the continuum are “foragers” and “collectors.” Foragers are identified with high residential mobility organized in a circulating pattern of land-use, while collectors are characterized by a pattern of logistical radiating land-use centred on a more sedentary home base. Both foragers and collectors hunt and gather from aggregation sites known respectively as *residential bases* or a *base camps*. Short-term procurement locales or task sites were used by both groups and are referred to by Binford (1980) as *locations*. *Field camps* are sites where long-ranging task groups are maintained away from the collector base camps. Collector *caches* and *stations* were not considered here due to issues of survival and recognition in the archaeological record. Based on the archaeological visibility of site types, a general designation of *residential sites* is used to encompass residential bases, base camps, and field camps, while *task sites* can account for the remainder of site functions.

Foragers tend to employ a circular pattern of mobility based on "moving consumers to goods" (Binford, 1980). Foragers move residential bases when the risk of procuring sufficient resources from the local environment is considered to outweigh the risk of moving to another camp (after MacArthur and Pianka, 1966; Kelly, 1995: 132-148). As such, short-term residential sites are regularly created across the entire landscape and resulting artefact assemblages show low variability. Task groups hunt and gather food within a daily walkable radius of the camp site, but their activities leave few material remains. In highly patchy environments, where key resources are abundant in only a few places, foragers are expected to fall into a pattern referred to as *tethered nomadism*, wherein extreme redundancy is exhibited in the reuse of key environments (Taylor, 1964; Yellen and Harpending, 1972; Binford, 1980). The pattern of tethered foraging is expected in deserts where water is scarce, but even within the same desert environment the level of seasonal residential mobility varies greatly based on access to local resources (Kelly, 1995: 126-128).

Collectors exhibit lower residential mobility. Base camps are situated near key resources and occupations often extend over one or more seasons. Goods are moved to consumers through procurement of resources by different types of task groups (Binford, 1980). *Field camps* serve as temporary home bases for task groups operating far from the residential base and are expected to vary according to the nature of targeted resources. Task sites or *locations* are also typical of collector groups, but larger consumer group sizes may result in higher site visibility than those produced by foragers. As noted by Habu (1996) for the Early Jomon Moroiso phase in Japan, hunter-gatherer habitation sites with evidence of semi-subterranean houses and high inter-assemblage variability are good candidates for typical collector-type systems. Collector-type systems are thought to be most common in temperate, arctic, and subarctic environments because the seasonal constraints of mobility and availability of food resources play an important role in determining mobility and resource procurement (Binford, 1980; Lieberman et al., 1993; Kelly, 1995: 117).

In principal, archaeological evidence of residential and task sites should be quite different at extreme ends of the collector/forager continuum. However, extrapolation from the archaeological record is not so straight forward. Hunter-gatherer land-use strategies are not naturally dichotomous and can seldom be neatly categorized as such (Binford, 1980, 1982; Lieberman et al., 1993). Seasonal variation in acquisition strategies may typify a group as foragers in the summer months and collectors in the winter months, or vice versa. Interpretations of site function might vary according to differences in the original organization of habitation sites or methods of discard: carrying out certain tasks farther from the main group; provisioning of sites for subsequent reoccupation (caching); cleaning practices such as the removal of debitage and debris from the primary habitation area; or failure to discard valuable, highly curated tools (Schiffer, 1972, 1987: 58-72, 89-97). Palimpsest accumulations from multiple occupations of various types can also confuse interpretations of land-use patterning (Binford, 1982). Dense accumulations of archaeological remains are most prone to misinterpretation. While inter-assemblage variability should increase with length of occupation and be indicative of residential sites, overlapping task sites might also simulate a pattern of longer-term habitation (e.g., Schiffer, 1975).

However, distinguishing between residential and task specific sites should be easier than recognizing more detailed aspects of site function. Cooking activities would seldom occur outside of field camps, base camps, or residential bases. Similarly, the large grinding stones found in East Gobi assemblages are heavy and so were probably limited to residential rather than task sites. The fact that they are associated with denser accumulations of cultural remains confirms this point. In view of the cost of transporting grinding equipment and the laborious task of processing, it is likely that large formal grinding stones would only be found at longer-term residential bases where intensive processing was being undertaken. Grooved slabs used for finishing beads or used as shaft straighteners are likewise less portable. Despite frequent evidence for the use of pottery by hunter-gatherers, ceramic vessels are also somewhat less portable. This is especially true when considering less fragile technologies like baskets or more expedient ways of cooking such as with open-fires or earthen pits (Nelson, 1991; Sassaman, 1993). It is expected that both the friable nature of ceramics, particularly the low-fired ones used in Oasis 2, and spatial limitations on food preparation activities should limit their use to the base camp or forager residential base. Less portable tool types such as grinding stones, grooved slabs, and pottery are recorded for each site and are expected to give an indication of both site-specific activities and site type.

Site categorizations can be made based on the range of activities represented by tool types. Habitation sites should include evidence for a range of activities, while task sites are expected to be focused on one or possibly two. Cooking, manufacturing, hunting, bead-making, and lithic reduction are recognized as key activity types. Woodworking is tentatively assigned based on the presence of adze/axes (Hayden, 1989), though it is not clear that this was their primary or sole utility. The presence of bone is noted as it suggests butchering or processing meat was one on-site activity, but is not an especially significant distinction due to high variation in the survival rates of bone in such assemblages.

In this study, residential sites are primarily defined on the presence of pottery, grinding stones, hearths, or fire-cracked rocks, which are attributed to extensive “cooking.” Evidence for cooking is not considered definitive since pottery and hearths may be underrepresented as they are artefacts more subject to destructive post-depositional processes than lithics. “Manufacturing” includes tools such as scrapers, drills, grooved slabs, whetstones, knives, and slag, which are associated with production, processing, and repair activities. “Hunting” is based on the occurrence of large and small unifacial or bifacial points morphologically consistent with arrows or spears. The latter category is also expected in sites where manufacture and maintenance of hunting equipment was carried out. Microblades were probably multifunctional and are not used to infer site function. Lithic reduction is recognized by the presence of cores, hammerstones, and unused/unmodified debitage flakes. Ornament production or bead-making is recognized based on the presence of unfinished beads and pendants.

The presence of specialized tools and formal generalized tools is informative not only about site function, but also about site specific approaches to raw material use and the relative importance of different tasks. Tools manufactured explicitly for one function are expected to be more efficient. They should be most common at sites produced under time constraints, where only a limited range of activities took place (Torrence, 1983). A specialized tool kit includes a diverse range of highly efficient, but less multi-functional implements. An array of specialized tools is likely to be more common when there is ample time for increased investment in manufacture, but actual tool use occurs under situations of frequent repetition and limited time. In contrast, when many different tasks are being undertaken, a more generalized tool kit is expected. Generalized tools are those that serve a multitude of functions, but are not designed to fill any one particular role. For this reason, long-term residential sites are expected to contain a select range of formal specialized tools and numerous informal generalized types. Both specialized and generalized tools can be either expediently or formally made, although specialized tools are frequently types that require higher investment in labour.

Residential and individual mobility have a great affect on differences in access to high quality raw materials. Access to raw materials is expected to most heavily influence technological choices, since decisions of curation and transport are based on the frequency and predictability of resource distribution (Andrefsky, 1994). Highly mobile individuals are should produce assemblages consistent with the need to either transport required tools to each new location or make use of whatever raw material resources are immediately available (Shott, 1986; Kuhn, 1994; Brantingham, 2003; Barton et al., 2007). Formal tools are likely to have been favoured over more expediently produced ones in circumstances where the reliability of a tool is important and there is intermittent but predictable access to the quality of raw materials needed to produce standardized forms. When highly mobile individuals choose to transport formal tools, the constraints associated with transport or the *carrying costs* support the use of multi-functional rather than specialized tool types (Bleed, 1986; Torrence, 1989; Kuhn, 1994).

Composite hafts with microblade insets, as attested to in Gobi Desert assemblages (Dorj, 1971; Derevianko and Dorj, 1992; Derevianko et al., 2003), are an excellent example of multi-functional formal tools that are portable and easily maintained (Bleed, 1986). Some researchers have also suggested that they were favoured as being more reliable in big game hunting than previous technologies (Myers, 1989; Elston and Brantingham, 2002). These characteristics of portability, versatility, and reliability are thought to indicate both an increased investment in the aquisition of large game and high mobility among microblade-using post-LGM hunter-gatherers in Northeast Asia (Elston and Brantingham, 2002). The large bifaces used by Palaeoindians in North America are another example of a technology that is portable, versatile and reliable (Kelly, 1988; Surovell, 2003: 229-236). Such technologies can be thought of as generalized formal tools.

Conversely, higher levels of sedentism are usually associated with expedient tools and cores (Parry and Kelly, 1987). Expedient technologies are associated with a lower degree of raw material conservation and lessened emphasis on reliability (Wallace and Shea, 2006). Expedient tools are more common when raw material is plentiful. In such circumstances, generalized expedient technology should be favoured when a wide range of tasks will be undertaken, and there is plenty of time to complete specific tasks.

Specialized expedient technology would then be indicative of a situation where there is ample raw material, but constraints on other aspects of production/processing such as limited time or the need for a higher level of performance than a multi-functional tool could provide (i.e., reliability).

Therefore, within each assemblage tool characteristics such as expedient, formal, specialized, and generalized are indicative of both site function and raw material access. Raw material access is a function of both local distribution and relative levels of residential or individual mobility. Specialized tools in Gobi Desert assemblages include drills and awls (drilling – formal), perforators (drilling – expedient/informal), projectile points (hunting – formal), grinding stones (food processing – both formal and informal types), grooved grinding slabs (bead-making or hunting – formal[15]), pottery (cooking or storing – formal), edge-ground and possibly chipped adze/axes (woodworking – formal).

Generalized tools include used flakes (informal), expedient scrapers (informal), used and/or retouched microblades (formal), and bifacial knives (formal). Composite points with microblade inserts are also formal specialized tools, but can not be identified solely on the basis of microblades, which were used individually or as insets for a variety of tools. Microblades are considered a type of generalized formal technology. Wedge-shaped microblade cores are also considered to be generalized formal tools, which provide both a source of standardized tool blanks, and a knife-like edge for cutting.

Adze/axes are unique formal tools that can serve a multitude of purposes, but might also be considered specialized in that they are usually associated with

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[15] Grooved grinding slabs are known to have been used for bead manufacture, but were possibly also used as shaft straighteners (see Maringer 1950: 109-110; Janz, 2006).

woodworking (Hayden, 1989; Mills, 1993; Yerkes et al., 2003). Edge-ground tools are known to have been used during episodes of intensive, repetitive processing under high constraints on time (Hayden, 1989). The occurrence of chipped and/or polished adze/axes in Oasis 2 and Oasis 3 assemblages is particularly notable due both to implied function and implications for raw material conservation. While the majority of tools in these collections were made on small flakes, adze/axes are notable because they have the potential to be resharpened and reused over an extended period. Edge-ground adze/axes can be resharpened "seemingly indefinitely" (Hayden, 1989). At the same time, edge-grinding is extremely time-consuming and appropriate downtime would have been required to manufacture and maintain functionality (Hayden, 1989; Owen, 2007). Such tools are larger and heavier, so theorectically less portable, than the typical microlithic tools. Woodworking or other highly intensive processing and manufacturing activities are suggested when adze/axes are present.

The aforementioned characteristics of artefact type and assemblage composition were used to categorize each site as summarized in Appendix D. The dichotomous label of foragers versus collectors is not applied here. There is no clear evidence from the Gobi Desert of either large middens or permanent/semi-permanent prehistoric structures. Site occupations probably lasted no longer than one season. Collector-type settlement systems known among other prehistoric Northeast Asian hunter-gatherers like the Early Jomon in Japan are not typical of this region. Binford's (1980) emphasis on the continuum of hunter-gatherer adaptations and his overarching definition of foragers and collectors – the former focused on moving themselves to resources and the latter as focused on moving resources to themselves – is a more compelling distinction that can be better applied to the Gobi Desert archaeological record.

Due to variation in the organization of settlement systems and the difficulty in discerning discrete site functions, the three site type designations are used that transcend categorizations based on Binford's organizational systems. Residential A sites should coincide with either longer term base camps or frequently revisited residential bases. As artefact assemblages they can be recognized as larger (>1000 artefacts[16]) multipurpose sites with evidence of cooking. High variability in activities is attested to by the range of tool categories, use of less portable processing technologies, the dominance of generalized tool types, and a diverse array of specialized tools. Due to heightened levels of discard at longer term or reoccupied sites, highly valued and maintained artefacts such as adze/axes are more likely to be associated with Residential A type sites. Both caching behaviour and irreparable breakage can account for their presence.

Residential B sites are generally smaller (<1000) multipurpose sites. Such residential sites are considered to be shorter-term habitation sites such as singularly or infrequently occupied forager-type residential bases or satellite field camps of collector-type groups. They should contain a range of artefact types associated with different activities, but have fewer artefact types than Residential A sites. Fewer artefact types might also be present in field camps than in forager residential bases. Some less portable processing technologies could be present (e.g., grinding stones at a milling-intensive field

[16] Although artefact counts can be misleading since they do not take into account increased production of debitage from certain types of activities like intensive lithic reduction, assemblage magnitude is still often representative of occupation intensity and can be given some consideration. Inferred site size was not necessarily decisive in site type categorization.

camp), but are likely to be more portable versions of formal prototypes. Formal generalized tools such as bifaces and wedge-shaped microblade cores should dominate the tool kit.

Those sites referred to as task sites are consistent with *locations* in Binford's terminology. They are expected to occur within all types of organizational systems. Such sites are expected to produce highly variable artefact assemblages based on their different functions. In general, they are characterized by small site size (most notably sites with less than 100 artefacts) and a lack heavy equipment or evidence of cooking. The presence of specialized or generalized tools and degree of formality in manufacture should be related to site function and distance from a residential site; however, due to carrying constraints, generalized tools should be common and specialized tools rare or absent. When specialized tools do occur in task sites, they may suggest the importance of a singular activity. Scrapers should be found in notable quantities only when they are intensively used as part of a site specific activity. Discarded tools should be expedient or heavily utilized.

4.1.2.2. Results

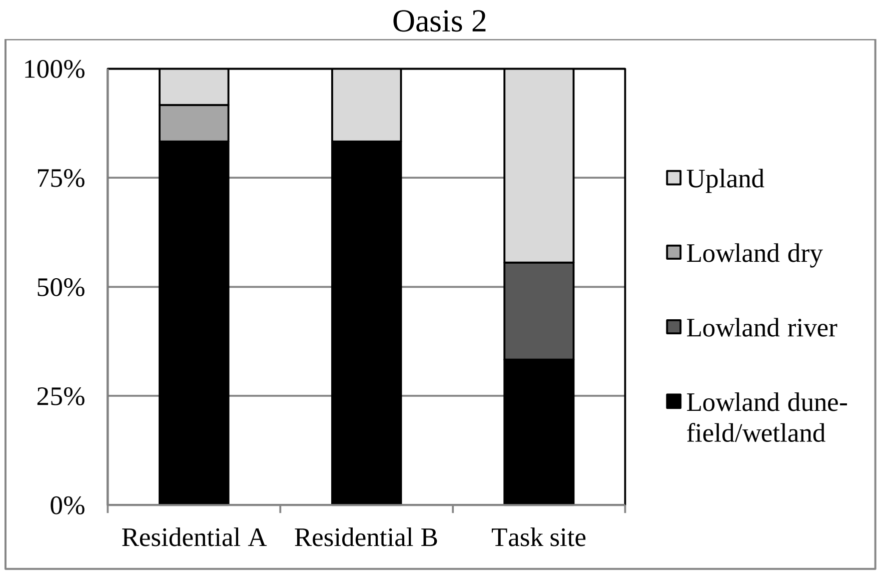
The environmental distribution of chronologically ordered residential and task sites allows for interpretations of land-use during the terminal Pleistocene to middle Holocene. Palaeolithic and Early Epipalaeolithic sites were not included in this analysis since they are so sparsely represented in the sample. This is partially due to my intentional selection of probable post-LGM sites. The primary focus is Late Epipalaeolithic and

Neolithic/Eneolithic (Oasis 1, 2, and 3) land-use. Oasis 1, 2, and 3 assemblages are most viable for comparison of inter-assemblage variability due to similarities in the basic modes of reduction, reliance on microblade core reduction sequences and the use of other microlithic tools.

Only one Residential B site and seven task sites were assigned to Oasis 1 across all regions. Since categorization of residential sites was based partially (but not entirely) on the presence of pottery, it is possible that residential sites were underrepresented; however, it is likely that Oasis 1 sites were simply more ephemeral than Neolithic/Eneolithic residential dune-field sites. Smaller site sizes and reduced inter-assemblage variability among Oasis 1 type sites might also have contributed to the failure to recognize some residential base camps. Alternately, as suggested by the relative dense concentration of finds at Chikhen Agui, more intensively occupied Oasis 1 sites may have been centred on environments that were not heavily sampled in these collections. Site distribution and reduction strategies for Oasis 1 assemblages were not further tested due to low sample size. Clear differences in site distribution are sufficient to support the hypothesized shift in land-use by about 8.0 kya.

The distributions of residential sites across ecozones for the entire Gobi Desert are represented in Figure 4.7 and Table 4.9. Residential sites are primarily confined to lowland dune-field/wetland environments. Task sites are situated in a range of different environments and probably represent lowland-dwelling groups using upland environments in a pattern reminiscent of collectors – characterized by the strategy of moving select resources from upland environments into lowland environments where residential camps were situated.

As with the previous samples, counts of some variables were so low as to make suspect the results of Pearson's chi-square test. Raw counts (Table 4.9) indicate that for Oasis 2, Residential A sites are more common in lowland dune-field/wetland environments and less common in upland environments. Residential B sites are similarly common in lowland dune-field/wetland environments, with few sites found in other environments. Individual cell counts show that the distribution of task sites is most notable. Task sites are fewer than expected in lowland dune-field/wetlands for both periods and significantly more common in upland environments during Oasis 2. The majority of Oasis 3 sites were derived from dune-field/wetland environments and there are too few sites in other environments to accurately test the significance of distribution. Nevertheless, this situation may also reflect an increasing reliance on dune-field/wetland habitats, which is itself significant.



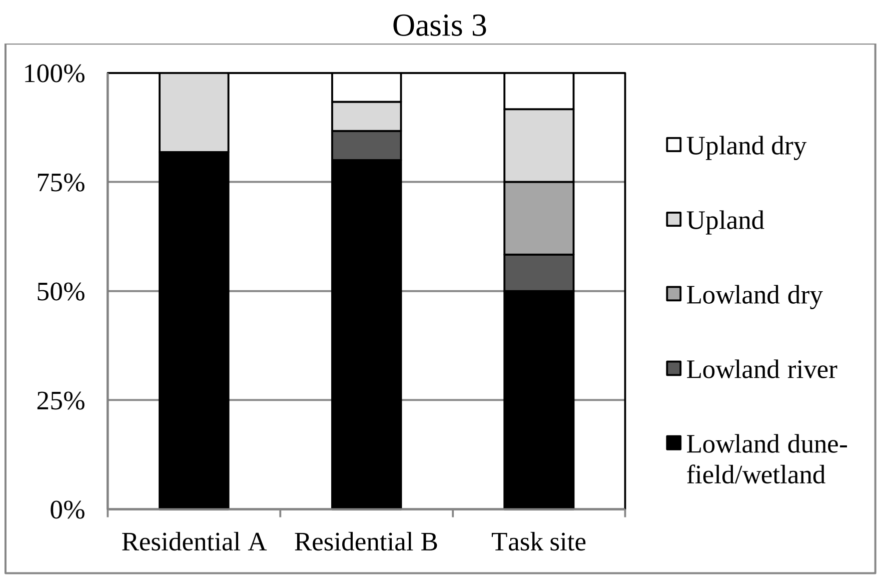


Figure 4.7 Distribution of site types across Gobi Desert for Oasis 2 and Oasis 3.

Oasis 2

Ecozone	Residential A	Residential B	Task site
Lowland dune-field/wetland	10 8.0	5 4.0	3 6.0
Lowland river	0 0.9	0 0.4	2 0.7
Lowland dry	1 0.4	0 0.2	0 0.3
Upland	1 2.7	1 1.3	4 2.0

$X^2 = 10.62$, $p = 0.1007$

Oasis 3

Ecozone	Residential A	Residential B	Task site
Lowland dune-field/wetland	9 7.8	12 10.7	6 8.5
Lowland river	0 0.6	1 0.8	1 0.6
Lowland dry	0 0.6	0 0.8	2 0.6
Upland	2 1.4	1 2.0	2 1.6
Upland dry	0 0.6	1 0.8	1 0.6

$X^2 = 7.93$, $p = 0.4399$

Table 4.9 Actual and expected distribution across Gobi Desert ecozones for Oasis 2 and Oasis 3 sites.

Table 4.10 shows the regional distribution site types within each ecozone. The Alashan Gobi is notable for the high frequency of Residential B sites during Oasis 3. Otherwise, broadly similar trends in site type distribution are visible.

Ecozone	Site type	East Gobi		Gobi-Altai		Alashan Gobi	
		O2	O3	O2	O3	O2	O3
Lowland dune-field/wetland	Res. A	5	4	3	3	2	2
	Res. B	2	2	2	2	1	8
	Task	0	0	1	0	2	6
Lowland river	Res. A	0	0	0	0	0	0
	Res. B	0	1	0	0	0	0
	Task	1	0	1	1	0	0
Lowland dry	Res. A	0	0	0	0	1	0
	Res. B	0	0	0	0	0	0
	Task	0	0	0	0	0	2
Upland	Res. A	0	1	0	0	1	1
	Res. B	1	1	0	0	0	0
	Task	2	1	1	1	1	0
Upland dry	Res. A	0	0	0	0	0	0
	Res. B	0	0	0	0	0	1
	Task	0	0	0	0	0	1

Table 4.10 Regional distribution of Oasis 2 and Oasis 3 sites for each ecozone.

Residential A and Residential B sites are expected to represent two different types of residential organization. A greater reliance on Residential A sites would suggest either more long term occupation of residential sites, or more frequent reoccupation of the same sites. If certain sites are frequently revisited or regularly incorporated into a yearly round, hunter-gatherers are more likely to cache heavy equipment or stockpile raw materials at key locations. In contrast, an increase in the number of Residential B sites should be related to either shorter term habitation or to less frequent visits. Table 4.11 shows the distribution of site types for the entire Gobi Desert and for each region during

Oasis 2 and Oasis 3. In contrast to the sharp increase in the relative frequency of Residential B sites during the Oasis 3 period in the Alashan Gobi, the distribution of site types in the East Gobi and Gobi-Altai is similar in both periods. This indicates that the Alashan Gobi sample is unique, with a possible decline in Residential A sites and a corresponding increase in Residential B sites during the Oasis 3 phase. Statistically, the difference in distribution of Alashan Gobi residential type sites between periods is significant (X^2 = 4.41, p = 0.0358).

Site Type	Period	All Gobi Desert sites	East Gobi	Gobi-Altai	Alashan Gobi
Residential A	Oasis 2	12	5	3	4
	Oasis 3	11	5	3	3
Residential B	Oasis 2	6	3	2	1
	Oasis 3	15	4	2	9
Task site	Oasis 2	9	3	3	3
	Oasis 3	12	1	2	9

Table 4.11 Actual and expected distribution of residential site types for Oasis 2 and Oasis 3 across the entire Gobi Desert and for each region.

A few notable divergences in tool kits, including the greater visibility and formality of grinding stones in the East Gobi, suggests that regional trajectories may have been quite different during the Neolithic/Eneolithic despite cross-regional trends in the transition from Epipalaeolithic to Neolithic. Local environments were also quite divergent, as is detailed in Chapter 5. For that reason, variation at the regional level is highly important. East Gobi sites show no significant difference in the frequency of different site types between Oasis 2 and Oasis 3 (df = 1, X^2 = 0.084, p = 0.771). The

Gobi-Altai sample (N = 10) is too small to test, but the distribution of residential site types is identical for Oasis 2 and Oasis 3 (Table 4.11).

Despite a lack of statistically significant temporal variability for the East Gobi, residential sites may be more widely distributed in Oasis 3 than in Oasis 2. During Oasis 3, both Residential A and Residential B sites were found outside of dune-field/wetland environments, while only one such Residential B site can be attributed to Oasis 2. Yeggah Bolagah In Sumu (Site 15) was found in an upland setting near a major water source and may represent occasional use of upland environments for short-term habitation, or perhaps misidentification. Residential A sites were confined to dune-field/wetland environments during Oasis 2. Distribution of sites in the Gobi-Altai region is mostly consistent between periods, with residential sites restricted to lowland dune-fields. Upland zones appear to have been more commonly exploited for residential locales, including Residential A, in the Alashan Gobi during both Oasis 2 and Oasis 3. These habitations are related to an extensive series of archaeological sites in the Ukh-Tokhoi/Khara Dzag plateaux region, only a small portion of which were sampled. It is probable that the tool stone rich region was an important locale for seasonal habitation and raw material procurement (Maringer, 1950: 97-99, 103-111; Bettinger et al., 1994).

The lack of Residential A sites prior to 8.0k cal yr BP suggests that early post-LGM hunter-gatherers exhibited high residential mobility, while the site distribution suggests the utilization of a variety of environments with a focus on high elevations (> 1200 m a.s.l.). After 8.0k cal yr BP, low elevation dune-field/wetlands were extensively utilized for residential sites, while small sites probably represent task group oriented procurement of additional resources from a wide range of environments. These indications so far support the original hypotheses; however, the organization of residential mobility within dune-field/wetland environments is not defined and there is no clear indication of variation in organizational strategies between the Neolithic (Oasis 2) and Eneolithic (Oasis 3).

4.1.3. Lithic reduction strategies

Defining residential mobility and exploring possible changes in land-use between Oasis 2 and Oasis 3 are the focus of quantitative lithic analysis. The increased importance of bifacial technology, decorative elements (ostrich eggshell beads, decorative pottery finishes), higher investment in pottery, polished adze/axes, and a decline in the importance of formal milling technology all suggest a change in prioritization of needs during Oasis 3. A shift in the the relative frequencies of non-portable tool types like large grinding stones, and the introduction of lugs and handles to pottery manufacture could be an indication of an underlying increase in residential mobility. Raw material conservation practices can also attest to this type of strategic reorganization. Quantifiying certain aspects of lithic raw material conservation can test assumptions about changes in residential mobility between periods.

The previous section indicates that there are two types of Neolithic/Eneolithic residential sites – Residential A and Residental B. These two site types functioned during both Oasis 2 and Oasis 3 A and Residential B sites are distinguished in the previous section based on site size, inter-assemblage variability, and relative importance of formalized technology. Successive reoccupation, however, can contribute greatly to the illusion of long-term habitation since the potential is greater for accumulation of a variety of tool types and the incorporation of less frequently used expedient technologies as the site is successively reoccupied. However, if all sites are related to the same length of occupation and function, there should be no difference in the use of tool stone aside from that imposed by local availability of raw material.

Consistent differences in the use of lithic raw materials between site types would support the distinction of two separate types of residential occupation, just as temporal differences would support a shift in land-use over time. In order to identify differences in the length of occupation related to time period and residential site types, lithic analysis is used to address issues of raw material procurement, relative intensity of use and retouch prior to discard, and relationships between patterns of such and degree of residential mobility. Primary variables of analysis included: core dimensions, relative frequency of formal to informal core types, remnant core and scraper cortex, and scraper retouch.

4.1.3.1. Modeled expectations and methods

The degree to which artefacts are reduced or retouched before discard signals aspects of raw material access and conservation that is related in part to individual and residential mobility. Assemblage-specific reduction strategies reflect choices in raw material use that give an indication of both transport limitations, and the proximity and/or regularity of access to raw material sources (Binford, 1979; Bamforth 1986; Bleed 1986; Kuhn 1991, 1994, 1995). When it is impossible or inconvenient to acquire more raw materials for tool manufacture, the knapper will regularly make more efficient use of the materials on hand. If raw material is readily available he/she will be less inclined to retouch and reuse tools or to reduce cores in a conservative manner (Shott, 1986). As a result, highly mobile hunter-gatherers who may not encounter tool stone for long periods tend to organize technological systems around the curation of artefacts, while decreased residential mobility is usually related to the use of less standardized and more expedient tools as raw materials can be more easily stockpiled (Shott 1986; Parry and Kelly 1987; Torrence 1989; Kuhn 1995). Some tools or cores may be discarded at an early stage due to raw material flaws or mis-strike, but an assemblage considered as a whole should indicate a particular pattern of raw material use and tool curation (see Kuhn, 1995; Surovell, 2003).

Various characteristics were quantified in order to gauge intensity of raw material use and curation: relative abundance of formal and informal core types, relative percentage of cortex remaining on cores and scrapers, invasiveness of scraper retouch, core dimensions, and variability of core size (CV). The analysis focuses on cores and scrapers. These two artefact types have proven useful in demonstrating a correlation between length of occupation/level of mobility and intensity of use and reduction because they tend to be repetitively reduced, reused, and retouched (Kuhn 1990, 1991; Andrefsky, 1998; Blades, 2003; Eren et al., 2005; Wallace and Shea, 2006). Equally important, these artefact classes are virtually ubiquitous in Gobi Desert sites, occurring in a range of ecological contexts, independent of site size (see Fairservis, 1993; Maringer, 1950).

Flexibility and formality

Quantifying relative frequencies of formal and informal core types is one method of recognizing more conservative reduction strategies. According to Shott's (1996) definition of curation, formal core technology can not necessarily be identified as exhibiting high levels of curation, since curation is a continuous category and relative to the maximum utility of the object. At the same time, it is clear that formal prepared cores are volumetrically and strategically designed to produce high numbers of standardized blanks, which minimizes risk, and extends the use life of raw materials and potential for curation (Andrefsky, 1987; Clark, 1987; Wallace and Shea, 2006). As such, formal cores do represent heightened raw material conservation.

Such "conservative" reduction strategies therefore suggest limited access to raw materials; level of access generally being a function of specific provisioning strategies (see Kuhn, 1995, 2004). Provisioning strategies are most closely linked with the organization of land-use, including mobility. Kuhn (1995) outlines two potential methods of planned provisioning – *provisioning places* or *provisioning individuals*. Choice of provisioning strategy is expected to reflect the frequency and duration of residential moves. Provisioning of places, or stockpiling raw materials at frequently revisited sites, should be most extreme when residential moves are few and occupations are more long-term. In contrast, when the frequency of residential moves is high and occupations are more short-term, individuals make sure that they, themselves, are constantly provisioned with raw materials. Provisioning of highly mobile individuals requires attention to transport costs. As previously noted, transported tool kits ideally contain flexible multi-functional tools which are resharpened and reused until their edges wear out (Kuhn, 2004) or until new high quality raw materials can be procured and new tools made. Exploitation of environments with less even distribution of high quality raw materials are likely to encourage more conservative patterns of use and discard.

Specialized microblade core reduction sequences in the Gobi Desert suggest the continuous importance of provisioning individuals with efficiently transportable equipments from the period immediately following the Last Glacial Maximum (LGM) until the early Metal Ages. Microblades appear to have been used as inset blades for organic hafts in many Northeast Asian assemblages (Derevianko and Dorj, 1992; Kirillov and Derevianko, 1998; Elston and Brantingham, 2002; Derevianko et al., 2003). Microblade cores offer a number of benefits, including the potential to be heavily volumetrically reduced before reaching a point of non-utility, a very low failure rate once microblade production is initiated (Bamforth and Bleed, 1997), and potential to be used as both cores and tools (*sensu* Kuhn, 2007). Dual platforms on cylindrical microblade cores would have further extended use life by allowing for greater reworking opportunities when mis-strikes and raw material flaws resulted in heavy step-fracturing around one platform. Wedge-shaped microblade cores may have been used as an ideal transportable core-tool, providing knife-like edges that offered additional utility to microblade production, and making them well-suited for use in transported tool kits (Kuhn, 1994). This is also true of large bifaces and biface cores (see Kelly, 1988; Hofman, 1992; Ingbar, 1992; Surovell, 2003), which are common in late Oasis 2 and early Oasis 3 sites.

Curation through "conservative" approaches to raw material use can also be recognized within "flexible" reduction sequences. When raw material is limited and artefact curation important, flexible and versatile design is important. If an artefact is to be carried and used over long distances and in diverse settings, it must be able to perform in a wide range of activities since the timing and specific uses are not consistently predictable (Nelson, 1991). Microblades make flexible tools because they can be shortened and retouched as component insets of a larger blade, or left long to be hafted as individual tools (see Tabarev, 1997). Flexibility of microblades allowed users to adapt these tools to continually changing needs and resources.

Additionally, changes in Northeast Asian microblade core reduction sequences following the LGM, specifically an increase in less formally prepared cores and more flexible core types (see Chapter 3), suggest that flexibility became increasingly valued during the terminal Pleistocene and early Holocene. It can also be asserted that the appeal of less formally prepared and more flexible microblade core reduction sequences was their potential for continuous rejuvenation and adaptability to raw material size and shape. While some microblade core preforms from Yingen-khuduk exemplified a reduction strategy based on the production of cylindrical/conical rather than wedge-shaped cores, several examples of Gobi Desert microblade cores clearly indicate the transformation of a heavily reduced wedge-shaped core into a conical or more rarely a cylindrical shape. Judging from the dimensions of exhausted cores in Gobi Desert assemblages, microblade cores tend to take on a conical form when heavily reduced. Conversely, wedges were often present on the backs of extant conical and cylindrical core types. Such a pattern of core reduction indicates that microblade cores were designed to be rejuventated and reused until most they were very small and most of the original nodule was used.

Thinking about microblade core technology as the basis for a highly portable tool kit can help explain the lasting popularity of this technology among mobile hunter-gatherers in Northeast Asia, despite the requirement of relatively high quality raw materials. Ethnographic data from Nunamiut informants suggests a pattern of use for discoidal transported cores that might be comparable to microblade cores, "as they put it, you carry a piece that has been worked enough so that all the waste is removed, but that has not been worked so much that you cannot do different things with it" (Binford, 1979: 262). Flexibly designed reduction strategies, those able to be adjusted according to immediate and changing needs, are also archaeologically attested in other regions. Mousterian sites from southwest France indicate a mode of core reduction that could be redirected at different points of use, transport, and/or reduction, creating a sort of branched operating sequence (*chaîne opératoires ramifiées*) (Bourguignon et al., 2004). Tool kits based on microblade core technology represent an organizational strategy broadly focused on regular raw material conservation and formal standardized forms.

Wallace and Shea (2006) explored the relationship between expectations of reduced mobility in the archaeological record and an increase in informal core types during the Levantine Mousterian. By reclassifying Middle Palaeolithic core types as "formal" and "expedient," they found that later assemblages, particularly ones with signs of more prolonged occupation or occurring in richer environmental regions capable of supporting longer term habitation, emphasized expedient core types. According to Kuhn's (1995) detailed analysis of strategic approaches to raw material use, the strategy of provisioning places in anticipation of future needs should contribute to a decline in the importance of formal core and tool technologies due to the greater availability of raw materials (also Kuhn, 2004). Regardless of the underlying motivation for the use of expedient core technologies, it is clear that such strategies prioritize the importance of immediate functional needs over long-term raw material conservation (Binford, 1979; Wallace and Shea, 2006).

The relative importance of formal to expedient core technology relays information about both group-wide adaptations and site-to-site variation in the production of different core types. Availability and the quality of raw material play an essential role in the manufacture of formal versus informal cores. Andrefsky's (1994) analysis lithics from western North America suggests that the manufacture of formal cores and tools is more often mediated by raw material availability than length of site occupation. Formal and informal tool types are both produced when high quality stone is abundant, but informal tools are produced when only low quality tool stone is available, irregardless of quantity. High quality raw materials in low abundance are usually related to formal manufacture.

As such, we can infer that Gobi Desert assemblages indicate infrequent access to high quality raw materials at the supraregional scale. Such an interpretation is notable since high quality raw materials are widely available across the Gobi Desert. The importance of microblade core technology in the Gobi Desert indicates either high residential mobility or regular periods of high individual mobility with sporadic access to raw materials.

Therefore, site-to-site variation in the relative frequency of formal to informal tools should give some indication of differences not necessarily in the distribution of high quality raw material, but in individual access to those resources. Inhabitants at some locales appear to have relied extensively on one type of low quality raw material, which we can assume came from a local source. Such circumstances do mirror local raw material availability. On the other hand, raw material use should be consistent within site categories and variable between them if site type categorizations (i.e., Residential A, Residential B, and task sites) reflect real differences in site function and length of occupation rather than simply resulting from differences in the frequency of reoccupation. Temporal changes in residential mobility might also be reflected in frequencies of formal to informal tool types between Oasis 2 and Oasis 3 sites.

Based on the importance of microblade and other formal core types in extending the life of a nodule, the ratio of formal to informal cores should reflect situational conservation at the regional level, differentially representing: constant, frequent, and reliable access to raw material when expedient cores are numerous and formal cores rare; reliable access to raw materials with anticipated periods of short term or individual restrictions (e.g., preparation of cores/flakes for use in hunting forays or other tasks); or at the other extreme, highly restricted access to raw materials. According to Andrefsky's (1994) model, the presence of low quality raw materials but restricted access to high quality tool stone can also influence the frequency of expedient core types. The use of lower quality tool stone in assemblages with a high frequency of expedient types should be considered. Frequency of informal/expedient cores at each site is recorded in Appendix E. The ratio of microblade to other cores at each site is recorded in Appendix D.

Remnant cortical surface

Just as the use of formal rather than informal cores can be a measure of raw material conservation, the amount of cortical surface remaining on cores and scrapers at discard is related intensity of reduction. Since high levels of remnant cortical core surface generally indicate a lack of extensive reduction, principles of raw material conservation or lack thereof can be applied. As with the measure of formal to informal core types, mean percentage of remnant cortical surface within an assemblage should vary between site types and time periods according to raw material access. High levels of remnant cortex are expected at sites where large amounts of raw materials are stockpiled and where primary reduction occurs (Dibble et al., 2005).

Extensively prepared formal cores tend to exhibit lower levels of remnant cortex since much of the original surface is removed during initial preparation (Dibble et al., 2005). Since informal cores are considered to represent a less conservative approach to raw material use, a high percentage of remnant cortical surfaces could represent either a less intensive reduction of cores or a more expedient and less conservative approach to raw material use. Assemblages with higher numbers of expedient/informal cores are expected to display higher levels of remnant core cortex. Circumstances of interest are those where cortex percentages are low and informal core types predominate, or where there are many formal core types and above average distributions of high cortical surface.

Core morphology is an important consideration for explanations of intra-assemblage variability as different formal core types exhibit natural divergences relative to remnant cortical surface. Most core reduction sequences practiced in the Gobi Desert were based on extensive core preparation prior to flake removal, a method that leaves very little cortex (see Dibble et al., 2005). Microblade cores are naturally more likely to have low levels of remnant cortex. Exhausted microblade cores should have little remaining cortex. Wedge-shaped cores may maintain cortex on the knife-like edge if the wedge back is not heavily bifacially worked. Similarly, flat-backed microblade cores might bear evidence of a cortical surface until entirely exhausted. There should be less remnant cortical surface on conical and cylindrical microblade cores. Expediently prepared or “informal” microcores have minimal preparation of the nodule prior to removal of useable flakes and should have high percentages of remnant cortical surface. Cores most sensitive to measurements of cortical surfaces are amorphous cores, and to a lesser degree expediently prepared microblade (< 10 mm), bladelet (11-15 mm), and elongated flake cores.

Remnant cortical surface for scrapers should be correlated with both intensity of reduction and the types of flakes used. Continuous core reduction following removal of all cortical surfaces results in increasingly low frequencies of remaining cortical surface in the assemblage (Dibble et al., 1995; Dibble et al., 2005). Assemblages with high levels of cortex on scrapers would then be indicative of the types of flakes used: scrapers produced on primary flakes indicating primary reduction, and scrapers produced on unreduced pebbles or cobbles.

At the same time, scraper cortex will not necessarily fit these expectations. Cortical flakes are larger and may be selected for transport due to increased utility in comparison to smaller flakes produced later in reduction (*sensu* Kuhn, 1994; Douglass et al., 2008). Adding to the incongruity of this relationship, sites of primary reduction may also be loci for replacement and discard of transported formal tools (Gramly, 1980), suggesting that heavily reduced scrapers (and cores) may be found at sites of primary reduction due to transport from another locale rather than on-site use. Depending upon the conditions, remnant cortical surface on flakes may be underrepresented in situations of primary reduction and overrepresented in conditions of high curation (see Douglass et al., 2008). Heavily used and retouched scrapers with remaining cortex are more likely products of transport and extended curation than those only minimally used. This combination of qualities can particularly bias samples within smaller assemblages. Remnant cortical surface must be considered based on other elements of the assemblage in order to determine whether they relay useable information about practices of transport and discard.

Several expectations related to the measure of remnant cortical surface can be outlined:

a. In typical circumstances, a reliance on informal core types should be mirrored by relatively high frequencies of remnant cortical surface.

b. Sites where the majority of tools were locally manufactured, used, and discarded should be associated with higher levels of remnant cortical surface on both cores and scrapers.

c. Remnant cortical surface should be even higher in conditions where raw materials were stockpiled in anticipation of recurrent occupations or longer stays. This is especially true if unreduced or minimally reduced nodules were transported to the site, as may have been typical of nodule procurement in microblade core manufacture (Bleed, 2002).

d. When a site is occupied for only a short duration, we expect the relative percentage of remnant cortical surface to be most sensitive to differences in distance (whether logistic or geographical) from raw material source, conditions of transport, and situational use and discard.

Methods of calculating remnant cortical surface and extent of reduction vary. A scale based on percentages of remant cortex was used in this study (after Dibble et al., 2005). Remaining cortical surface was measured by categorizing cores and scrapers according to approximate percentage of entire surface covered by cortex: 1 = 0%, 2 = 1-25%, 3 = 26-50%, 4 = 51-90%, 5 = 91-100%. Microblade cores require relatively extensive reduction and most of the cortex is removed prior to use. Cores with cortex covering more than 25% of the total surface area are considered to have notably high percentages of remnant cortical surface. The same measure will be used for scrapers, since the main reduction strategy represented in these assemblages – the production of microblades – results in high numbers of non-cortical flakes that are used for unifacial tools like scrapers. Assemblages classified as having “high” overall levels of remnant cortex are those assemblages where at least 50% of a particular artefact type (i.e., cores or scrapers) has cortex on over 25% of the total surface area. Assemblages with “low” levels of remnant cortical surface ones where 50% of cores or scrapers exhibit less than 25% remnant cortical surface at discard. The results are summarized in Appendix E and in section 4.1.3.2, they presented along with relative frequencies of formal versus informal core types and core dimensions in order to better understand overall patterns in raw material use.

Dimensions

Extensive reduction prior to discard is related to recurrent use and rejuvenation, suggesting fuller exploitation of the maximum core utility (Shott, 1996). Core dimensions can give a good indication of reduction. Core volume at discard is determined by both the original nodule size and the intensity of reduction. An assemblage with larger cores may result from consistently less intensive reduction, but may also represent the regular use of larger nodules. The use of larger nodules might arise in a number of situations, including the procurement of stone from primary rather than secondary deposits (Kuhn, 2004), or similarly quarrying large blocks rather than collecting smaller surface nodules through embedded procurement (see Reher, 1991). Platform surface area (cm^2) is even more sensitive to level of reduction at discard than core volume because it most closely represents remaining working surface.

By comparing core dimensions with remnant cortical surface, a clearer understanding of how volume and surface area relate to reduction and original nodule size is possible. For example, smaller cores have a higher cortex-to-volume ratio and may retain more cortical surface at the final stage of reduction due to size constraints. An assemblage with a low mean core volume should represent the use of small nodules, rather than intensive reduction, if remnant cortical surface is high. Likewise, a high mean core volume in combination with low percentages of cortex suggests that large nodules were being used. Since larger cores can be more extensively reduced prior to discard they will exhibit extensive reduction in the form of low remnant cortical surface at a larger size (and with larger platform surface area) than will cores worked from smaller cobbles. These measurements draw attention to variation between assemblages in procurement strategies.

The following interpretations can be made based on different combinations of core volume/platform dimensions and remnant cortical surface:

a. large core/platform + low cortex = large raw materials used, more reduction
b. small core/platform + low cortex = small nodules and more reduction, or larger nodules and very high reduction
c. large core/platform + high cortex = large raw materials, little reduction
d. small core/platform + high cortex = small raw materials, little reduction

Coefficient of variation ($C_V = \delta/\mu$) can also contribute to a more accurate assessment of reduction intensity by measuring variability in core/platform size within the assemblage. The coefficient of variation (CV) is a standardized measure of variability that takes into account differences in sample size. High variability of core dimensions in one assemblage can suggest differences in either reduction or original core sizes, allowing for inferences about consistency in nodule size and reduction intensity. A low CV indicates low variation in core dimensions. When associated with a low mean core volume, low CV should reflect original nodule size, particularly in very large assemblages where highly extensive reduction of all raw materials is unlikely.

Measurements of core volume, relative remnant cortex, and favoured reduction strategies can be combined to give a more accurate indication of site specific patterns in the use of tool stone. If informal core types tend to be more expedient, less extensive reduction is expected. As such, consistently small core volumes are expected for informal cores only when raw materials are procured in small packages. In situations of extremely low raw material conservation, we can expect a combination of high core volume, a predominance of informal cores, and high remnant cortical surface on cores. At the other end of the spectrum, extremely high levels of raw material conservation would result in a hypothetical situation of low core volume, formal core types, and low levels of remnant cortical surface. In both circumstances, a very low CV can be attributed to consistency in original nodule size. Among cores made on smaller nodules, high standardization in size is even less likely because the increased regularity of raw material flaws and human error can make more cores unworkable at an early stage in reduction. For that reason, a high CV and low mean core volume and platform surface area are most likely related to the consistent use of smaller raw materials.

Core volumes (cm^3) and platform surface areas (cm^2) were both recorded. Core volume was measured for each core based on three dimensions. Microblade cores dominated the collections and were best measured according to height and two perpendicular platform measurements including the length and width or shortest and longest measurements of the platform ("P1" and "P2"). Amorphous cores without an obvious length, width and thickness were measured based on the two longest perpendicular measurements and the shortest major edge to major edge measurement (i.e., shortest length excluding measurements of odd protrusions atypical of overall core shape). Original measurements were taken in mm, but core volume was recorded in cm^3 for ease of analysis. Mean core volume was generated for each site assemblage. Results are summarized in Appendix E.

Retouch

Scraper retouch was also considered. Invasiveness of retouch is compared to other variables in order to assess the relationship between intensity of use and remnant cortical surface, and between core volume and overall patterns of raw material conservation. Scraper retouch and use is conditioned by numerous variables, including situations of short-term intensive processing, which are not necessarily related to availability of raw materials or length of site occupation. Periods of short-term intensive processing should promote retouch rather than replacement, particularly on hafted endscrapers (which make up the majority of the collection) since we expect that it is easier to retouch than rehaft a small tool. Despite various possible controlling factors, the extent/intensity of scraper use and retouch complements interpretations of overall use patterns.

By measuring the proportion of total artefact width lost during retouch, we can essentially compare relative frequencies of retouch prior to discard. Invasiveness of retouch is calculated based on measurements used in Kuhn's (1990) reduction index for unifacial tools (t/T or vertical thickness of flake at termination line of retouch scars divided by maximum medial thickness of the flake). Since retouch was accomplished using pressure-flaking rather than hard-hammer percussion, as on the specimens measured by Kuhn, initial dramatic changes in the depth of retouch scars are expected to be minimal and progressive retouch episodes more gradual. A contrasting method for measuring loss of volume during reduction has also been proposed (Eren et al., 2005), but Kuhn's method is considered more appropriate due to the small size of typically hafted endscrapers which dominate this collection and the high remaining mass and volume at discard in comparison to original size.

4.1.3.2. Results

It was suggested at the introduction to this chapter that during Oasis 3, sometime after about 5.0 kya, increasing aridity might have resulted in the reduced availability of resources outside dune-field/wetland environments, encouraging further reliance on dune-field/wetland resources with the geographic expansion of small field camps and task sites in order to supplement declining local resources. Such a shift should be evidenced by either longer-term occupation of residential sites or an increase in the number of residential sites in dune-field/wetland environments. A decline in the frequency of Residential A sites and a corresponding increase in Residential B sites appear to have taken place in the Alashan Gobi during Oasis 3. Since the relationship between Residential A and Residential B sites is based primarily on site size and inter-assemblage artefact variability, either an expansion of residential sites due to increased population (i.e., new residential sites established in Oasis 3 would be smaller and less diverse because they have been less frequently reoccupied since the beginning of Oasis 2) or an increase in residential mobility (i.e., sites are occupied for shorter periods of time, also resulting in smaller, less diverse assemblages) could contribute to this result.

Using the methods outlined in the previous section, we can assess whether Residential A sites were more frequently reoccupied than Residential B sites or whether they were occupied for longer durations. Lowered residential mobility is frequently related to a decline in formal technology, a corresponding increase in informal/expedient technology, and the provisioning of places rather than people. If Residential A sites were occupied by for longer periods of time, they should show higher ratios of informal to formal core types. Provisioning of places suggests that raw materials were stockpiled at frequently used locations. Such provisioning is most directly associated with planned reoccupation of certain sites, but transporting raw materials to a locale is most likely when people return frequently to a residential base after regular short-term foraging trips over a long period of time. Such locales should be characterized by a relatively higher ratio of informal to formal core types, a somewhat higher % remnant core cortex, relatively larger platform sizes (less intensive reduction), and evidence of greater variety in original nodule size (suggesting provisioning from different sources).

Residential A and Residential B sites were compared for the entire sample using the *t*-test. Significant differences were evident for measurements of core volume, platform and length, mean % microblade and expedient core types, and mean % of cores with remnant cortex over 25% (Table 4.12). Comparisons among sites within the Gobi-Altai region were not significant for any variables. Variation between core volume, platform, and length, and remnant core cortex were all significant for East Gobi sites, indicating that cores from Residential B sites were smaller, more heavily reduced, and tended to have less remnant cortex than those from Residential A sites. Tests for differences in mean % expedient core types and mean t/T for scrapers had p-values of 0.0598 and 0.0658 respectively. While these values are slightly below statistical significance, they indicate a 93-94% probability that variation between samples was not due to random sampling. Residential A type sites appear to have had higher numbers of expedient core types and more invasive scraper retouch on average. Alashan Gobi sites also reflect the overall pattern with significant variation for variables of remnant cortical surface and expedient core types.

Variable		All sites	East Gobi	Gobi-Altai	Alashan Gobi
% informal cores	Res. A mean Res. B mean *t* = p =	33.5 15.9 7.19 0.0105	45.3 25.1 4.19 0.0598	37.8 28.2 0.255 0.6295	16.9 4.9 6.44 0.0228
% microblade cores	Res. A mean Res. B mean *t* = p =	58.1 75.9 5.40 0.0250	49.9 63.7 1.13 0.3056	55.0 70.5 0.48 0.5073	69.8 85.2 3.87 0.0680
Mean % cores with remnant cortical surface (25%+)	Res. A mean Res. B mean *t* = p =	30.5 10.7 18.08 <0.0001	33.6 14.0 6.04 0.0276	37.6 19.0 2.65 0.1423	21.8 5.6 7.14 0.0174
Mean % scrapers with remnant cortical surface (25%+)	Res. A mean Res. B mean *t* = p =	18.0 11.3 1.12 0.3314	14.3 6.9 4.20 0.0595	22.3 17.5 0.25 0.6304	19.3 12.1 0.57 0.5776
Mean core volume (cm^3)	Res. A mean Res. B mean *t* = p =	190.6 97.0 6.40 0.0152	182.6 74.9 5.35 0.0364	243.2 169.6 0.43 0.5295	160.1 91.1 1.41 0.2539
Mean core platform surface area (cm^2)	Res. A mean Res. B mean *t* = p =	46.7 27.8 9.38 0.0038	44.7 27.5 5.35 0.0364	55.5 39.5 0.69 0.4293	42.3 24.8 3.35 0.0871
Mean t/T (scrapers)	Res. A mean Res. B mean *t* = p =	0.571 0.515 1.17 0.2848	0.537 0.361 3.98 0.0658	0.530 0.567 0.36 0.5638	0.641 0.640 0.0003 0.9863

Table 4.12 *T*-test results for Residential A and B lithic data sets. Values for the entire sample and individual regions are included.

Despite a lack of statistical significance between residential site types in all regions, there is a consistent pattern: in comparison with Residential A sites, all Residential B sites exhibit smaller core volumes, smaller platform and length measurements, lower ratios of informal to formal core types, higher ratios of microblade to other core types, and less remnant cortex on cores and scrapers. These data indicate that Residential A sites had better access to raw materials and were either being provisioned with stone or habitually situated in areas with better access to raw materials.

The latter is unlikely since both Residential A and Residential B type sites were sometimes collected in the same vicinity (within a 5 km radius). A combination of smaller remaining platform surface area and lower remnant cortex show that cores from Residential B sites were more extensively reduced than those from Residential A sites. An emphasis on transportable core types at Residential B sites also suggests strategic conservation of raw materials and the importance of reliably standardized blanks.

Coefficient of variation (CV) indicates that cores from Residential B sites show more overall variation in volume (CV = 1.24) and platform surface area (CV = 0.721) than those from Residential A sites (respectively, CV = 0.653, CV = 0.444). More uniformity in core sizes in conjunction with more remnant cortex and larger platform surface area might indicate a combination of both larger original nodule sizes and less intensive reduction for Residential A sites. Differences in raw material procurement strategies are also implied, with higher variation in original core size suggesting a wider range of exploited raw material sources with a more embedded strategy of procurement associated with Residential B occupations. Somewhat less invasive scraper retouch is implied for Residential B sites in the East Gobi, but may be related to less intensive processing activities at the sampled sites. Residential B sites were not simply reoccupied less frequently, but were probably occupied for shorter periods than Residential A sites.

An increase in the number of Residential B and decline in the number of Residential A sites in the Alashan Gobi suggests higher residential mobility, as evidenced by more short-term habitation sites. An increase in population density could also contribute to such a pattern by necessitating the use of new habitation sites. Having been less intensively used over the millennia, new habitation sites could potentially mimic short-term residential sites, but implied variation in raw material use and access does suggest a difference in site function. Residential A sites assigned to Oasis 3 include (see Figure 1.2 for subregions): Gashun Well (Site 207) (Galbain Gobi subregion); Yingen-khuduk (Site 212), associated with both Oasis 2 and Oasis 3 occupations (Galbain Gobi); Site 218 (Ukh-tokhoi/Khara Dzag subregion); and Site 223 (Ukh-tokhoi/Khara Dzag), thought to belong to either late Oasis 2 or early Oasis 3. Mantissar 7 (Site 293) is classified as Residential B, but could have been classified as Residential based on the wide range of artefact types. It is the only possible Residential A site in the Gurnai Depression. Distribution of Residential A sites in the Alashan Gobi suggests that the Galbain Gobi and the Ukh-tokhoi/Khara Dzag plateaux subregions may have been the primary centers for longer-term residential base camps during Oasis 3. Residential A sites were probably also located in the Juyanze subregion during Oasis 3, but probable Oasis 3 sites were not studied in this analysis. Further analysis of sites in Juyanze, Galbain Gobi, and the Ukh-tokhoi/Khara Dzag subregions might help clarify patterns in regional-wide Alashan Gobi land-use.

East Gobi and Gobi-Altai assemblages show no significant shift in the relative importance of Residential A and Residential B sites after 8.0k cal yr BP, but we can also consider possible temporal differences in mobility based on implied access to raw material. The same set of variables applied to evaluation of residential type sites can be applied to period categorizations. Table 4.13 summarizes statistical results for the entire sample, as well as each target region. As a unified sample, similar differences are exhibited between Oasis 2 and 3 as were noted for Residential A and B: in comparison with Oasis 2 sites, Oasis 3 sites exhibit smaller core volumes, smaller platform and length measurements, lower ratios of informal to formal core types, higher ratios of microblade to other core types, and less remnant cortex on cores and scrapers. General trends suggest decreased access to raw material in the Oasis 3 period, corresponding to a probable increase in residential mobility. However, at the regional level, the differences between periods are not significant for the East Gobi or the Gobi-Altai and relationships for each variable are inconsistent. These results do not support the conclusion that there is a significant difference in raw material conservation in either the East Gobi or the Gobi-Altai from Oasis 2 to Oasis 3.

The Alashan Gobi is markedly different than the other regions. In this sample, *p*-values for variables related to core type, size, and remnant cortex in the Alashan Gobi region do show significant variation. Microblade cores are relatively more common during Oasis 3, while the use of informal core types declines. A reduction in core size during Oasis 3 is best represented by a significant reduction in platform surface area. When associated with a possible trend towards decreased remnant cortical surface (p = 0.0633), evidence of more intensive core reduction can be proposed. Calculations for CV further indicate higher variation in core volume (Table 4.14). Together, a higher CV and low mean core volume suggest the use of smaller nodules during Oasis 3. Degree of variation in platform surface area between periods is too small to be significant. The use of smaller nodules might be related to the use of randomly encountered cobbles rather than quarrying of large blocks, or simply to the transport of smaller pieces to production sites. Knowledge of raw material sources would give us a better indication of the situation; however, there is a clear difference in raw material use and procurement. Alashan Gobi data support the hypothesis of increased residential mobility and more transitory occupation of residential bases during the Oasis 3 period. However, the higher frequency of Residential B sites that is implied could also result from an increase in the number of logistical field camps and tasks sites associated with each residential base, rather than higher residential mobility. Regardless of the circumstances, the data imply more conservative use of tool stone in Oasis 3.

Data on invasiveness of retouch and remnant cortical surface for scrapers do not contribute to interpretations of collection-wide patterns in reduction strategies. The results are insignificant and variable. Scraper data are expected to yield more useable results at the level of individual sites they do for regional comparisons. High variation in the intensity of retouch and the use of primary flakes between sites, particularly smaller task sites, is likely controlled more by specific site function and incidental availability of blanks than by region-wide trends in raw material use.

Variable		All sites	East Gobi	Gobi-Altai	Alashan Gobi
% informal cores	Oasis 2 mean	34.4	37.8	47.2	17.6
	Oasis 3 mean	21.9	44.0	37.0	4.8
	t =	3.01	0.27	0.34	9.74
	p =	0.0877	0.6065	0.5708	0.0045
% microblade cores	Oasis 2 mean	51.6	47.3	45.9	63.6
	Oasis 3 mean	71.5	51.5	60.8	87.9
	t =	6.75	0.09	1.82	10.66
	p =	0.0117	0.7708	0.3765	0.0033
Mean % cores with remnant cortical surface (25%+)	Oasis 2 mean	23.6	22.4	27.9	20.6
	Oasis 3 mean	21.2	33.1	35.6	8.9
	t =	0.18	1.42	0.32	3.79
	p =	0.6686	0.2504	0.5796	0.0633
Mean % scrapers with remnant cortical surface (25%+)	Oasis 2 mean	17.3	13.1	25.7	13.7
	Oasis 3 mean	15.0	10.4	10.6	19.8
	t =	0.23	0.34	3.11	0.34
	p =	0.6362	0.5681	0.1034	0.5656
Mean core volume (cm^3)	Oasis 2 mean	196.6	132.7	267.1	198.1
	Oasis 3 mean	142.7	165.4	271.3	80.0
	t =	1.41	0.41	0.001	3.96
	p =	0.2400	0.5296	0.9741	0.0580
Mean core platform surface area (cm^2)	Oasis 2 mean	475.8	37.8	57.7	48.4
	Oasis 3 mean	343.1	42.8	50.4	23.3
	t =	3.59	0.35	0.20	4.99
	p =	0.0630	0.5593	0.66	0.0350
Mean t/T (scrapers)	Oasis 2 mean	0.502	0.421	0.447	0.667
	Oasis 3 mean	0.529	0.463	0.523	0.565
	t =	0.24	0.20	0.40	1.65
	p =	0.6247	0.6590	0.5383	0.2120

Table 4.13 *T*-test results for Oasis 2 and Oasis 3 lithic data sets. Values for the entire sample and individual regions are included.

Variable	Period	CV
Core volume	Oasis 2	0.988
	Oasis 3	1.353
Platform surface area	Oasis 2	0.813
	Oasis 3	0.797

Table 4.14 Coefficient of variation for core volumes and platform surface areas of Oasis 2 and Oasis 3 assemblages from the Alashan Gobi.

4.2. Discussion

Three hypotheses were detailed at the beginning of this chapter. The first hypothesis is that Oasis 1 foragers were organized in a circulating pattern of mobility and exploited a wide range of habitats, including the occasional use of dune-field environments. The sample size is very small for Oasis 1 sites; only two sites characteristic of a residential type habitation (based primarily on evidence of cooking) are currently recognized during this period – Shara KataWell and Chikhen Agui cave. Both were found in mountainous environments, suggesting a preference for upland environments. This is further supported by site distribution according to ecozone (Table 4.7). The lack of Residential A type sites supports the hypothesis that Oasis 1 groups showed a higher level of residential mobility compared with later periods, but the study of additional Oasis 1 sites should be conducted to further support this hypothesis. The short-term exploitation of dune-field/wetland environments is indicated in both the Gobi-Altai and the East Gobi (Figure 4.6 and Table 4.8). There is some evidence from the Gobi-Altai of early Epipalaeolithic task sites in dune-field/wetland environments, but the site was overlain with sand and may pre-date establishment of the dune-fields that were exploited in later periods. It is expected that additional data will reveal more task sites dating to the end of the Epipalaeolithic and corresponding with Oasis 1.

A climatic optimum, characterized by high effective moisture, in the early Holocene would have created an extremely rich ecological niche around recently stabilized dune-fields. It is hypothesized that the beginning of Oasis 2 coincides with this ecological shift. Longer term seasonal base camps centred on dune-field/wetland environments were hypothesized, and thought to have been complemented by pattern of radiating field camps and task sites. Distribution of sampled sites clearly supports the oft-mentioned claim in existing literature that the occupation of dune-field/wetland environments was central to hunter-gatherer organizational strategies by this time.

Oasis 2 marks the beginning of a definitive phase in hunter-gatherer organizational strategies with the establishment of the longer-term multipurpose Residential A sites, mostly situated in dune-field/wetland environments (Figure 4.7 and Table 4.9). In the Alashan Gobi, longer-term base camps are not restricted to lowland dune-field/wetland localities, but are also present in drier lowland plains (one site in the Black Gobi, west of Juyanze) and among the higher elevation wetlands of the Ukh-tokhoi plateau. Distribution of high quality tool stone and local hydrology probably contribute to this situation. Additional shorter term multipurpose Residential B sites were identified throughout the same low-lying wetland habitats. Task sites were distributed across the remaining ecozones, from which additional resources would have supplemented those available at residential locales (Table 4.10).

Residential A sites appear to have been provisioned with raw materials and inhabited for longer (Table 4.12). The occurrence of large, heavy formal grinding technology in the East Gobi further suggests that Residential A sites in that region were provisioned for planned reoccupation during seasons when resources such as tubers and seeds could have been gathered, dried, and ground for future use. Such provisioning is frequently associated with locations where heavily utilized foods or other resources are more abundant (Kuhn, 1995: 22).

Late middle Holocene climatic deterioration may have resulted in the contraction of lakes and wetlands, as well as the desiccation of early Holocene steppe and desert-steppe environments (see Chapter 5). It is hypothesized that Oasis 3 hunter-gatherers responded by intensifying the seasonal use of dune-field/wetland environments, which were oases of primary productivity. At the same time, they more often would have supplemented their diets from a wider range of environments.

Various data support this hypothesis. In the East Gobi, the distribution of Oasis 3 residential sites is consistent with such a shift, including evidence for an increased focus on the use of upland environments compared with Oasis 2 (Table 4.10). Increased residential mobility in the Alashan Gobi during Oasis 3 is also supported by differences in the distribution of Residential A and Residential B sites (Table 4.10) along with changes in raw material curation practices that includes higher relative frequencies of formal core types and more intensive reduction of cores prior to discard during Oasis 3 (Table 4.13). A greater reliance on formalized core technology includes the increased use of highly portable and flexible wedge-shaped core technology during Oasis 3 (see Chapter 3). The use of dune-field/wetland environments did not decline, but mobility may have increased either through more frequent moves or by an intensified radiation of inhabitants into short-term field camps and task sites. This suggests less group aggregation with a pattern of dune-field/wetland habitation that is less concentrated. Such a shift in land-use is consistent with an avoidance of over-utilization that might be tied to lowered productivity. A higher frequency of residential sites in dune-field/wetland habitats during Oasis 3 suggests the creation of additional sites through more frequent moves. It is not clear if this trend is related to an increase in the number of radiating field camps associated with longer-term Residential A sites, or to fewer instances of aggregation at larger residential sites in favour of overall higher residential mobility.

The hypothesis that smaller field camps and task sites were used more extensively during Oasis 3 is not supported by data from lithic analysis in the East Gobi or the Gobi-Altai regions, but *is* supported for the Alashan Gobi. Based on differences in the distribution of Oasis 2 and Oasis 3 sites, it is probable the East Gobi groups extended the range of residential camps into upland environments during the Oasis 3 phase. Additional attention to the distribution of Neolithic/Eneolithic sites in the East Gobi and Gobi-Altai regions is required in order to assess possible differences in land-use over time. A larger, more geographically extensive sample of archaeological sites is most essential in the Gobi-Altai region.

Finally, it is hypothesized that hunter-gatherers began to adopt herd animals towards the end of Oasis 3 in order to make up for declining productivity in dune-field/wetland environments. The adoption of domesticates is proposed to have culminated under conditions of relatively extreme desiccation after 3.0k cal yr BP. The increased exploitation of upland and plains environments is consistent with pasturage needs and typical of later nomadic pastoralist land-use (Fernandez-Gimenez, 1999), but is not definitive. Ceramic spindle whorls in some East Gobi and Alashan Gobi sites are similarly both suggestive and inconclusive.

At the same time, it is clear that by about 3.2-3.0k cal yr BP, nomadic pastoralism had become established across much of Mongolia. Agropastoralists along the southern border of the Gobi Desert were long-since acquainted with domesticated herd animals. Painted pottery from Gurnai Depression sites show stylistic similarities with pottery belonging to agriculturalists and/or agropastoralists farther east. Although the sample size is limited and the shards are very small, black-on-red painted shards bear possible affinities to Majiayao or Qijia (Figure 3.7, Appendix B). A relationship between neighbouring agropastoralist groups and Gobi Desert hunter-gatherers is particularly persuasive considering the stylistic similarities evidenced in these pottery traditions. The apparent termination of a long-standing dune-field/wetland adaptation after 3.0k cal yr BP further supports the assertion that these ephemeral traces of pastoralist adaptations do indeed represent the first stirrings of a production economy within the still strong bounds of hunter-gatherer subsistence.

Data from lithic analysis supports many of the original hypotheses and provides additional insight into organizational strategies associated with different types of residential sites. Due to the small sample size, hypotheses about Oasis 1 land-use can be neither supported nor negated. During Oasis 2 longer-term multipurpose sites appeared in the lowland dune-field/wetland environments. Cores from such sites, categorized as "Residential A," show a tendancy towards less intensive reduction and the locales were probably provisioned with raw materials in anticipation of regular reoccupation. In contrast, smaller multipurpose residential sites, categorized as "Residential B," were likely inhabited for shorter durations and core data suggests that they are associated with more intensive raw material conservation, and perhaps more embedded procurement strategies. An increase in the number of Residential B and decline in the number of Residential A sites in the Alashan Gobi suggests higher residential mobility and more transitory occupation of residential bases in that region during Oasis 3. Although there is a clear difference in lithic reduction strategies between Residential A and Residential B sites, the hypothesized shift in land-use during Oasis 3 is not supported by data in any region other than the Alashan Gobi. Variation in site distribution for the East Gobi does support the possibility of increased logistical mobility through an expansion of residential sites into new ecozones, possibly in response to declining dune-field/wetland resources. In the following chapter, a synthesis of recorded palaeoenvironmental data offers a unit of comparison for Holocene organizational strategies across the Gobi Desert.

CHAPTER 5 – PALAEOENVIRONMENTAL CONTEXT

Climate in the Gobi Desert is largely controlled by an interplay in the relative strengths of the Indian and East Asian Summer Monsoon systems, the Siberian-Mongolian high pressure system (which is the source of the East Asian winter monsoon), and the Westerlies. When the Siberian-Mongolian high dominates, beginning at the end of August and continuing until April, strong Westerlies force the East Asian summer and winter monsoons south, blanketing the region with cold dry air. When this high pressure system weakens in the summer, strong summer monsoons bring warm wet air into the region. The strength of the summer monsoon is related to heat transport over an area stretching from the southern Indian Ocean to the Tibetan Plateau (Winkler and Wang, 1993). Numerous recent palaeoenvironmental studies in this region permit better consideration of human ecology following the end of the Last Glacial Maximum (LGM).

Palaeoenvironmental studies allow us to infer a great deal about the nature and timing of climatic shifts, but can be contradictory and otherwise problematic. The recent wealth of palaeoclimatic studies in northeast Asia has drawn considerable attention to inconsistencies at both the local and regional level (An et al., 2006; Zhao et al., 2009). Proxy data indicate a much different timeline for climatic amelioration in the East Gobi than either the Gobi-Altai or the Alashan Gobi. Due to the influence of the mid-latitude Westerlies, climate in the latter regions is more directly controlled by topography and surface temperatures in the North Atlantic Ocean and western Eurasia than by conditions in southern Asia (Chen et al., 2008). Furthermore, large-scale reconstructions aimed at interpreting general climate trends across Central or East Asia can give some insight into the timing of periodic shifts in controlling mechanisms like the summer and winter monsoon systems, but extreme variability in elevation, topography, and soil type result in each climatic event being expressed differently from region to region. For example, a strengthening in summer monsoons after the LGM would have positively affected many semi-arid regions, but irregular precipitation could have stimulated enhanced evaporation in the extremely arid desert regions like the Alashan Gobi, resulting continued or increasing aridity until precipitation stabilized (see Broccoli and Manabe, 1992; Herzschuh, 2006).

Even at the more local level, contradictory results and interpretational disagreements can occur. Various proxy measures such as pollen, sediment grain-size, and depositional sequences sometimes yield differing results, and incongruous interpretations of "relative" humidity and aridity contribute to the confusion. Pollen studies allow for a more detailed understanding of vegetation which can be used to infer ecological context of relevant landscapes, but can be difficult to interpret due to the lack of reliable modern environmental comparisons and differential transport of certain pollen types. As noted, variability in the relative influence of the East Asian summer and winter monsoons, and various high and low pressure systems across the Gobi Desert play a role at the larger-scale, while local vegetation, elevation, groundwater and fluvial hydrology further influence the effects precipitation and temperature (An et al., 2006; Zhao et al., 2009). Further limitations exist in this particular study due to a lack of highly localized data for most key locales.

Despite these limitations, the abundance of recent high resolution palaeoenvironmental studies across Northeast Asia gives some important information about the nature and timing of important climatic events. In combination with more detailed studies of how local environments respond to changes in precipitation, temperature and other climate influenced events, we can infer a great deal about resources that hunter-gatherers might have exploited or the suitability of certain environments during periods of occupation. The range of methods used for palaeoenvironmental reconstruction also contributes to a more nuanced recognition of environmental conditions. The goal of this chapter is to avoid deterministic causal interpretations by synthesizing regional palaeoenvironmental records in order to understand more complex aspects of the relationship between human land-use and climate change.

5.1. Palaeoenvironmental chronology of the Late Pleistocene and Early Holocene in Northeast Asia

Late Pleistocene climates in the Gobi Desert and across adjacent regions can be described in a very general way that relates to the intensification and weakening of the Asian summer monsoon systems and gives an overall picture of climate change dynamics. Four broad periods are relevant to understanding the regional evolution of climate and include: the middle and late stages of Marine Isotope Stage (MIS) 3 (43.0-25.0ka); early to middle MIS 2 (25.0-19.0ka); middle to late MIS 2 (19.0-11.5ka); and the early to late middle stages of MIS 1 (11.5-3.0ka).

5.1.1. Middle to late MIS 3 (43.0-25.0k cal yr BP)

During middle and late MIS 3, the climate reached a condition of high effective moisture (Herzschuh, 2006), witnessed by several periods of palaeosol formation and the infilling of massive palaeolake basins (Shi et al., 2001; Grunert and Lehmkuhl, 2004; Feng et al., 2007). Desert lakes persisted with only brief periods of lower water, and the Gobi was reduced by north and south extension of steppe forest and steppe (Feng et al., 2007). To the south, on the Tibetan Plateau, it is estimated that mean annual temperature was 2-4^{o}C higher than at present (Shi et al., 2001). Increased humidity in the north is evidenced by contraction of desert expanse at around 34.0, 31.0, 29.0 and 25.0k yr BP (39.5, 35.0, 33.5, 30.0k cal yr BP), and in the south at 50.0-40.0, 37.0-32.0, and 29.0-23.0k yr BP (54.0-44.0, 42.0-36.0, and 33.5-27.5k cal yr BP) (Feng et al., 2007). This shift in effective moisture is probably due to significant increases in precipitation during the summer. The northward extension of the summer monsoons would probably have greatly exceeded conditions in the middle Holocene, as suggested by the existence of large lakes in the Tengger and Badain Jaran Deserts (Shi et al., 2001). As we tend to perceive ideal environments for human habitation in more arid environments in terms of higher biotic productivity, the middle to late MIS 3 likely witnessed the most optimal environmental conditions during the entire period that anatomically modern humans occupied North Asia.

5.1.2. Early to middle MIS 2 (25.0-19.0k cal yr BP)

Mean moisture values decreased noticeably due to a strong intensification of the winter monsoon and a weakened summer monsoon throughout much of MIS 2 (~25.0-19.0k cal yr BP) (Herzschuh, 2006). A period of increased humidity at the end of MIS 1 and the beginning of MIS 2 allowed the northward expansion of semi-arid conditions between 25.0-21.0k yr BP (30.0-25.0k cal yr BP) and a southward expansion between 29.0-23.0k yr BP (33.5-27.5k cal yr BP) (Feng et al., 2007). As summer monsoons retreated during a period of reduced temperatures, an overall moisture minimum known as the Last Glacial Maximum (LGM) caused a decline in lake levels and an increase in aeolian deposition (Grunert and Lehmkuhl, 2004; Wünnemann et al., 2007). Many Asian lakes dried out and hyperarid areas reached their maximal extent between 21.3-19.0k cal yr BP (Pachur, et al. 1995; Lehmkuhl and Haselein, 2000; Herzschuh, 2006; Feng et al., 2007). Desert vegetation shifted south to the Loess Plateau and eastward between 32^{o} N and 40^{o} N to the coast line, while taiga extended far south into former desert steppe (Yu et al., 2000; Feng et al., 2007). This general trend may have been expressed somewhat differently across the Gobi Desert depending on pre-existing conditions, as there is evidence that lower rates of evaporation due to lower temperatures actually allowed for stable or increased effective moisture (Komatsu et al., 2001; Liu et al., 2002b; Herzschuh, 2006).

5.1.3. Middle to late MIS 2 (19.0-11.5k cal yr BP)

The immediate post-LGM period can be broadly characterized as one of gradual climatic amelioration. Between 19.8-17.2k cal yr BP mean moisture values gradually increased (Herzschuh, 2006). Lake levels were medium-to-high as steppe and forest-steppe expanded (Wünnemann et al., 2007; Herzschuh and Liu, 2007). A phase of stable and slightly wetter conditions occurred in Asia between 18.5-17.0k cal yr BP, due either to glacial melt or the onset of a summer monsoon circulation after the LGM. Moisture values for monsoonal Central Asia gradually increased until 17.2k cal yr BP, with stable to somewhat drier values until 15.4k cal yr BP (Herzschuh, 2006). Amelioration is indicated by the dramatic retreat of the northern Gobi Desert boundary between 19.0-16.0k cal yr BP (16.0-13.0k yr BP). Intense aridification immediately followed with a re-expansion of desert areas to their maximal extent between 16.0-9.5k cal yr BP (13.0-8.6k yr BP). Aeolian deposition extended at least as far north as 55^{o} N and south to 33^{o} N (Feng et al., 2007). Extreme low moisture availability, corresponding to the cold Younger Dryas event, occurred at 13.0-11.6k cal yr BP across monsoonal Central Asia and 12-10 ka on the Loess Plateau (Madsen et al., 1998; Herzschuh, 2006).

5.1.4. Early to late middle MIS 1 (11.5-3.0k cal yr BP)

Early to late middle MIS 1 is the period most directly relevant to this study. Following the cold/dry Younger Dryas, the trend towards warmer and wetter conditions continued. A strong intensification of both the Indian and East Asian monsoons occurred at the Pleistocene/Holocene transition ~11.5k cal yr BP, and conditions became significantly wetter in monsoon-influenced regions at this time (Herzschuh, 2006). Corresponding periods of aridity in regions influenced by the Westerlies may have resulted from enhanced subsidence of air masses to the lowland areas (Broccoli and Manabe, 1992; Herzschuh, 2006). Although annual average temperatures and precipitation had both increased by 9.6k cal yr BP (9.0k yr BP), orbital changes acting on summer and winter monsoon systems caused an increase in seasonality, with colder winters and warmer summers, that would have limited the expansion of some species. Seasonality was temporarily reduced after 9.6k cal yr BP (9.0k yr BP) and even more so after 6.8k cal yr BP (6.0k yr BP). Heightened seasonality returned after about 3.2k cal yr BP (3.0k yr BP) when the strength of the winter monsoon declined (Kutzbach, 1981; Winkler and Wang, 1993).

The retreat and advance of arid lands reflects these shifts in weather systems. In regions less influenced by the monsoonal systems than the Westerlies, the northern boundary of arid lands retreated most dramatically between 9.6-7.8k cal yr BP (8.6-7.0k yr BP). In monsoon-influenced regions, the southern boundary of arid lands retreated northwards between 10.1-4.5k cal yr BP (9.0-4.0k yr BP) due to an increase in monsoonal precipitation (Starkel, 1998; Feng et al., 2007). Altitudinal zones also reflect the shift in climate-mediated ecotones as indicated by changes in the upper and lower tree lines and permafrost limits (Starkel, 1998). During the early Holocene, hyperarid and arid zones retreated to an area that extended maximally between 38^{o} N and 48^{o} N (Feng et al., 2007).

Divergence in the palaeoclimatic records of separate Gobi Desert regions influenced by different circulation systems is especially notable during the Holocene (Table 5.1). Data from the East Gobi, influenced by the East Asian Monsoon system, indicate wet conditions from about 11.5-1.7k cal yr BP, with optimal moisture between 8.3-5.5k cal yr BP (Herzschuh, 2006). In stark contrast, the Gobi-Altai and Alashan Gobi, areas under the influence of the Westerlies do not show a pronounced a moisture maximum, but rather more constant values between 12.1-2.7k cal yr BP with a much more arid climate prior to 8.0k cal yr BP and a short maximum between 7.5-6.8k cal yr BP (Herzschuh, 2006; Chen et al., 2008). The end of optimal conditions in the Gobi-Altai is signalled by the expansion of permafrost and a decline in precipitation between 5.8-4.5k cal yr BP (5.0-4.0k yr BP) (Starkel, 1998), and in the Alashan Gobi by an overall decrease in mean effective moisture after ~3.0k cal yr BP (Herzschuh, 2006).

5.2. Regional Variability

5.2.1. East Gobi

The East Gobi Desert region, for the purposes of this study encompasses an area between 41^{o} 00’ - 44^{o} 00’ N and 108^{o} 00’ - 115^{o}00’ E. Situated primarily within the Nei Mongol or Inner Mongolia Autonomous Region of the People’s Republic of China (PRC), the region extends from south to north from just above the northernmost bend in the Yellow River into the southeastern corner of Mongolia, and from the northernmost bend of the Yellow River in the west to the Hunshandake Sandy Land in the east (see Figure 5.3). Of the three regions discussed, the East Gobi climate is the least continential and arid, being more heavily influenced by the East Asian monsoon system. In recent times annual average precipitation has been approximately 200-400 mm. The climate is considered middle-temperate sub-dry, a designation that applies to an area extending southwest across the Ordos Plateau into the southwestern reaches of the Yellow River (Winkler and Wang, 1993). Today, the northern limit of the summer monsoon divides the target region diagonally from southeast to northwest.

Most palaeoenvironmental studies have centred on the transitional zone between semi-humid and semi-arid environments southeast of the study area, where shifts in the extent of monsoonal precipitation are most noticeable. Here, monsoonal precipitation is a controlling factor in Holocene moisture availability, which in turn helps to regulate vegetative cover. According to proxy data from chronostratigraphic biologic and geomorphic research, the northern extent of the summer monsoon has changed dramatically throughout the Holocene. At about 10.0k cal yr BP (9.0k yr BP), the summer monsoon reached no farther than the southernmost boundary, but by 6.8k cal yr BP (6.0k yr BP), in concert with a northward shift of the Westerlies, it extended into Mongolia as far as 44^{o} N (Rea and Leinen, 1988; Winkler and Wang, 1993: 224, Figure 10.3.b).

This progressive northerly shift in monsoonal precipitation during post-LGM warming would have played an important role in Holocene environmental change. According to studies of sediment cores derived from a series of lakes lying between 40^{o} 30’- 43^{o} 00’ N, 112^{o} 30’-117^{o} 00’ E, temperatures were much cooler and annual precipitation much lower than modern averages prior to 16.5k cal yr BP (13.5k yr BP). Indicators of climatic amelioration after 16.5k cal yr BP (13.5k yr BP) include a reduction in aeolian activity (Wang et al., 2001). Slight increases in humidity and temperature are seen to have led to a decrease in Chenopodiaceae pollen after about 14.0k cal yr BP (12.0k yr BP), although humidity increased again about 12.4k cal yr BP (10.5k yr BP) (Wang et al., 2001; Liu et al., 2002a; Wang et al., 2010), when the climate was somewhat warmer and wetter than today (Shi and Song, 2003). Pollen studies show that prior to the Holocene, *Betula* (birch), Chenopodiaceae, Artemisia and *Ephedra* dominated, suggesting a woodland-steppe mosaic (Wang et al., 2001; Wang et al., 2010). Palynological records from Diaojiao Lake (41° 18’ N, 112° 21’ E), at the northern foot of the Daqingshan Mts., indicate that between 10.4-8.8k cal yr BP (9.2-7.9k yr BP) desert-steppe vegetation dominated an environment that was once rich arboreal species (Shi and Song, 2003). This brief decrease in arboreal species due to lower temperatures and increased aridity would have interrupted earlier Holocene amelioration.

Temperatures appear to have begun rising around 8.9k cal yr BP (8.0k yr BP). There were corresponding increases in *Picea* (spruce) and *Ulmus* (elm) (Liu et al., 2002a; Shi and Song, 2003; Peng et al., 2005; Wang et al., 2010; but see Jiang et al., 2006). At Lake Bayanchagan (41° 38' N, 115° 12' E, 1355 m a.s.l.), this climatic amelioration was followed by decreases in the length of growing season. Decreases in mean temperature of the coldest month, mean temperature of the warmest month, and mean annual temperature around 8.0k cal yr BP (ca. 7.5k yr BP) were also noted (Jiang et al., 2006).

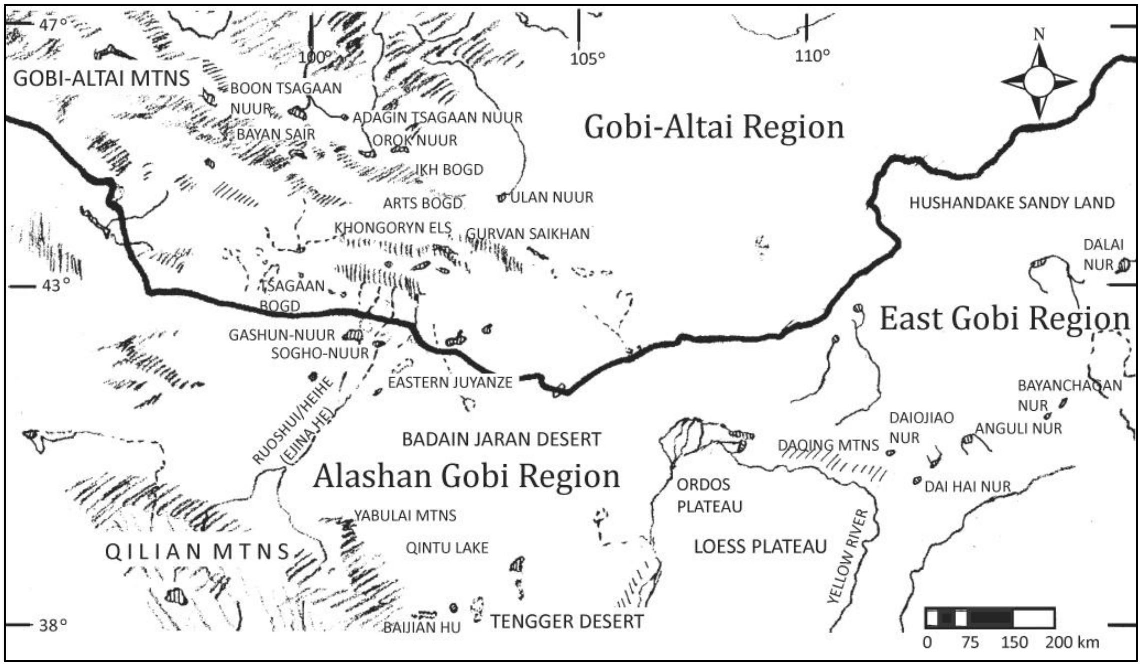


Figure 5.1 Map of Gobi Desert showing palaeoenvironmental locales and study regions.

The Holocene Climatic Optimum occurred at different times after 8.9k cal yr BP (8.0k yr BP) and is recognized by an increase in forest species pollen and decreased representation of steppe species (Jiang et al., 2006). Increases in *Picea* (spruce), *Pinus* (pine) and *Quercus* (oak) are attested to in various locales before 7.8k cal yr BP (7.0k yr BP) (Wang et al., 2001; Wang et al., 2010) and there is evidence of an optimal forest zone with a more mosaic forest-steppe vegetation in the immediate vicinity of Daihai Lake (40° 35' N, 112° 40' E) at 7.9-6.5k cal yr BP (7.5-5.5k yr BP). Pollen data from Daihai Lake indicate that arid herbs and shrubs dominated the lake basin during the early Holocene, but from 7.9k cal yr BP to 4.45k cal yr BP large scale covers of mixed coniferous and broadleaved forests marked a warm and humid climate in the lake area. Before the end of the Holocene Climatic Optimum woodlands and woodland-steppes formed with *Quercus* (oak), and *Pinus* (pine) at higher elevations, replacing arid steppe and *Betula* (birch) -dominated woodland or woodland-steppe in some regions (Wang et al., 2001; Liu et al., 2002a; Peng at al., 2004; Jiang et al., 2006).

This trend toward increased humidity throughout the semi-humid/semi-arid transitional zone can be generally seen as peaking around 7.7k cal yr BP (6.9k yr BP), but there is some variation between studied locations (Wang et al., 2001; Peng et al., 2005; Jiang et al., 2006). At Anguli-nuur (41° 18-24' N, 114° 20-27' E, ~1315 m a.s.l. – Wang et al., 2010) the climatic optimum occurred much earlier than 7.7k cal yr BP, but at the more westerly locale of Diaojiao it occurred later (Shi and Song, 2003). The period of maximum humidity lasted for approximately 1,000 years and was followed by a steady decline across the entire region, marked by increases in aeolian activity (Wang et al., 2001).

The decline in overall vegetation, particularly deciduous and coniferous trees, continued after the Holocene Climatic Optimum as steppe vegetation became increasingly dominant. At Lake Bayanchagan mosaic forest-steppe vegetation gave way to a steppe-dominated environment with small forest patches along mountains and river valleys between 6.5-5.1k cal yr BP (5.5-4.3k yr BP) (Jiang et al., 2006). Decreases in humidity and ensuing environmental degradation appear to have occurred later in the south, where climatic conditions may have peaked between 5.0-4.8k cal yr BP (Peng et al., 2005), and at Diaojiao Lake, where drainage from nearby mountain ranges might have prolonged the effects of climatic amelioration (Shi and Song, 2003). Palaeosol formations in the Hulun Buir (Kölün Buyir) (48^{o} N, 120^{o} E) and Hunshandake sandy lands (42-44^{o} N, 112-118^{o} E), estimated by archaeologists to date to about 5.0-3.0 ka, may be associated with the same climatic event (Winkler and Wang, 1993; Yang et al., 2008). Post-optimum increases in aridity and declines in temperature are characterised first by the declining representation of deciduous trees in favour of coniferous species (Jiang et al., 2006; Wang et al., 2010), and by the formation of sparse coniferous tree woodland-steppe in the mountains (Shi and Song, 2003).

Increasing regional variation in climatic optima and ensuing aridity by the mid-Holocene may be related to local vegetational and hydrological feedback. After 4.5k cal yr BP (4.0k yr BP) pollen profiles at Lake Bayanchagan indicate a notable rise in the frequency of desert species (Jiang et al., 2006). This transition appears to have been prolonged at Diaojiao Lake, where drainage from the mountains may have buffered the effects of decreased precipitation until after 3.2k cal yr BP (3.0k yr BP) (Shi and Song, 2003). Beginning around 2.9k cal yr BP, there is a decline in representation of woody plants at Daihai Lake, suggesting a transition from warm/humid to cold/dry climatic conditions (Peng et al., 2005).

In summary, the Pleistocene-Holocene transition in the East Gobi was marked by an increase in humidity and temperature by 12.4k cal yr BP (10.5k yr BP) that was followed by a period of optimal climatic conditions between 8.9-6.3k cal yr BP (8.0-5.5k yr BP), peaking at about 7.7k cal yr BP (6.9k yr BP). Increasing arboreal pollen in the southeastern reaches of the study region indicate that the early Holocene was typified by a shift in both the composition of tree species and the gradual expansion in the extent of woodland environments. The Holocene Climatic Optimum was typified by a peak in the extent of woodlands, with temperate coniferous and broadleaved forests extending across the East Gobi (see also Figure 10.11., Winkler and Wang, 1993) and some loss of open steppe environments, though forests dominated only in high elevations and river valleys. After 6.3k cal yr BP (5.5k yr BP) there was a decline in arboreal species at lower elevations corresponding to the expansion of steppe environments. Increased aridity marked by increased aeolian activity and the prevalence of desert species in pollen profiles differed regionally according to local hydrology between 4.5-2.9k cal yr BP (4.0-2.8k yr BP).

While these data give a good indication of climatic conditions along the southeastern fringes of the study area, they lie farther south or east of the actual archaeological sites studied here. As such, it might be expected that these localities, which are now located in much more arid environments, experienced slightly later climatic and environmental amelioration in accordance with the lag in monsoonal migration. Optically stimulated luminescence (OSL) dates on palaeosol and sand sequences in two northeastern desert regions of Inner Mongolia, Hunshandake (~43° N, 116 ° E) and Hulun Buir Deserts (~49° N, 118 ° E) indicate a shift from dune formation to sand stabilization that began about 10.0 ka and continued until about 3.6 ka (Li et al., 2002), with optimal conditions (warm/wet) from about 5.0 to 3.0 ka (Yang et al., 2008). In both regions climatic amelioration appears to be broadly synchronous with developments in the semi-humid/semi-arid transitional zone. Vegetation composition in these arid regions would have differed significantly from that in the more verdant southeastern region, which falls along the modern boundary of semi-arid to arid environments. Corresponding conditions of heightened evapotranspiration and albedo feedback may have resulted in a less dramatic moderation of temperatures and groundwater retention, probably decreasing the significance of arboreal species (Ganopoloski et al., 1998; An et al., 2006; Zhao et al., 2009).

Conditions may have been similar to those across the comparably arid Loess Plateau, south of the Yellow River. Here the warm/humid Holocene was evidenced by semi-stabilization of dunes, the formation of steppe and forest-steppe environments and of lakes or swamps in interdune depressions (Yang et al., 2004). The distribution of pollen data from the northwestern Loess Plateau (~35^{o} 00’ - 38^{o} 30’ N, 104^{o} 00’ – 109^{o} 30’ E) indicate that at sites in river valleys and terraces the most warm/humid periods were characterized by forest, forest-steppe, or steppe with sparse trees. Other sites showed only sparse forest-steppe or humid steppe with some tree pollen, suggesting that elevation and hydrology play a major role in vegetation composition (Zhao et al., 2009). The occurrence or absence of forest-steppe environments is essential in understanding human land-use, as an increase in arboreal species would have dramatically altered the biotic landscape. We might infer that during the Holocene Climatic Optimum, the archaeological study area was typified by steppe with forest-steppe mosaic along upland plateaux and river valleys, while mixed forests may have dominated mountain ranges. *Quercus* pollen from Hulun Bair at about 5.0-3.0 ka indicates the presence of nut-bearing hardwood species in this northeastern desert region.

According to dates from East Gobi archaeological sites (see Chapter 3), it is probable that intensive use of dune-field/wetland environments may have begun around

8.0 kya and ending by 3.0 kya. Such archaeological sites, frequently associated with sand deposits and lake basins, belonged to hunter-gatherers described as "dune-dwellers" by Central Asiatic Expeditions members when they were discovered in 1925 (Nelson, 1926a). This period of dune-field/wetland habitation is contemporaneous with palaeosol formation and the expansion of steppe and forest-steppe in what were previously and are now desert environments. According to comparative data from neighbouring locales, this period of increased precipitation and warmer temperatures provided an environment of many small lakes and swamps in basins and interdunal depressions, expanded steppe, and mosaic mixed (coniferous and broadleaved) forest-steppe habitats along river valleys, mesas and upland plateaux. Based on dates for the expansion of forest species farther south, it is probable that the longer-term habitation in lowland dune-field/wetland habitats did not commense until forest stands comprised of species such as oak and pine were well-established.

The distribution of East Gobi archaeological sites dating to the terminal Pleistocene and early Holocene indicates that habitation shifted from a focus on higher elevations (> 1200 m a.s.l.) and river/streams during Oasis 1 (~13.5-8.0 kya), to the use of low (< 1200 m a.s.l.) and mid-altitudinal habitats (1201-1400 m a.s.l.) near lake/wetlands during Oasis 2 (~8.0-5.0 kya) (see Figure 4.2 and Table 4.4). Residential sites associated with Oasis 2 and Oasis 3 centred on lowland dune-field/wetland habitats (Table 4.11). They indicate an intensive type of planned longer term habitation that is not characteristic of earlier periods. Furthermore, formal grinding stones are typical of Oasis 2 sites and represent a sort of specialized non-portable processing equipment that is unique in Gobi Desert prehistory. Considering the types of resources available in dune-field/wetland habitats, such technology is expected to have been used for seeds and tubers, but the pollen data summarized above suggest that nut-bearing species such as oak and pine might also have been available. Forest expansion might also be represented by the development of adze/axe technology, frequently associated with woodworking, during Oasis 2. The shift in the focus of grinding technology towards less formal types during Oasis 3 suggests a change in diet or processing practices, perhaps related to a declining representation of deciduous nut-bearing trees such as oak (see Jiang et al., 2006; Wang et al., 2010). The decline in arboreal species, particularly deciduous types, would have been most pronounced at the end of Oasis 3, as indicated by decreasing representation in pollen profiles and the corresponding increase of desert species between 4.5-2.9k cal yr BP (Jiang et al., 2006; Shi and Song, 2003; Peng et al., 2005).

5.2.2. Gobi-Altai

The region referred to in this study as the Gobi-Altai encompasses an area extending from 43^{o} 00' – 46^{o} 00' N, 98^{o} 00' - 105^{o} 00' E and is part of the "arid Central Asia" region dominated by the Westerlies (Chen et al., 2008). Here precipitation depends on the availability of water vapour transported by the Westerlies from the North Atlantic Ocean, and inland seas and lakes along the mid-latitude cyclonic storm paths (Böhner, 2006). Analysis of dust storm and blowing sand records from over 680 stations in China and Mongolia, collected between the years 1961 to 2000, confirms that the Arctic oscillation (representative of non-seasonal sea-level pressure variations) and the

Westerlies control direct dust dispersal in Mongolia, suggesting that they also play an important role in climate shifts (Han et al., 2008). Despite the lack of direct monsoonal influence today, the region would have received increased moisture from both run-off and precipitation when the East Asian summer monsoon reached its northernmost limit (Figure 5.2; also see Figures 10.3(d)., Winkler and Wang, 1993).

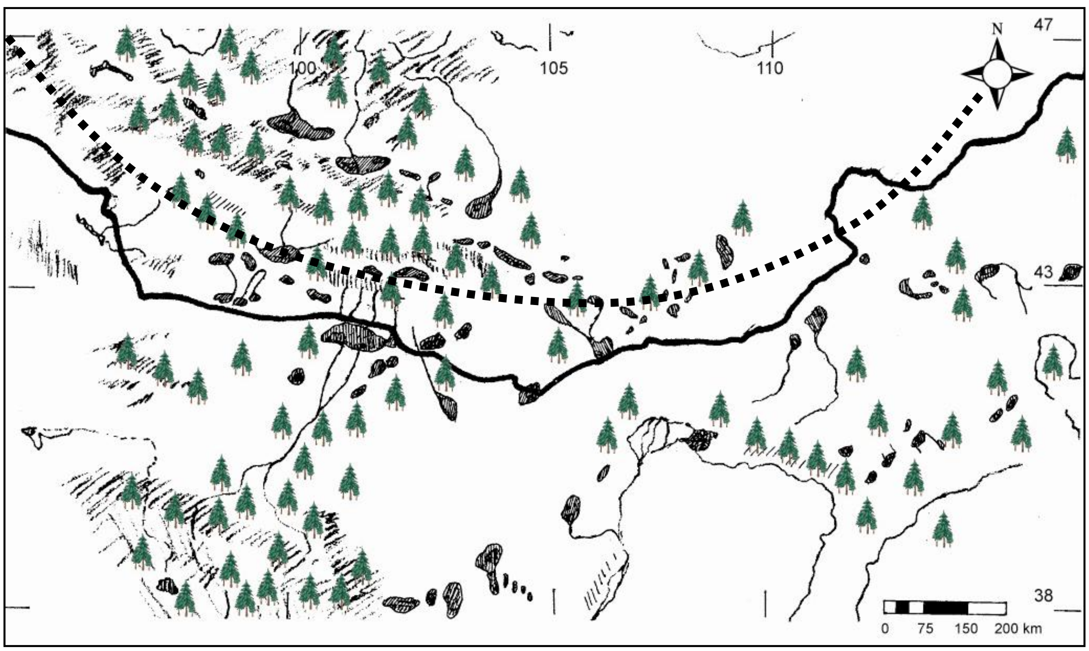


Figure 5.2 Map showing the study region at about 6.0 kya, including northernmost limit of East Asian summer monsoon. Approximation of forestation and lake extent derived from data cited in text. Monsoon data derived from Winkler and Wang, 1993.

The Gobi-Altai region is separated from the Alashan Gobi by the southeastern-most foothills of the Altai Mountains and includes the more temperate Valley of the Lakes, situated between the Gobi Altai and Khangai (Khangay) mountain ranges of Mongolia. These lakes are fed by rivers running from the Khangai Mountains. Depth fluctuates greatly on annual and decadal scales, but in recent times all are brackish, shallow and internally drained. Palaeoclimatic studies are more limited here than in the Chinese Gobi Desert. This is particularly true since much of the earlier Soviet work is largely inaccessible. Despite the paucity of literature pertaining to local climate change, several studies have focused directly on the southern Mongolian Gobi Desert.

Data suggests that conditions during the LGM were largely consistent with other parts of Central and East Asia. Optically Stimulated Luminescence (OSL) dates on cryoturbated structures around the Arts Bogd and Gurvan Saikhan (Gurvan Sayhan/Gurvan Sayhany nuruu) ranges (~43^{o} 41' – 44^{o} 26' N, 102^{o} 15' – 102^{o} 22' E, 1200-2400 m a.s.l.) indicate that permafrost was developed along the desert floors and alluvial fans during the Last Glacial Maximum (22-15 ka). Luminescence dates of sandy sediments close to the Late Quaternary ice margin indicate an age of about 21 ka for the maximum advance of glaciers (Lehmkuhl and Lang, 2001). The formation of alluvial fans between about 23-9 ka further indicates a period of increased of aridity and flash flooding (Owen et al., 1997). In support of this finding, OSL dates from sediments in the Khongoryn Els dune field, which receives drainage from the Gurvan Saikhan just to the north (44-43^{o} N, 102-104^{o} E), indicate the major accumulation of aeolian layers and fluvial-lacustrine sediments (probably from local river blockage by sand accumulation) occurred during a brief episode sometime between 18-11ka (~15ka) (Hülle et al., 2009).

Despite evidence for increased aridity, the physical quality of cryoturbation structures and the occurrence of ice wedge casts indicate that the region was characterised by adequate water. Detailed stratigraphic study of Chikhen Agui, an archaeological rockshelter site in the Gobi-Altai Mountains, also indicates a continuation of depositional processes and water percolation throughout the LGM (Komatsu et al., 2001). Colder temperatures may have contributed to reduced evapotranspiration and are indicated by an annual freeze-thaw depth of about 2 m, severe winter cooling with continuous permafrost, and mean annual air temperatures below approximately -6^{o} C (Owen et al., 1998). In contrast, the lack of permafrost structures in the southern and westernmost portion of the Gobi-Altai region (< 43^{o} 00' N, 100^{o} 30' E) might indicate either an insufficient ground water supply or an annual air temperature closer to 0^{o} C (Owen et al., 1998). Across the Gobi-Altai region, permafrost degraded with the onset of warmer average annual temperatures after about 13-10 ka (Owen et al., 1998). Divergent records of effective moisture may result from variation in the ability of local soils to hold seasonal melt-water and precipitation under regimes of reduced precipitation.

Holocene climate change in northern China, particularly northeast of the Yellow River, has been related to increased precipitation resulting from shifts in the northern extent of the summer monsoon, but the Gobi-Altai study region was not as heavily influenced by the East Asian summer monsoon system (see Figure 5.2). Even at its northernmost extent monsoonal precipitation would not have reached far beyond the modern border separating Mongolia and China. Earlier Soviet work, though based primarily in northwestern Mongolia, suggests that the climate across Mongolia was relatively stable from 11.5-8.9k cal yr BP (10.0-8.0k yr BP), but cooler and wetter from 8.9-5.8k cal yr BP (8.0-5.0k yr BP) (An et al., 2008). Western Mongolian Altai lakes Uvs Nuur and Bayan (Bajan) Nuur show evidence of post-glacial infilling around 13.0 ka with high lake levels at about 11.0 ka (Grunert et al., 2000). Pollen and plant macrofossil records from across Mongolia more precisely indicate a widespread drier climate before 9.5 ka and a distinctly more mild and wet climate during the early to mid-Holocene (Gunin et al., 1999; Tarasov et al., 2000). At Hoton-nuur, a lake in the far west Mongolian Altai Mountains, a cool/dry climate is evidenced during the terminal Pleistocene and early Holocene, until ca. 12.7k cal yr BP (10.7k yr BP), followed by forest development and a decrease in continentality (Rudaya et al., 2008). Humidity appears to have peaked between 10.5-7.4k cal yr BP (9.3-6.5k yr BP) with a slight cooling around 8.9k cal yr BP (8.0k yr BP) (Rudaya et al., 2008). Recent dates on ostrich eggshell from the Gobi-Altai region indicate that East Asian ostriches were present in the vicinity of Bayan-dzak (Shabarakh-usu locality) (44^{o} 10’ N, 103^{o} 42’ E) between 12.2-8.8k cal yr BP (10.3-7.9k yr BP) (Janz et al., 2009; Kurochkin et al., 2009), probably indicating a more moist, and perhaps less seasonal, environment (Janz et al., 2009).

Luminescence dating of beach strands along the shore of Adagin Tsagaan Nuur (Tsagaan/Adagin Cagaan Nuur/Nor) (~40^{o} 00’ N, 100^{o} 05’ E, 1331 m a.s.l.) indicate that by 8.5 ka this lake joined Bon Tsagaan Nuur (Böön/Bon Cagaan Nuur/Nor) to form a large palaeolake with an area of about 1923 km^{2} (Lehmkuhl and Lang, 2001) and a depth of up to 100 m (Komatsu et al., 2001). Covering sediments and geomorphology of a 1303 m a.s.l. beach line at Orok Nuur (Orog Nor/Nuur) (~45^{o} 00’ - 45^{o} 15’ N, 100^{o} 30 – 101^{o} 05’ E, 1303 m a.s.l.) correspond with those at Adagin Tsagaan Nuur, suggesting a similar date for this 394 km^{2} palaeolake (Lehmkuhl and Lang, 2001). Palaeoshoreline landforms around Orok Nuur are complex, large and well-established, implying that the palaeolake was stable for an extended period and did not experience frequent transgressions and regressions (Komatsu et al., 2001). Evidence from ten lakes across Mongolia suggests variable periods of Holocene lakeshore expansion with a widespread trend towards wetter conditions by 8.3k cal yr BP (7.5k yr BP) (Tarasov et al., 2000). The expansion of palaeolakes during the early Holocene was probably the result of a number of conditions, including the initial influx of glacial melt, higher seasonal groundwater availability due to permafrost melt, increased precipitation, and cooler temperatures (lower levels of evaporation) (see Komatsu et al., 2001).

Aridity and continentality gradually increased after about 7.4k cal yr BP (6.5k yr BP) (Rudaya et al., 2008). Warm/dry conditions prevailed between 5.8-2.6k cal yr BP (5.0-2.5k yr BP) (An et al., 2008). Animal bones and feces from caves in the Tsagaan Bogd Mountains (Cagan Bogdo/Segs Tsagaan Bogd Uul) indicate a trend towards increased aridity after 5.2k cal yr BP (4.5k yr BP) with two more humid phases following this, including one after 3.2k cal yr BP (3.0k yr BP) (Kniaziev, 1986; Starkel, 1998). Dramatic retreat of boreal forests and significant lowering of lake levels throughout Mongolia by 4.0-3.0 ka indicate a drastic change in climate, resulting in essentially modern conditions since 2.0 ka (Tarasov et al., 2000).

Radiocarbon dates on pottery from archaeological sites in the Gobi-Altai region are later than those from the East Gobi. Sampling may have contributed to this result; however, human habitation at Chikhen Agui overlaps with the earliest dune-field/wetland occupations in the East Gobi (see Figure 3.1) and this may indicate that Late Epipalaeolithic land-use persisted longer in the Gobi-Altai. Based on comparisons of pottery and artefact typology, many dune-field/wetland sites can be assigned to a period dating to between approximately 6.0-3.0 kya. This period corresponds with greatly reduced seasonality across Northeast Asia between 6.8-3.2 kya.

If climatic amelioration – particularly higher effective moisture – was the driving factor behind a shift to dune-field/wetland-centric organizational strategies, we could predict that this pattern of land-use would have arisen in the Gobi-Altai sometime between 9.5-7.4k cal yr BP; however, such a pattern is so far not evident in the archaeological record until the middle Holocene. Instead, human population density and dune-field/wetland use in the Gobi-Altai region appears to have been most intensive after the onset of gradually increasing aridity (7.4 kya). At the Shabarakh-usu locality, many sites were found below high water strandlines and are firmly dated to between 4.9-3.4k cal yr BP (see Chapter 3). The termination of Oasis-type land-use occurred only after a more dramatic retreat of lake levels and boreal forests across Mongolia (see Tarasov et al., 2000). Despite the trend towards increased relative aridity, we can not assume that middle Holocene environments were typified by the modern desert and desert-steppe landscapes. According to the data summarized above, the Gobi-Altai would continue to have been characterized by numerous stable lakes, and probably by arid or desert-steppe until at least about 4.0 kya.

5.2.3. Alashan Gobi

The Alashan Gobi lies south of the Gobi-Altai mountain ranges and north of the Qilian Mountains. For the purposes of this study, a territory encompassing 40^{o} 30’ – 43^{o} 00’ N,

97^o 00’ – 106^o 30’ E is considered. Although this represents a larger territory than that of the other target regions, environments are less variable and archaeological sites more dispersed. The Alashan Gobi is part of “arid Central Asia,” in which the modern climate is controlled by the Westerlies. Monsoon activity over the Tibetan Plateau also contributes to effective moisture due to the importance of drainage from higher elevations in the south. The northward advance of monsoonal precipitation would have played a greater role in Holocene precipitation than in the Gobi-Altai, but less of a role than in the East Gobi.

Two landforms are of particular importance in both palaeoenvironmental and archaeological studies: the Badain Jaran (Badan Jarang) Desert, which covers much of region; and the Juyanze palaeolake system. The Badain Jaran Desert is a landscape of active dune fields that includes some of the highest dunes in the world (up to 460 m). It is located between 39^o 20’ – 42^o 00’ N and 99^o 48’-104^o 14’ E and bounded in the south by mountains and in the north and west by former lake beds. The Yabulai Mountains border Badain Jaran in the southeast. Varying levels of precipitation, derived primarily from the East Asian summer monsoon system, are reported throughout the region, from 118 mm in the southeast to 37 mm in the northwest (Yang et al., 2003).

The Juyanze palaeolake system is located in the northwest portion of the study area. It is an endorheic or closed basin with a drainage pattern of river channels from the south and presently dry channel systems from the northern highlands in the Gobi-Altai region (see Figure 5.1; Hartmann and Wünnemann, 2009). At its southern extent, the Juyanze landscape is typified by a network of current and former river channels, marshes and oases. The area is known for an abundance of both prehistoric sites and significant historical remains (Sommerström, 1956). The palaeolake was historically fed by the Ruoshui/Heihe drainage system (called Heihe in the southern mountainous regions and Ruoshui [Ejina He/O-Chi-na Ho] in the north), which originates in the Qilian Mountains on the Tibetan Plateau. The Ruoshui/Heihe forms two primary branches, the western is called the Xihe (Moren Gol) and the eastern is the Donghe (Dongduer or Edsen/Etsin Gol). Although both these rivers once drained into the Juyanze palaeolake, they now terminate before reaching the terminal basin due to heavy use for irrigation (Lu et al., 1997; Yang and Williams, 2003).

The Juyanze palaeolake system (including Gashun-nuur [Gaxun], Sogho-nuur [Sogo/Sokho-nor/nur] and Eastern Juyanze) appears to have reached its maximum extent earlier in the Pleistocene, but between 37-20 ka a large freshwater lake and swamp area several times larger than present still existed (Wünneman et al., 1998a, 1998b). This suggests more effective runoff from surrounding mountain ranges and considerably higher levels of precipitation on the Tibetan Plateau (Wünneman et al., 1998a; Wünneman et al., 2007). This period of increased precipitation probably occurred under the influence of the Westerlies, since the East Asian summer monsoon was quite weak during glacial times (Yang et al., 2003). After about 30.0k cal yr BP (25.0k yr BP) aeolian deposition increased and cold-dry conditions predominated, although lake levels did not reach modern lows (Wünneman et al., 2007). A period of complete desiccation characterised the Eastern Juyanze between 23.0-17.2k cal yr BP (19.0-14.0k yr BP) (Wünneman et al., 1998b). Increased lake levels are evident at Eastern Juyanze around

17.0k cal yr BP (13.8k yr BP). The formation of lake carbonates around 16.0k cal yr BP (13.0k yr BP) at Baijian Hu, in the Tengger Desert south of the Yabulai Mountains, also indicates a return to warmer/wetter conditions following the LGM (Wünneman et al., 1998a, 1998b).

The Badain Jaran is a sand desert characterised by high dunes and numerous lakes, most of which are concentrated in the southeast. There are over 100 permanent lakes in the south. The southeastern edge of the Badain Jaran hosts many small shallow lakes less than 0.2 km^2 in extent and 2 m deep. Large, deep lakes are found farther north (Yang and Williams, 2003). Aside from the Juyanze system, these lakes have no surface in- or outflow. Recent studies of ion chemistry from water in several of the lakes indicate that they are mostly charged by precipitation-derived groundwater rather than runoff from adjacent mountains. Many of the lakes with low salinity were probably formed by the emergence of freshwater springs in new locations when the movement of the dunes changed groundwater flows (Yang and Williams, 2003).

At one time, the lakes in this area were much larger and deeper and many were joined forming single large lakes. Thermoluminescence (TL) and radiocarbon dates on sediments and peat from dried lake beds indicate that high lake levels occurred between about 8.8-4.5k cal yr BP (8.0-4.0k yr BP), but that even as late as ca. 800 years ago, lake levels were much higher than today (Yang and Williams, 2003). A more humid climate in the region between ca. 9-4 ka probably indicates increased precipitation from the East Asian summer monsoon, which reached its maximum northern extent during this period (Yang et al., 2003). Pollen assemblages reveal more abundant middle Holocene vegetation, with tree pollen of *Pinus* (pine), *Picea* (spruce), *Ulmus* (elm) and *Salix* (willow) from peat samples dated to 7.8k cal yr BP (7.0k yr BP) and 7.4k cal yr BP (6.5k yr BP) (Yang and Williams, 2003). Grass and bush pollens from these samples were typical of desert-steppe to steppe with riparian or wetland conditions (compare to Herzschuh et al., 2003; Xu et al., 2009; Zhao et al., 2009). Although lake levels were higher, lakes changed gradually from freshwater to saline toward the end of the middle Holocene due to increasing aridity (Yang et al., 2003).

In the Yabulai Mountains, southwest of the Badain Jaran Desert, a similar system of groundwater-fed lakes exists as in the east. This mountainous region is better vegetated than the sand seas of the Badain Jaran, and permanent lakes exist in closed depressions (Yang, 2006). Groundwater is partially recharged by melting ground frost in spring, but is maintained primarily through local precipitation that rapidly infiltrates the sandy dunes and sediments throughout the region’s mountainous terrain (Yang, 2006). TL dates on sediments from interbedded lacustrine and aeolian sediments at Shugui Lake indicate high lake levels at about 128 ka, 16 ka, and intermittently between 7.5-4.5 ka (Yang, 2006).

Today, as in the Gobi-Altai, precipitation in the Badain Jaran/Yabulai Mountain region is controlled by the Westerlies with little influence from the East Asian summer monsoon, which now reaches only the southeastern margin of the Badain Jaran Desert. During the middle Holocene, however, precipitation would have reached an average of perhaps about 200 mm/year, probably due to the northward migration of the Asian summer monsoon (Wünneman et al., 1998a; Yang and Williams, 2003). By about 6.8k cal yr BP (6.0k yr BP), northward migration of the East Asian summer monsoon would have ensured increased precipitation throughout the entire Alashan Gobi region (Winkler and Wang, 1993). Higher levels of evapotranspiration would likely have maintained a desert-steppe environment, despite an increase in the availability of surface and groundwater.

Studies of Holocene palaeoenvironments on the western Alashan Plateau have focused on three small lakes, once a part of the Juyanze palaeolake system. Today the palaeolake system is divided into two sections – the Western and Eastern Juyanze – and three lakes – Gashun-nuur (Xi/Western Juyanhai), Sogho-nuur (Dong/Eastern Juyanhai), and the Eastern Juyanze Lake Basin (East Lake Etsina). The latter now exists as two ephemeral lakes – Jingshoutou and Tian'e Hu (Mischke, 2001: 10). The areal extent of these lakes has undergone dramatic changes since their final separation by 5.5k cal yr BP (4.8k yr BP) (Lu et al., 1997). Western and Eastern Juyanze were separated from the Gashun-nuur system through tectonic movement, either during the Holocene (Becken et al., 2007; Hölz et al., 2007; Hartmann and Wünnemann, 2009) or possibly much earlier around 40.0k cal yr BP (35.0k yr BP) (Wang et al., 2004). Western Juyanze did not become separated into the modern Gashun-nuur and Sogo-nuur until the 17th century CE. Since the earliest historical records (ca. 300 BCE) until that time, the basin was described as continuously filled by a large lake (Mischke, 2001: 16).

Changes in the flow of the Ruoshui/Heihe drainage system, including intermittent variability in the position and flow of its northern branches (Xihe [Moren Gol] and Donghe [Edsen Gol]), have affected the levels of these terminal lakes. Over the past

2000 years, the Ruoshui/Heihe has been known to periodically change its course, sometimes flowing into the Eastern Juyanze Basin (East Juyanze/Juyanze/Juyan Lake, including Lake Jingshoutu) and sometimes into Gashun-nuur and Sogo-nuur (Mischke, 2001: 16; Wang et al., 2004). Palaeoenvironmental records for each minor lake basin should mirror shifts not only in temperature and precipitation, but in the relative dominance of minor river branches.

The early to mid-Holocene landscape would have been much different from today, particularly in terms of hydrology. Human activities in the region have dramatically altered the hydrological landscape. Changes in lake levels related to human activities are noted in historical records since 317-534 CE. Intensification of farming around the town of Ganzhou (established by the Han in 111 BCE) during the Sui and Tang Dynasties (6^{th}-10^{th} centuries CE) resulted in the inital shrinking of the terminal lakes, while subsequent rejuventation occurred during the Mongol occupation beginning in the 13^{th} century CE (Lu et al., 1997). However, even in 1927 when Sven Hedin visited the region, Sogho-nuur was 2.9 m at its deepest point and it took Hedin almost four hours to cross the river by canoe (Hedin, 1943: 166-168). At this time the area was home to the largest poplar forest in China (Lu et al., 1997). More recently, periods of war followed by industrial and agricultural development have led to desiccation and the destruction of vegetation (Lu et al., 1997). These examples attest to the vulnerability of both lake levels and forest vegetation to human activities along the Ruoshui/Heihe, and indicate that current climatic conditions are a poor indicator of early to mid-Holocene environments.

Lake evolution in the Juyanze palaeolake basin illustrates the relationship between climatic change in the Alashan Gobi and neighbouring territories, and the stabilization of lakes and water tables throughout the terminal Pleistocene and Holocene. At 19 ka, Western Juyanze (Gashun/Sogo-nuur) was completely dry until a freshwater lake was established by 11.3 ka (Lehmkuhl and Hasselein, 2000). Similarly, Eastern Juyanze was not fully developed until after 11.0k cal yr BP, before which the basin was characterised by high energy fluvial transport and gravel deposition (Hartmann and Wünnemann, 2009). After Eastern Juyanze was separated from the larger system, run-off from the Tibetan Plateau may have ceased to contribute to its formation (Hartmann and Wünnemann, 2009), but desiccated drainage channels to the north indicate strong fluvial input during the early to mid-Holocene Gobi-Altai wet period between about 10.5-7.4k cal yr BP (9.3-6.5k yr BP) (see Hartmann, 2003). Evidence for periods of increased run-off into Eastern Juyanze indicates that high lake levels did occur during highly variable periods of amplified precipitation in the catchment area between 10.7-8.9k cal yr BP (Hartmann and Wünnemann, 2009). This correlation indicates that palaeoclimatic studies at Juyanze may be useful in inferring short-term climatic shifts to the north.

Lake levels at Eastern Juyanze were still unstable in the early Holocene and fluctuated rapidly in accordance with changes in precipitation. Early Holocene lake levels reached their height at about 8.9k cal yr BP (Wünneman et al., 1998b), after which dry conditions prevailed between 8.9-8.1k cal yr BP. There was an abrupt change to moister conditions with enhanced run-off between 8.1-7.6k cal yr BP (Hartmann and Wünnemann, 2009). Evidence of this increase in moisture is mirrored in the pollen record by a spike in the relative frequency of steppe pollen between 8.0-7.3k cal yr BP (Herzschuh et al., 2004). Biome reconstruction based on a pollen record from the Eastern Juyanze core indicates that the period between 10.7-5.4k cal yr BP was still probably typified by relatively dry desert-steppe vegetation (Herzschuh et al., 2004), but erosional factors in run-off might have resulted in an overestimation of desert taxa (Hartmann and Wünnemann, 2009). Overlapping with greater development of steppe vegetation, lake levels declined from their early Holocene height between 7.7-5.4k cal yr BP, interrupted by a period of high run-off (6.2-6.0k cal yr BP) and the expansion of steppe species (6.5-5.9k cal yr BP) but no distinct lake formation (Herzschuh et al., 2004; Hartmann and Wünnemann, 2009). This period of high run-off and steppe expansion corresponds with the northernmost extent of summer monsoon migration (see Winkler and Wang, 1993).

Refilling of the aquifer and lake formation began again between 5.4-5.0k cal yr BP (Hartmann and Wünnemann, 2009). Deposition of lake mud reduced groundwater infiltration leading to both increased stability of lake levels and salinization during periods of low precipitation and increased evaporation (Hartmann and Wünnemann, 2009). Despite increased salinity, complete desiccation during dry spells was buffered by a newly stabilized water table (Mischke et al., 2003; Hartmann and Wünnemann, 2009). Lake levels were at their highest between 5.4-4.0k cal yr BP[17] (Hartmann and Wünnemann, 2009), especially 5.1-4.6k cal yr BP (Mischke et al., 2005), when a desert-steppe environment likely predominated (Herzschuh et al., 2004). Stable isotope analysis, studies of pollen, ostracods and other microfauna indicate significant inflow of

[17] Although Wünneman and colleagues (1998b) assert that high lake levels occurred at 8.9 (8.0k yr BP) and 5.8k cal yr BP (5.0k yr BP).

river water from the Ruoshui/Heihe drainage system (Mischke et al., 2003; Mischke et al., 2005). Increased moisture lasting until about 4.0k cal yr BP is consistent with records from small lakes in the Badain Jaran Desert (Yang et al., 2003; Yang and Williams, 2003; Yang, 2006). Significant groundwater input between 4.0-3.5k cal yr BP suggests an end to this period of high inflow and the maintenance of lake levels through local groundwater (Mischke, 2001: 87).

Aridification and desert expansion occurred again between 3.9-1.7k cal yr BP (Herzscuh et al., 2004; Mischke et al., 2005), although conditions were probably not as arid as during the early Holocene (Herzschuh et al., 2004). Pollen levels remained high until about 3.2k cal yr BP, suggesting that lake level decline beginning since 4.1k cal yr BP may not be related to any increase in regional aridity (Mischke et al., 2003). Stable isotope analysis suggests that groundwater may have contributed more significantly to the water budget around this time (Mischke et al., 2005), perhaps suggesting a decline in both direct monsoonal precipitation and the influx of water from the Ruoshui/Heihe drainage system. Palynological studies of mid- to late Holocene lacustrine sediments from Gashun-nuur indicate an abundance of arboreal and shrub riparian vegetation around the lake between 3.5-3.2k cal yr BP, including *Hippophaë* (seabuckthorn[18]) and *Populus* (poplar/aspen), indicating a peak in available moisture when lake levels were decreasing at Eastern Juyanze (Demske and Mischke, 2003). The divergence between lake levels and vegetation is probably due to the reliance of lakes on drainage from

[18] Seabuckthorn is a traditional food and medicinal plant which grows in sandy soil and is native in East Asia to cold climates and altitudes above 1200 m a.s.l. The species has recently been widely planted not only for economic reasons, but because it prevents erosion, controls water loss, increases vegetation cover, and provides habitat for foxes, hares, and pheasants.

higher elevations, with lake levels more closely mirroring changes in precipitation at river origins than local changes in effective moisture. The spread of montane forests at high elevations, as indicated by *Picea* and *Betula* pollen, supports a shift toward cooler conditions around the same time (Demske and Mischke, 2003).

Between about 2.9-2.7k cal yr BP a severely arid regional climate is evidenced in pollen concentrations at Gashun-nur. As lake levels remained higher in Eastern Juyanze than Western Juyanze, it is expected that the lake was positively influenced by a shift in the river drainage system (Mischke et al., 2003). Following this period of extreme aridity lake levels rose again around 2.7k cal yr BP (Demske and Mischke, 2003).

By 3.2k cal yr BP, lake levels in both lakes had became less stable. Eastern Juyanze dried up three times between 3.2-2.9k cal yr BP and disappeared after ca. 1.7k cal yr BP (3rd century CE) (Demske and Mischke, 2003; Mischke et al., 2003; Herzschuh et al., 2004; Mischke et al., 2005). Despite the late Holocene return to a climatic regime more similar to that of the early Holocene, steppe vegetation may have been more plentiful in the region than in the early Holocene due to the establishment of more stable hydrological systems and plant communities during the preceding climatic optimum.

These results are broadly comparable to climatic records from the Tengger Desert, but the period of climatic optimum is much later in the Juyanze palaeolake region than that attested to in the south. Lithology and fossil pollen data from Qingtu palaeolake (39^{o} 04’ 15” N, 103^{o} 36’ 43” E, 1302 a.s.l.), a terminal lake in the Shiyang River Basin illustrates this point. By 7.2k cal yr BP, under moister conditions following a period of high aridity, a stable, shallow lake surrounded by a steppe desert environment and denser vegetation had formed in the basin of a large Pleistocene lake (Zhao et al., 2008). Climate was highly variable from 5.2-3.0k cal yr BP, after which a dry climate persisted and the lake dried up (Zhao et al., 2008). Extreme aridity led to the termination of fluvial-lacustrine depositional processes beginning at about 3.2k cal yr BP (3.0k yr BP) (Zhang et al., 2000). The latter date correlates well with decreasing lake levels in both Gashun-nuur and Eastern Juyanze, but an earlier period of climatic optimum and more severe aridification by 3.0k cal yr BP are represented. The former may be a signal of earlier and stronger penetration by the East Asian summer monsoon in the more southerly location. The latter implies a greater availability of moisture in the Badain Jaran Desert following the onset of widespread aridification, perhaps as a result of direct positive moisture influence from the Westerlies or drainage from the north during a humid phase represented in the Gobi-Altai record after 3.2k cal yr BP (Kniaziev, 1986; Starkel, 1998).

Holocene climates in the Alashan Gobi are characterized by increased precipitation beginning after 9.0 kya and continuing until at least 4.0 kya. According to pollen assemblages from the southern Badain Jaran Desert, high elevation and riparian woodlands may have been established by 7.8 kya, along with wetlands and desert-steppe to steppe grasslands (Yang and Williams, 2003). Farther north, in the Juyanze region, two periods of high effective moisture occurred: once in the early Holocene, prior to 8.9kya; and the other in the middle Holocene between 5.1-4.6 kya (Mischke et al., 2003; Mischke et al., 2005; Hartmann and Wünneman, 2009). There is no evidence of arboreal development at such an early date; however, pine and birch are represented in pollen profiles until after 3.2 kya and suggest high elevation forestation in the late middle

Holocene (Demske and Mischke, 2003). Riparian arboreal/shrub vegetation and arid to desert-steppe grasslands remained stable until about 3.2 kya despite lower lake levels beginning almost 1000 years earlier (Demske and Mischke, 2003; Mischke et al., 2003).

Some of the archaeological sites in this region may date to the late Pleistocene and early Holocene, but those belonging to the late middle Holocene are most numerous (Table 3.7c). The earliest dates are from Mantissar 12, a dune-field/wetland site in the Gurnai Depression (6460 ± 700 [5.76-7.16] ka), a major erosion basin east of the Ruoshui/Heihe located south the Juyanze palaeolake system and north of the Yabulai Mountains (Figure 5.1). Overlappping, but probably slightly younger dates come from Yingen-khuduk (5690 ± 350 [5.34-6.04] ka), along the Mongolia-China border. This date can probably be considered approximately contemporaneous with those from the Ulan Nor Plain site in the Gobi-Altai (see Table 3.1). The high range of error in these dates makes it difficult to assign the habitations to a period of relative humidity or aridity, but they appear more closely related to the dry phase between about 7.5-5.5 kya.

The association of early dune-field/wetland sites with a relatively dry phase is notable since the majority of dates indicate an age of younger than 4.0k cal yr BP (Table 3.1). A similar trend has been noted for the Gobi-Altai region. In addition to the abundance of studied Oasis 3 sites situated around lakes, there is possible evidence from Gashun-nuur of anthropogenic burning at about 3.7-3.2k cal yr BP and human or fluvial transport of coniferous wood at 3.3-3.0k cal yr BP (Demske and Mischke, 2003; Demske, personal communication, May 2010). Most archaeological sites in the Alashan Gobi can be attributed to between 4.0-3.2 kya. Residential sites continued to be centred on lakes.

This pattern suggests that lakes attracted hunter-gatherers during a drier phase of early to late middle Holocene humidity.

As discussed in Chapter 3, Oasis 3 belongs to the last phase of the hunter-gatherer oasis adaptation that predates the florescence of a cultural and economic milieu associated with early Bronze Age nomadic pastoralists. Additional continuity between periods is further indicated by such archaeological evidence as fragments of a bronze vessel or helmet with pottery and typical microliths at Sogho-nuur (Maringer, 1950; personal observation, October 2008). This late period of hunter-gatherer subsistence in the Alashan Gobi took place in an environment characterized by an abundance of arboreal and shrub riparian vegetation, arid steppe to desert-steppe grasslands, and many stable lakes primarily sustained through groundwater input. Forest growth at higher elevations would probably have begun in the early to middle Holocene and continued into the Bronze Age.

DATE (k cal yr BP)	REGION	TEMPERATURE (relative to previous)	MOISTURE (relative to previous)	VEGETATION	FORESTS
12.0	East Gobi	warmer	wetter	mosaic steppe	mosaic
	Gobi-Altai	warmer	wetter	N/A	not establ.
	Alashan	warmer	dry	desert	not establ.
10.0	East Gobi	cooler	drier	desert-steppe	N/A
	Gobi-Altai	warmer	drier	arid to desert-steppe	expansion
	Alashan	N/A	wetter	desert	N/A
9.0	East Gobi	warmer	wetter	arid steppe	expansion
	Gobi-Altai	cooler	high lake level	arid steppe to steppe	expansion
	Alashan	N/A	wetter	desert	N/A
8.0	East Gobi	cooler	wetter	arid and forest-steppe	mixed
	Gobi-Altai	cooler	high lake level	steppe to arid-steppe	expansion
	Alashan	N/A	wetter	desert-steppe	mixed
7.0	East Gobi	as above	as above	arid steppe	as above
	Gobi-Altai	warmer	drier	arid steppe	expansion
	Alashan	N/A	drier	desert-steppe	mixed
6.0	East Gobi	cooler	drier	arid steppe	coniferous
	Gobi-Altai	warmer	drier	arid steppe	developed
	Alashan	N/A	high lake level	arid or desert-steppe	mixed
5.0	East Gobi	warmer	drier	steppe	coniferous
	Gobi-Altai	as above	drier	arid steppe	coniferous
	Alashan	N/A	high lake level	arid or desert-steppe	N/A
4.0	East Gobi	N/A	drier	arid steppe	decline
	Gobi-Altai	warmer	drier	desert-steppe	coniferous
	Alashan	N/A	drier	arid or desert-steppe	N/A
3.0	East Gobi	N/A	drier	desert-steppe	decline
	Gobi-Altai	cooler?	wetter	desert-steppe	decline
	Alashan	cooler	wetter	desert-steppe to desert	riparian
2.0	East Gobi	modern	drier	desert-steppe	decline
	Gobi-Altai	modern	modern	desert	decline
	Alashan	N/A	modern	desert	riparian

Table 5.1 Summary of regional climate change from 12.0k cal yr BP to 2.0k cal yr BP.

5.3. Desert forests

Recent research on relic forests of the Gobi-Altai region draws attention to the possible importance of wooded environments in determining Gobi Desert hunter-gatherer settlement patterns. Reconstructing vegetation distributions is particularly important to understanding human land-use throughout the Holocene, as it determines the composition of available plant and animal species. Compared to steppe or desert-steppe environments, forests and forest-steppe offer a highly divergent range of useable flora and fauna. In the East Gobi, where dated Oasis 2 type sites are almost two millennia older than in the west, forest and forest-steppe were established by at least 8.0k cal yr BP. Forest development probably began on the southern fringes of the Alashan Gobi by 7.8k cal yr BP, but the establishment of riparian and higher elevation woodlands is expected to have been later in the more arid north. The timing of forest development in relation to the establishment of Oasis 2-type habitation may suggest a correlation between forest development and the new patterns of land-use.

Currently, there are no detailed studies of the development of post-LGM vegetation in the western Gobi Desert; however, reconstructed sequences of post-glacial vegetative colonization on the Ulagan high-mountain plateau (48-59^{o} N, 82-90^{o} E, 1985-2150 m a.s.l.) in the Altai Mountains of southern Siberia provide a clear example of the forestation process farther north. After 16.0k cal yr BP glaciers and bare ground gave way to pioneer herbaceus vegetation (*Artemisia*, Gramineae, Cyperaceae, *Salix*, and *Potentilla*). By 15.0k cal yr BP, steppe vegetation dominated by *Artemisia* and Chenopodiaceae and had encroached into areas of formerly bare ground. Primarily deciduous forests began to fill in areas covered by steppe as glaciers receded and climate continued to warm; by 9.5-7.5k cal yr BP fully developed forests were present (Blyakharchuk et al., 2004). Forest-steppe environments were more common across Central and East Asia at this time, especially at higher altitudes.

Pollen records and wood macrofossils from the Mongolian Altai Mountains indicate slightly later forest development following deglaciation, though a similar series of developments probably occurred. Prior to 9.5 ka, the Khangai region of the Altai Mountains, just north of the Gobi Desert, would probably have been mostly treeless with cold steppe and dwarf-shrub vegetation dominating the basins (Tarasov et al., 2000). *Larix* (larch) appeared later, along with *Pinus* (pine), both of which probably had a much greater distribution during the middle Holocene than they do today. Forest vegetation would have been fully developed by about 6.0 ka. Distribution of vegetation might have been similar to modern times, only with more widespread arboreal representation due to the heightened availability of moisture (Tarasov et al., 2000).

Various wood fragments from Bayan Sair (45^{o} 34’ N, 96^{o} 54’ E, 2600 m a.s.l.) in the Gobi-Altai region, were radiocarbon dated to between 5.2 and 3.8k cal yr BP (4.5-3.5k yr BP) and included samples of *Abies* (fir), *Picea* (spruce), *Pinus sibirica* (Siberian pine), and *Larix* (larch) (Gunin et al., 1999; Tarasov et al., 2000). Fir is particularly sensitive to moisture, winter temperatures and soil richness. Today, it grows only in a few of the northernmost boreal forests of Mongolia, along with spruce and Siberian pine. Spruce is another moisture sensitive species, whose modern habitat is restricted mostly to river valleys north of 48^o. Larch is more tolerant of varying conditions and macrofossils of this species date much later than the others at 2.6-2.0k cal yr BP (2.5-2.0k yr BP).

The late appearance of larch and the disappearance of other species probably represent high elevation forests under conditions of decreasing precipitation. Although larch does not grow at Bayan Sair today, it still is found in individual stands throughout the region (Gunin et al., 1999). According to proxy data from other regions of Mongolia, we can assume that this macrofossil record captures a period of transition in the decline of arboreal species after 3.5k cal yr BP, following the end of the Holocene climatic optimum. This change may be related to the dramatic increase in aridity in the Gobi-Altai region after 4.0k cal yr BP.

Forests are rare in the Gobi Desert today, but two relict populations of *Betula-Salix* (birch-willow) forests in the Gobi-Altai region have been studied: the first grows on the north-exposed slopes of Ikh Bogd (Ih Bogd) Mountain; and the second in the isolated Gurvan Saikhan (Gurvan Saykhan) mountain ranges. Notably, they contain a variety of plant species similar to other boreal flora found in conifer forests to the north and as far away as northeastern Tibet (Miehe et al., 2007). While many of these species are subject to long-distance dispersal or by birds or humans, others, such as *Viola dissecta* (violet) and *Adoxa moschatellina* (moschatel or muskroot), can only migrate in a step-wise manner and require fairly continuous habitats (Miehe et al., 2007). The existence of a relatively continuous Holocene forest belt stretching across the mountain bands of Mongolia and northwestern China is further supported by the more general lack of distinct floral and faunal species within the fragmented and distant forests. The lack of connected mountain chains indicates a former continuity between high elevation and riparian forests, as they stretched across dry, low elevation basins such as those in the Alashan Desert.

Therefore, the most notable difference between palaeo- and modern environmental conditions is widespread forest expansion between 10.8-5.2k cal yr BP (9.5-4.5k yr BP), after which more moisture sensitive arboreal species gradually vanished. As at Bayan Sair, stands of more resilient species like larch also eventually retreated. Pollen from dated Eastern Juyanze and Gashun-nuur profiles indicate that spruce and birch forests receded sometime after 3.2k cal yr BP (3.0k yr BP) in the Alashan Gobi region (Demske and Mischke, 2003; Mischke et al., 2005).

The widespread decline of forests, though clearly linked to climate, was related to a series of factors that would have acted on vulnerabilities within the complex system of sustaining mechanisms. Water retention systems, heat regulation and multiple reproduction methods have allowed the few remaining Gobi Desert forests to maintain themselves even in a region which in recent times would otherwise be much too hot and dry. High-elevation forests in the Gobi-Altai region are distributed on northern exposures, where there are lower levels of evapotranspiration (Starkel, 1998; Cermak et al., 2005). The dense forest canopy protects active permafrost layers and rainwater, prolongs the availability of snow meltwater, and provides shade and protection for young trees (Cermak et al., 2005; Miehe et al., 2007). When complete deforestation of high elevation forests occurs, re-establishment is extremely difficult or impossible under conditions of heightened aridity (see Miehe et al., 2007).

Similar positive feedback mechanisms to those recognized in birch-willow forests would have existed along the stable watercourses and lakes that were once more common across the Gobi-Altai and the Alashan Gobi. The existence of individual *Ulmus*, *Larix*, or *Pinus* trees among meadow steppes, rare extended open forests in semi-desert vegetation like *Stipa glareosa* (bunchgrass) and *Anabasis brevifolia* (a type of Chenopodiaceae), and the dispersal of *Ulmus pumila* (Siberian elm) in zonal desert steppes, indicates that sufficient access to groundwater and protection from humans and animals allows long-lived species to survive in drier environments (Cermak et al., 2005; Miehe et al., 2007; Wesche et al., 2011). Such evidence has important implications for the distribution of arboreal species during the mid-Holocene, with increased groundwater availability and warmer temperatures.

The impact of anthropogenic factors, particularly herding practices on forest environments, is an especially important consideration in palaeoenvironmental reconstructions of a region populated primarily by pastoralists. Recent studies of relic desert forests indicate that climate change can not entirely account for extensive deforestation in the late Holocene. Studies of reproduction and genetic structure of Siberian elm stands (single trees and woodlands) in the Mongolian Gobi Desert suggest that the trees are actually well-adapted to modern conditions of high aridity and extreme seasonal variation in cold and heat. Trees can sustain themselves for hundreds or even thousands of years through clonal reproduction (suckering) when conditions are not suitable for pollination and germination, but genetic diversity among Gobi Desert stands indicates that elms have managed to persist through sexual reproduction. Considering their ability to reproduce normally, they should be more commonplace along potentially suitable habitats like drainage lines, riverbeds, and ravines (Wesche et al., 2011). The authors suggest that extensive grazing is responsible for their absence. The potential for forestation under modern climatic regimes is exemplified by recent forest expansion Ikh Bogd. Since a major earthquake and landslide in 1957 covered the main entrance route to a valley once seasonally occupied by pastoralists, birch-willow forests have recolonized the cleared land (Cermak et al., 2005; see also Starkel, 1998). Hedin also comments on the effects of grazing in respect to one frequented oasis, where old popular trees were common and young ones rare, as wandering camels "would not leave a single new shoot uneaten" (Hedin, 1943: 143-144). Additionally, he noted that rapid deforestation was occurring along caravan trails due to the indiscriminate use of trees for campfires.

Overgrazing has also been cited as the primary factor leading to processes of desertification and deflation in oasis environments of the southernmost Mongolian Gobi Desert (Pankova, 2008). Just as the destruction of vegetation cover in oasis environments leads to a loss of surface soils and groundwater retention capacity (Pan and Chao, 2003), gradual reduction of forest cover through both grazing of the forest fringes, and directed anthropogenic clearance leads to soil aridification and increases vulnerability. The intensification of herding practices during the Bronze and Iron Ages should be considered as contributing factors to widespread deforestation after 2.6k cal yr BP (2.5k yr BP) (see Gunin et al., 1999). Likewise, the attested decline of riparian shrub and woodland in the Juyanze region after 3.2k cal yr BP might be connected to the intensified use of local environments by hunter-gatherers, or by the introduction of herd animals into oasis-based habitation sites.

5.4. Discussion

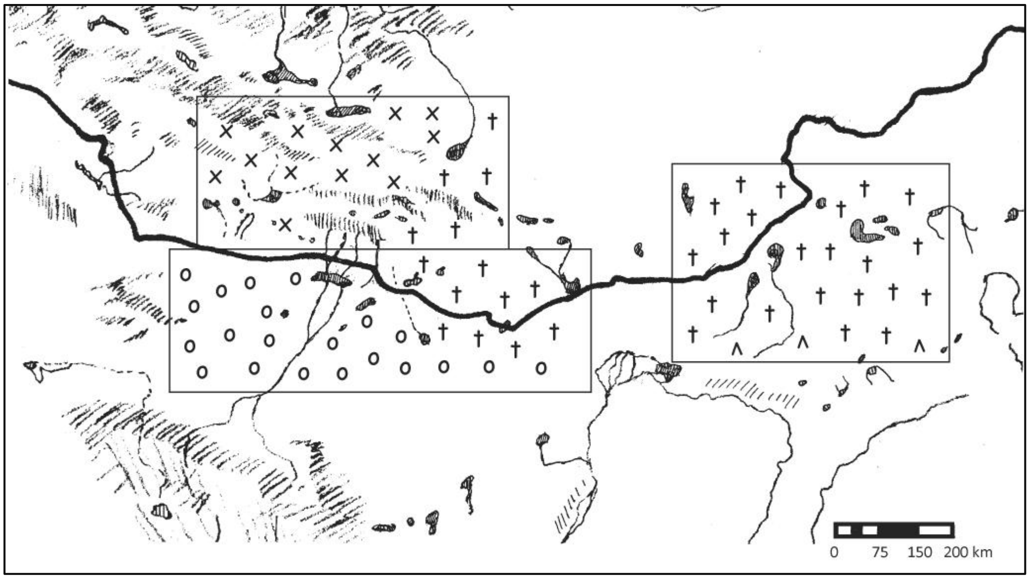
The interplay between climate change and human land-use is most closely related to the ecological effects of temperature and precipitation. The story of post-LGM climatic amelioration summarized above is one of rising groundwater tables, infilling of basins, and soil formation, all of which contributed to the establishment of stable lakes and rivers, increasing grassland productivity, and forest habitats. Climate change following the LGM is broadly characterized by gradual increases in temperature and humidity that culminated in the Holocene Climatic Optimum and the development of new Holocene ecozones like stable dune-fields, rich wetlands, and riparian woodlands. As early as the terminal Pleistocene and early Holocene, dune-field/wetland habitats were beginning to form around more stable water systems, and woodlands were slowly developing in river valleys and at higher elevations.

Palaeoenvironmental signatures from the East Gobi indicate that the earliest Oasis 2 sites occur during a period of increased moisture availability and sand stabilization. By 8.0 kya, temperatures and the annual growing season had declined slightly since the initial Holocene, and mixed coniferous and broad-leaved forests would have been present at high elevations and around lakes. A high in effective moisture is noted by 7.7 kya. Together, these data suggest that the wetland-centric focus of Oasis 2 in the East Gobi coincides with high lake levels, increased forest cover, and the expansion of steppe or arid steppe.

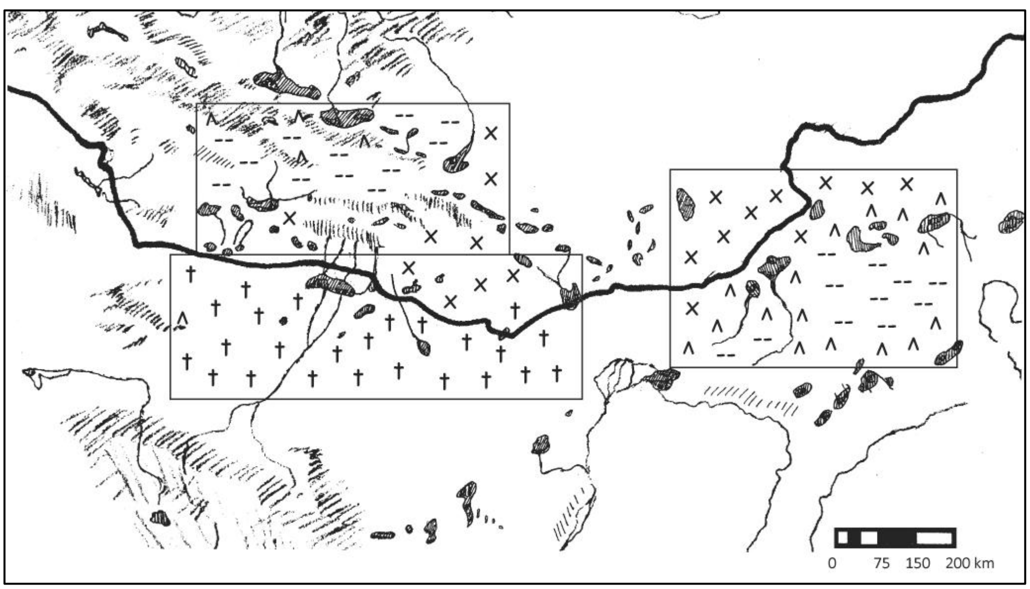
Further west, the earliest dates for Oasis 2 sites suggest a later establishment of dune-field/wetland specialization, by about 6.0 kya. Additional sampling of western sites could produce earlier dates, but the current lack of early Holocene dates might simply be symptomatic of a later shift in organizational strategies. Conditions in the Gobi-Altai, such as the widespread survival of permafrost until 13.0-10.0 ka (Owen et al., 1998) and evidence of low effective moisture and flash flooding until the early Holocene (Owen et al., 1997; Hülle et al., 2009), indicate a lack of stable ecological development within lowland environments. Lake level pollen data summarized above suggest that lowland environments would have been well-developed by 8.5-8.1 kya. Forest expansion probably reached its height throughout the Gobi-Altai and Alashan Gobi by 6.0 kya (see Tarasov et al., 2000; Miehe et al., 2007). In contrast to the East Gobi, western sites post-date initial peaks in humidity, high lake levels, and cooler temperatures. While the earliest East Gobi sites are associated with a high in Holocene humidity, western sites seem more closely associated with relatively arid phases of overall Holocene humidity.

Despite an apparent reliance on dune-field/wetlands, dates for Holocene archaeological sites indicate that those environments were not typically used for long-term habitation until long after they were fully established, and that there was a closer relationship between the expansion of forests and dune-field/wetland intensification. In the East Gobi, the earliest longer-term residential sites date to 7.6 and 6.8k cal yr BP. This corresponds well to evidence for the spread of high elevation forests and mosaic forest-steppe environments around lakes. Forest development was later in the western Gobi Desert, with full development by at least 6.0 kya. Here, the earliest such habitation sites also date to about 6.0 kya, and possibly slightly earlier in the Gurnai Depression of the southern Alashan. The common characteristic between eastern and western sites is the relationship between the timing of shifts in land-use and the establishment of high elevation and riparian forests.

The establishment of these new Holocene habitats has been summarized in this chapter and shows that their development was a gradual process, periodically interrupted by phases of aridification and enhanced seasonality. Moreover, the establishment of the stable dune-fields and rich wetlands favoured by Holocene hunter-gatherers was itself only temporary and the disappearance of those contributed to the much different landscape of modern times. According to published palaeoenvironmental data summarized here, widespread remobilization of dune-fields and the retreat of high elevation and gallery forests were probably well underway by the end of Oasis 3, when nomadic pastoralism was established across Mongolia and northern China. Although many factors contribute to changes in economy, land-use is still inextricably tied to the availability of local resources. Vegetative and hydrological changes outlined in this chapter can be compared to patterns of land-use attested in the archaeological record in order to assess interpretations of hunter-gatherer organization in light of existing knowledge about hunter-gatherer ecology.

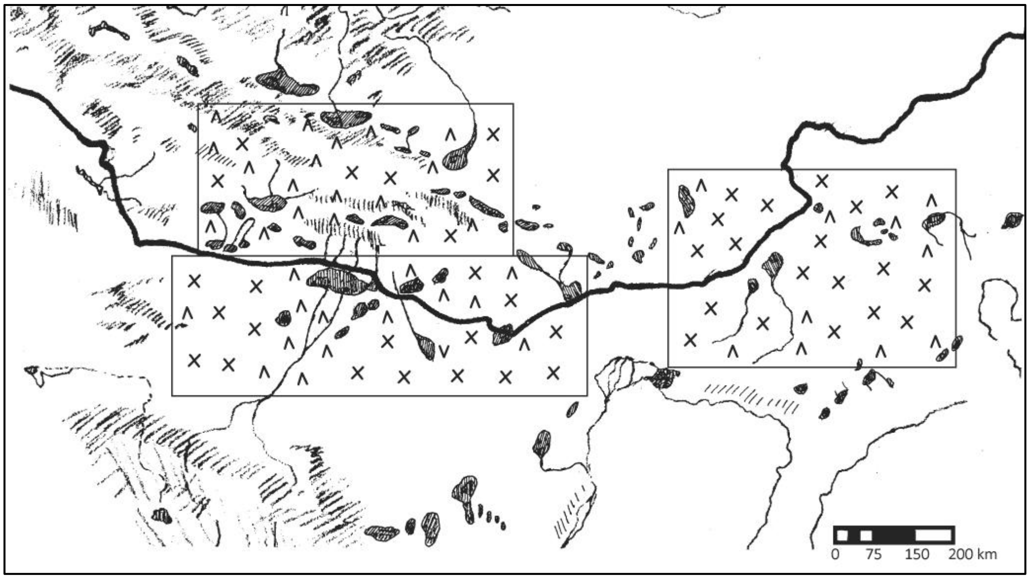


10.0k cal yr BP

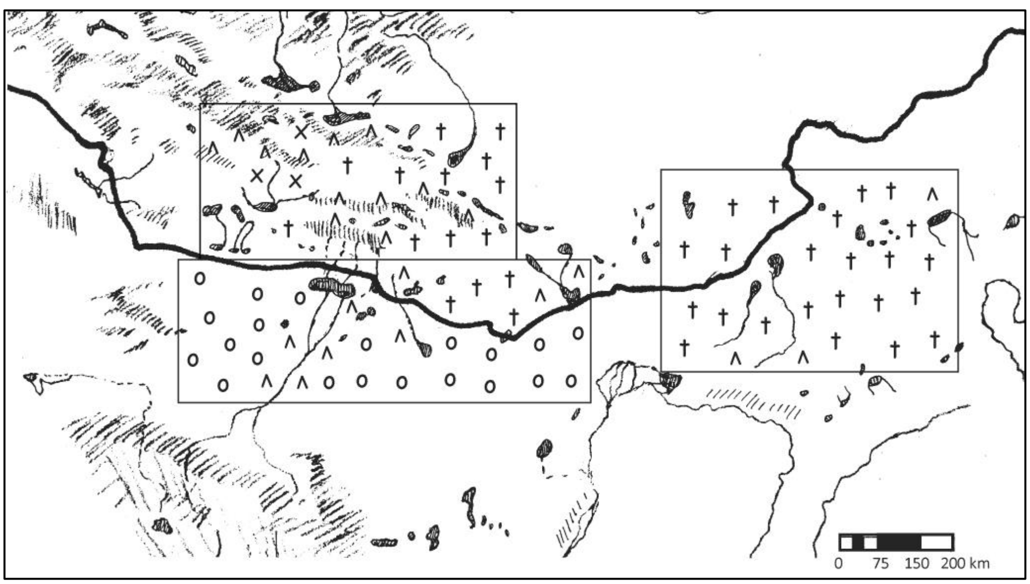


8.0k cal yr BP

Figure 5.3a Approximation of hydrology and vegetation in three Gobi Desert regions for 10.0k and 8.0k cal yr BP. Reconstructions are based on data cited in text. Key: **v** indicates forest, riparian woodland, or forest-steppe mosaic; **o** indicates desert; **†** indicates desert-steppe; **x** indicates arid steppe; **--** indicates steppe.



6.0k cal yr BP



3.0k cal yr BP

Figure 5.3b Approximation of hydrology and vegetation in three Gobi Desert regions for 6.0k and 3.0k cal yr BP. Reconstructions are based on data cited in text. Key: **v** indicates forest, riparian woodland, or forest-steppe mosaic; **o** indicates desert; **†** indicates desert-steppe; **×** indicates arid steppe; **--** indicates steppe.

CHAPTER 6 – DISCUSSION AND CONCLUSIONS

Hunter-gatherer archaeology in the Gobi Desert of Mongolia and China has received little attention from scholars, despite the importance of this region as a frontier between two culturally and environmentally divergent zones of East Asia. Exhaustive archaeological collections exist in Western and Asian museums and universities, but are largely unstudied. While scholars have suggested various relationships between hunter-gatherers of this region and contemporary groups in China and Siberia (see Chapter 2), this thesis constitutes the first attempt to define material culture and establish a chronology of artefacts and land-use from which further study can be directed.

Results indicate that major reallocations in land-use began by at least 7.6 kya in the east and 6.0 kya in the west, and were characterized by the dramatically intensified use of lowland dune-field/wetland habitats, and the provisioning of longer-term residential sites. Hunter-gatherers retained high residential mobility, despite the specialized use of dune-field/wetlands. Contemporary communities neighbouring parts of Northeast Asia show largely divergent economic strategies. By 7.6 kya developments in North China represent the early stages of agriculture and a shift towards chipped and polished adze/axes, bone tools, large grinding tools, and other agricultural implements (Lu, 1999). Archaeological evidence from sites in Northeast China represent both typical hunter-gatherer assemblages with microblade core, flake, and bifacial technology, and the occurrence of sedentary villages whose inhabitants used a range of technologies including microblades, large formal grinding tools, and chipped/polished adze/axes, hoes, and spades (Guo, 1995a; Tan et al., 1995a; Lu, 1998; Jia, 2007). By 6.0 kya, archaeological sites in northwestern China, just south of the Alashan Gobi, show the establishment of agricultural economies that incorporated a range of domesticated plant and animal species (Barton et al., 2010; Bettinger et al., 2010a).

Developmental trajectories in the Gobi Desert differ from reconstructed for nearby regions dominated by agriculture. The dispersal of chipped and edge-ground adze/axe technology across the Gobi Desert and the increased importance of large formal grinding tools in the East Gobi paralleled technological developments in parts of northern China (particularly Northeast China), but were much more limited in frequency and never associated with sedentary communities. Pottery appears to have been used in the East Gobi by at least 9.6 kya. Specialized tools that required time- and labour-intensive manufacture, such as knobbed rollers or pestles and edge-ground or polished adzes/axes, were found in the earliest Oasis 2 sites. The use of these new technologies has traditionally been related to the emergence of small-scale agricultural production (Derevianko and Dorj, 1992; Cybiktarov, 2002), but the present study suggests that they were more likely the products of specialized foraging strategies.

6.1. Palaeoenvironment and local ecology

Gobi Desert “dune-dweller” sites are related to early and middle Holocene climatic amelioration, as recognized by increased precipitation, lake formation and stabilization, and heightened vegetative biomass. Recent research on relict forests in the Gobi-Altai suggests widespread forestation across the western Gobi Desert by the middle Holocene (Miehe et al., 2007). Archaeological sites in the Gobi Desert indicate that the region was once well-populated. New dates on these archaeological sites indicate that such habitations are associated with a period of increased humidity, when the Gobi Desert would have been characterized by high elevation forests, scattered lowland riparian forests, desert-steppes, and extensive developed wetlands around lakes. The Holocene development of forests at higher elevations and mature wetlands in lowland habitats would have created distinct upland and lowland foraging patches that are were not typical of Pleistocene environments.

As such, the stabilization of lowland environments would have played an integral role in modification of land-use. The formation of alluvial fans between 23.0-9.0 kya in the Gobi-Altai region suggests that although lake levels had begun to recover from Last Glacial Maximum lows, aridity and flash flooding were prolonged into the early Holocene (Owen et al., 1997; Hülle et al., 2009). The Eastern Juyanze in the Alashan Gobi similarly indicates a period of high run-off with little stable lake development during the terminal Pleistocene and early Holocene (Hartmann, 2003; Hartmann and Wünneman, 2009). Localized data on lake development is less available in the East Gobi, but increased humidity after 8.9 kya and the spread of a woodland-steppe mosaic just south of the study region (Wang et al., 2001; Peng et al., 2005; Jiang et al., 2006) indicates an earlier Holocene climatic amelioration.

Unlike in the East Gobi, western areas of the study region were not intensively occupied during the height of effective moisture. By 6.0 kya, when intensive habitation of western lowlands began, lake levels had declined from early Holocene highs (Herzschuh et al., 2004; An et al., 2008; Hartmann and Wünneman, 2009). Increased aridity in the context of a humid early to mid-Holocene climate would not have been detrimental to human habitation as effective moisture and vegetative biomass would still have far exceeded modern conditions. While Oasis 1 archaeological sites are usually distributed around rivers and streams, Oasis 2 and 3 sites are found around both river/stream and lake/wetland environments (Figures 4.1). This distribution is particularly notable in the East Gobi (Figure 4.2). Newly developed wetlands around lakes or slow-moving, shallow rivers would have provided a range of resources attractive to hunter-gatherers, including reeds, tubers, waterfowl, eggs, and various small aquatic or semi-aquatic animals. Nutrient-rich wetland soils supported rich vegetation. Wetlands probably formed following initial infilling and periodic retreat of water, developing first around shallow lakes, playas, or large pools in interdunal hollows. Here water levels were more sensitive to annual changes in precipitation and temperature, quickly reaching a maximal height and retreating to leave rich soils for the benefit of new vegetation and associated fauna.

During the terminal Pleistocene, in the early stages of post-LGM climatic amelioration, the Gobi Desert would have been typified by desert and desert-steppe environments with lake levels supported by infilling from post-glacial melt (see Chapter 5). Where forest development did occur, we can expect a more open woodland mosaic to have been present (Wang et al., 2001; Wang et al., 2010). Upland environments (>1200 m a.s.l.) are expected to have hosted a range of flora and fauna typical of montane environments in Mongolia, including medium-sized ungulates like ibex (*Capra sibirica*), and argali sheep (*Ovis ammon*). Lowland environments (< 1200 m a.s.l.) would have offered diverse hunting opportunities in the form of camel (*Camelus bactrianus*), horse (*Equus ferus przewalskii*), khulan (*Equus hemionus*), marmot (*Marmota sibirica*), and various species of antelope, fox, and hare. Ostrich (*Struthio* sp.) eggs were collected, but the large birds might also have been hunted (see Janz et al., 2009). An array of seasonally available plant foods such as *Allium*, grass and legume seeds, and berries would have probably been found across the desert-steppes, with a few zones of higher diversity and productivity.

Distribution of resources during the middle Holocene was much different than during the terminal Pleistocene and initial Holocene, and the landscape was clearly much differently used. Forest development in upland zones during the Holocene (8.0 kya in the East Gobi and 6.0 kya in the western regions) would have altered foraging opportunities, creating more distinct upland and lowland foraging patches. Heightened moisture availability and vegetative cover resulting from Holocene climatic amelioration would have converted sand-covered lowland expanses – intersected with drainage channels, and dotted with small lakes and interdunal hollows – into large heterogeneous oases of heightened productivity surrounded by arid steppes. Some of these oases were expansive. The dune-field/wetland habitat in the Gurnai Depression of the Alashan Gobi stretched over 100 km (Maringer, 1950: 151-152). While this is not typical of all Gobi Desert dune-field/wetland locales, dune-fields often covered several kilometres (see descriptions in Nelson, 1925; Pond, n.d.).

Season	Wetlands	Dune-fields	Plains	Foothills/Mountains
Year round	Roe deer (riparian) Père David deer Fish Water Reeds Saplings (riparian) Clay Fuel (dry reeds)	Windbreak Fuel (saxual, other shrubs)	Camel Khulan Horses Gazelle Saiga Raptors Stone Fuel (dung)	Boar (forest) Red deer (forest) Argali sheep Windbreak Saplings Fuel (dead trees, leaves, etc.) Stone
Spring	Horses (pregnant/newborn) Waterfowl (April) Eggs (May) Young greens	Birds Eggs Herbs	Khulan herds Horses (pregnant/newborn) Fox/hare/marmot Allium greens	Ibex herds Young greens
Summer (end of June to September)	Bear Shellfish Waterfowl Fat rodents Reptiles/ amphibians Eggs Green legumes Allium greens Chenopodium seed (flour and jam) Grass seeds[19] (August-September)	Fat rodents Wild cat Birds Reptiles Eggs Succulents Niter fruit (*Nitraria sibirica*, August-September) Berries Herbs	Khulan pairs Gazelle herds (*P. gutturosa* aggregation) Saiga (newborns) Argali sheep Fox/hare Fat marmots/rodents Reptiles Green legumes Allium greens/bulbs[20] C. ammannii Berries	Female ibex Wild cat Hare Green legumes Allium greens Flour tubers (*Rheum nanum*) Berries (*Ribes altissimum*) Convoluvus ammannii Herbs
Fall	Fat bear Reptiles Waterfowl Legume seeds Caraway seeds Allium bulbs Tubers/roots	Wild cat Bulbs and tubers Herbs	Horse herds Gazelle herds (*G. subgutturosa* aggregation) Argali sheep Legume seeds Allium bulbs C. ammannii Berries	Female ibex Nuts (acorn/pine) Legume seeds Allium bulbs C. ammannii Herbs
Winter	Fuel (dry rushes)	Wild cat Rodents (hibernating)	Khulan herds Horse herds Gazelle herds (*G. subgutturosa* aggregation) Fur mammals C. ammannii	Hibernating bear Ibex herds Argali herds Fur mammals C. ammannii Water (snow)

Table 6.1 Possible seasonal distribution of raw material and edible resources.

[19] Various types of grass seeds unique to the Mongolian Gobi Desert would have been potential sources of carbohydrates for hunter-gatherers, including *Eragrostis pilosa* (same genus as teff), and two types of indigenous barley - *Hordeum bogdanii* and *Hordeum brevisubulatum* (see Jigjidsuren and Johnson, 2003). Seed maturation occurs in late August and September.

[20] Allium greens are still an important plant food for herders, as described by Khasbagan et al. 2000.

Our understanding of species composition within each ecosystem is limited by a scarcity of zooarchaeological remains, a lack of local palaeobotanical studies, and the absence of modern analogs. However, based on modern studies of plant and animal distributions, there are likely patterns of seasonal resource availability according to different ecozones. Table 6.1 summarizes hypothesized dispersal of key raw material, plant and animal resources based on our knowledge of early to middle Holocene palaeoenvironments, current home ranges, and environmental preferences (see Allen, 1934; Jigjidsuren and Johnson, 2003; Batsaikhan et al., 2010).

Woodlands would have offered a distinct foraging patch along rivers and in high elevations. Forest environments are notable for the availability of certain raw materials such as bark and wood, and offer much different foraging opportunities than steppe and dune-field/wetland environments. Species that are now confined to the forests of northern Mongolia may have been present in Gobi Desert forests during the middle Holocene, including wild boar (*Sus scrofa nigripes*), and red deer (*Cervus elaphus*). Roe deer (*Capreolus pygargus* or *C. c. tianschanicus*) could have inhabited riparian and transitional woodlands, including in lowland settings. Edible and fur-bearing species such as bear (*Ursus arctos baikalensis*, *Ursus arctos isabellinus* [or *U. a. gobiensis*]), raccoon dog (*Nyctereutes procyonoides*), marten (*Martes* spp.), weasel (*Mustela* spp.), and lynx (*Lynx lynx*) are all expected to have extended their ranges beyond modern boundaries and were probably much more common in Gobi Desert riparian woodlands or upland forests than modern zoogeography suggests (see Batsaikhan et al., 2010 for description of habitats). Territories of ungulates adapted to upland grassland environments, such as ibex and argali sheep, would have been more confined. Edible vegetation would have included berries and tree nuts. Based on the current distribution of *Pinus pumila*[21], a shrubby nut-bearing species of pine tree, pine-nuts might have been an important resource for Holocene hunter-gatherers in both upland and lowland forests. Abundant *Quercus* pollen, identified in mid-Holocene palaeosols of the Hulun Buir sandy land (Winkler and Wang, 1993), also suggests that acorns were available in parts of the East Gobi.

Wetland habitats would have offered a very different range of foods. As uniquely rich transitional zones between dry land and water, boasting a high diversity of plant and animal species, they could play a key role in foraging strategies (Nicholas, 1998). Within arid environments, they are especially notable for offering a stable water source. Waterfowl, many small rodents, fish, and shellfish are confined to oases of swamplands, and the marshy margins of lakes and rivers. Carnivorous and omnivorous species, including humans, are drawn to wetlands in search of such prey. Ungulates tend to be present around wetlands. In the Gobi Desert, they might have included roe deer in more wooded settings, and Père David deer (*Elaphurus davidianus*)[22]. Edible plant foods like tubers, cattail pollen, and grass seeds are also more abundant around wetlands. Clay,

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[21] *Pinus pumila* is currently distributed across northern Mongolia, Inner Mongolia, and PRC provinces of Heilongjiang and Jilin. They grow up to 6 m in height, but have creeping branches and (Wu and Raven, 1999).

[22] Père David deer (milu/sibuxiang) are large, marshland-dwelling ungulates. They are no longer found in the wild, but their natural habitat is reed-covered marshes. Although the species are now confined to the Dafang Nature Reserve in southern China, faunal remains were recovered from the North China Neolithic site, Nanzhuangtou, along with wolf, pig/boar, dog, red deer, roe deer and fowl (Lu, 1999). Notably, this suite of faunal remains suggests both wetland and forest exploitation.

reeds, and saplings can also be important raw materials for constructing firepits, containers, hunting equipment, and clothing.

On the adjoining plains, an array of large- and medium-bodied ungulates would have complemented dune-field/wetland resources. At present, the desert-steppes are populated by herd ungulates prone to seasonal aggregations of tens (*Camelus bactrianus ferus*, *Equus przewalskii*), hundreds (*Equus hemionus* – winter/spring; *Gazella subgutturosa* – autumn/winter), or even thousands (*Procapra* [*Prodorcas*] *gutturosa* – especially mid-June/July) of individuals (Allen, 1934; Batsaikhan et al., 2010). Due to high annual variation in the distribution of resources, herd size and migration are currently unpredictable. We can not know if they were more predictable in prehistory. Hunting animals from large herds could have provided high returns and would have been less risky than the pursuit of solitary animals, but it is not known if hunter-gatherers attempted to predict and target herds or simply hunted during opportunistic encounters. In either case, the presence of equid bones in dune-field/wetland sites suggests that large-bodied ungulates were available to hunters stationed in those habitats.

Positioning residential bases around lowland dune-field/wetlands would have allowed hunter-gatherers shelter within the stable dunes, a good view of the surrounding landscape, and easy access to several key ecozones. Longer-term habitation was possible due to the range of available resources in the nearby plains, riparian woodlands, wetlands, and lakes. The availability of plant foods, such as grass seeds, tubers, fruits, and berries, would have been spatially and temporally predictable. Environmentally restricted small animal species like waterfowl (and their eggs) and fish would have been present on a reliable schedule. Species like carnivores and reptiles are behaviourally predictable according to season, but are more dispersed and likely to have been hunted in the course of foraging for more predictable foods (see Bird et al., 2009). Early to mid-Holocene lowland dune-field/wetlands in the Gobi Desert would have been characterized by a range of reliably available resources. Although forests contain an array of important edible plant and animal species, the reduced accessibility, lack of mobility, and hunting inefficiency in forests can make them less ideal environments for residential bases (see Winterhalder, 1981).

6.2. "Dune-dweller" foraging strategies

Despite evidence for exploitation of low-ranked foods (i.e., foods with low caloric returns compared to energy expended in capture and processing) prior to Oasis 2 and Oasis 3, site distributions for those periods indicate a substantial change in the way that dune-fields and wetlands were used. The discovery of terminal Pleistocene sites in arid Northeast Asia containing grass seeds (Derevianko et al., 2008) or technologies associated with processing low-ranked foods (Elston et al., 1997; Bettinger et al., 2007; Derevianko et al., 2008; Elston et al., 2011; Chapter 3), makes it is clear that such resources were exploited in the Gobi Desert during Oasis 1; however, the preferential distribution of sites in upland environments suggests that their use was not a decisive factor in the positioning of residential bases. In contrast, Oasis 2 and Oasis 3 residential sites were clearly concentrated in lowland dune-field-wetlands.

The presence of Oasis 2 and Oasis 3 task sites in a wider range of habitats (Figure 4.7 and Table 4.9) indicates that task groups were used to procure resources from dune-field/wetland resources, nearby steppes, and more distant upland forests (e.g., ungulate meat, furs, tool stone, medicines and other highly valued plants). Residential habitation of uplands and open steppes appears to have been heavily restricted. Evidence of steppe species in dune-field/wetland assemblages along with the lack of habitation sites in such environments underscores the likelihood that they were exploited primarily by short-term task groups.

Unlike wetlands, montane environments are often typified by highly seasonal, homogeneous and dispersed resources, which favour high residential mobility (Morgan, 2009). Depending on the exact composition of woodland species and the density of forest growth, forestation might have increased primary productivity of upland zones but reduced accessibility, ease of mobility, and hunting efficiency (see, for example, Cree in Winterhalder, 1981). Dune-field/wetland bases offered access to and ease of mobility across multiple ecozones that would have been highly appealing. Furthermore, while upland forests would have offered a range of hunting and foraging opportunities, including solitary ungulate species, berries, and carbohydrate rich plant foods, such resources would be nutritionally redundant and less diverse when compared to the composition of mixed lowland (dune-field/wetland combined with arid/desert-steppe) resources (Table 6.1). The range of medium- to large-bodied steppe-dwelling ungulates in proximity to reliably available plant and small animal species in lowland dune-field/wetlands may have limited the exploitation of upland zones. Longer term exploitation of forest resources would have necessitated smaller group sizes, and more frequent moves. Residential B and task sites are more characteristic of a site structure resulting from such a strategy.

The occurrence of longer-term habitation sites in lowland dune-field/wetlands is consistant with foraging theory, which predicts that the use of such rich foraging patches results in less frequent moves due to high overall return rates and the avoidance of productivity loss during travel time between patches (MacArthur and Pianka, 1966; Charnov, 1976; Kelly, 1995: 90-97). At the same time, hunter-gatherers still relied on resources that could not be obtained in these habitats, such as tool stone. Task groups could have effectively extracted key resources from more distant environments while allowing other group members to focus on the procurement of plant and animal foods closer to the residential base. The wide array of resources characterizing early to mid-Holocene environments and the diverse range of skills required to exploit them would have favoured a division of labour (Lupo and Schmitt, 2002; Kuhn and Stiner, 2006), while the use of diverse plant and animal species rather than a reliance on large game might have allowed for the support of larger group sizes (O'Connell, 2006).

Since the majority of Oasis 2 and Oasis 3 residential sites are situated in dune-field/wetlands, which boasted a wealth of low-ranked resources, it is reasonable to assert that they would have made active use of small animals and plant foods.[23] Use of both low-ranked and high-ranked foods in the post-LGM diets of Gobi Desert hunter-gatherers

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[23] Bird (1999: 65) in her article on the sexual division of labor provides a list of ethnographic foraging strategies that exemplifies the importance of both low- and high-ranked species in a range of settings, illustrating the ubiquity of low-ranked resources in the diet of hunter-gatherers with access to them.

is further supported by the faunal assemblage from Chilian Hotoga, which includes equid, fox, frog, and bird remains. The use of grinding stones could be related to processing seeds and/or tubers, while knobbed rollers or pestles from the East Gobi may have been used for grinding nuts (*sensu* Wright 1994). Pottery might also be related to exploitation of low-ranked resources (see Brown, 1989; Hoopes, 1995). Finally, cordage and textile impressions on pottery suggest that hunter-gatherers had the appropriate technology to construct nets, which are associated with hunting of small prey (see Soffer, 2000; Lupo and Schmitt, 2002).

The incorporation of "low-ranked" or "high cost, low return" resources into post-LGM foraging strategies defines Epipalaeolithic hunter-gatherers (see Kuhn and Stiner, 2001). Flannery's (1969) Broad Spectrum Revolution hypothesis proposed that the trend towards increasing dependence on a widening range of plants and animals was related to higher population density and increased climatic variability following the LGM. The Broad Spectrum Revolution was seen as key step in the trajectory towards the agriculture. The work of Stiner and colleagues supported this theory, showing that animal species with low caloric returns in relation to energy expended were progressively incorporated into human diets throughout the Upper Palaeolithic (Stiner et al., 1999; Stiner et al., 2000; Stiner and Munro, 2002; Munro 2004; Stiner, 2005). Resource depression, as recognized by the decline of high-ranked prey (i.e., prey that has high caloric return rates relative to handling costs), was thought to have stimulated increased diet breadth, suggesting a correlation with demographic packing (Binford, 1968; Flannery, 1969; Cohen, 1977; Keeley, 1988; Winterhalder and Smith, 2000; Stiner et al., 2000). This relationship has been attested in the archaeological record (Kozłowski and Kozłowski, 1986; Stiner, 2001; Munro, 2004).

More specialized technology and intensive processing are often associated with diminishing resources, particularly when growing populations or other pressures make it necessary to acquire more food energy out of the same unit of land (Binford, 1968; Flannery, 1969; Cohen, 1977; Keeley, 1988; Stiner et al., 2000; Stiner, 2001; Stiner and Munro, 2002). However, the temporal correlation between Gobi Desert dune-field/wetland habitation and a presumed increase in productivity related to climatic amelioration indicates that a decline in the regional abundance of plant and animal species was unlikely. Locally, population density may have increased, but this is difficult to ascertain since Oasis 1 sites may be either more ephemeral in terms of their material culture or simply located in less well-surveyed regions. A stable balance between population density and carrying capacity is suggested by continued high residential mobility and the lack of territorial behaviour (e.g., the construction of visible graves or other monuments). Decreased residential mobility probably resulted initially from a change in resource distribution at the transition to from Oasis 1 to Oasis 2, but constricted foraging territories would certainly increase local population density, effectively resulting in resource depression, even if region-wide demography was unaffected.

At the same time, the use of low-ranked resources may not be as reliant on resource stress as previously modeled. New data has begun to suggest that low-ranked foods were often targeted alongside high-ranked foods, even in the absence of resource depression (Elston and Zeanah, 2002; Bird and Bleige Bird, 2005; Bird et al., 2009;

Starkovich and Stiner, 2009; also see Revedin et al., 2010). The idea that reliably obtainable, lower-ranked plant and animal species might have been targeted despite the availability of high-ranked species is supported by ethnographic data from Australia's Western Desert. Researchers observed that when Martu hunters were engaged in the pursuit of one species, they would forgo higher-ranked species if capture was riskier (Bird et al., 2009). Therefore, the opportunity to reliably procure lower ranked species can potentially outweigh the more precarious potential involved in pursuing more mobile high-return prey types (see also Hawkes et al., 1982: 392). Additionally, the pursuit of certain low-ranked resources like grass seeds is probably even more underrepresented in the ethnographic record due to the historical ubiquity of flour rations and other commercially available starches (e.g., O'Connell and Hawkes, 1981; see also Hawkes et al., 1982: 384). These data suggest that resource depression may not have been required to stimulate a focus on dune-field/wetland foods.

A lowland centred pattern of land-use, incorporating exploitation of low-ranked wetland species, is not unique to the Gobi Desert. Like the Gobi Desert, the Great Basin in the western United States is an arid, internally-drained basin-range environment. Pre-Archaic land-use strategies proposed by Elston nd Zeanah (2002) provide an intruiging comparison. During the Pleistocene-Holocene transition, Pre-Archaic hunter-gatherers exploited a broad spectrum of food resources that included mountain sheep, elk, bison, antelope, small mammals, birds, fish, and shellfish (Beck and Jones, 1997; Elston and Zeanah, 2002). Although small milling stones are occasionally present, the emphasis on formal, hafted tools such as points, bifaces and scrapers suggests a higher investment in hunting, and minimal investments in the seed processing and storage that defines Archaic groups. High residential mobility is indicated by the relative rarity and low density of Pre-Archaic sites, low variability among lithic assemblages, and a lack of residential structures, middens, or storage facilities. The most extensive Pre-Archaic sites are often found along lowland beach bars or lunettes associated with pluvial lakes or marshes, elevated surfaces on valley margins, or Pleistocene stream terraces, suggesting targeted exploitation of lake/marsh resources and mid- to low-elevation steppe (Elston and Zeanah, 2002).

Various models from behavioural ecology have been applied to the study of Pre-Archaic Great Basin hunter-gatherers, including the diet breadth model, patch choice model, and the Z-score model (O'Connell et al., 1982; Simms, 1987; Elston et al., 1995; Pinson, 1999); however, all models failed to predict the incorporation of high-cost/low-return resources like seeds into Pre-Archaic, Archaic, or ethnohistoric Great Basin diets (Elston and Zeanah, 2002). Elston and Zeanah (2002) propose that frequent moves by Pre-Archaic hunter-gatherers from basin to basin represent a complementary set of strategies that maximize large-game encounters while also focusing on reliable lower return species like small game and plants. Early Holocene lowland habitats are envisioned as highly productive environments which allowed low-density populations to move easily from patch to patch in order to increase frequency of encounters with large game. Hunters are expected to have targeted large game in low- to mid- elevation brushy steppe from fall to spring, when they could be easily hunted. Group members not actively involved in large game hunting could focus on seeds, small game, waterfowl, and fish (Elston and Zeanah, 2002). Extensive aridification during the middle Holocene desiccated many Great Basin wetlands, encouraging the establishment of Archaic period residential sites and seed storage facilities around the few remaining wetlands and perennial springs. Material culture from the Archaic period reflects decreased mobility in the decline of formal chipped stone industries and the proliferation of milling stones (Elston and Zeanah, 2002).

There are many notable similarities between the early Holocene archaeological records of the Great Basin and the Gobi Desert. The use of lowland environments along with indicators of high residential mobility and largely formal chipped stone technology are key characteristics in both. A broadly similar pattern of complementary steppic hunting and wetland foraging has also been recognized. Two important divergences from the Great Basin record illustrate unique aspects of Gobi Desert foraging: the use of formal milling technology and pottery during Oasis 2 in the East Gobi; and distinct artefact assemblage variability between sites in all target regions.

Both of these differences in technological organization probably relate to the relative importance of wetland resources within the broader subsistence strategy. Based on the time consuming manufacture of technologies associated with processing dune-field/wetland resources, low-ranked foods would have been more central to Gobi Desert foraging strategies. Clear differences between residential and task sites indicate that mobility was still organized more logistically than has been proposed for the Pre-Archaic Great Basin, but a lack of middens, storage facilities and other architectural features at Oasis 2 and Oasis 3 sites indicate that hunter-gatherers were still highly mobile.

Likewise, although formal and highly portable hunting technologies were maintained during Oasis 2 and Oasis 3, the diversified lithic assemblages (a combination of microblade core technology, informal flake/core technology, bifaces, polished stone adze/axes, and grinding stones) suggest that a wider range of tasks were prioritized and carried out by group members.

Lower residential mobility in connection with dune-field/wetlands is reflected not only in the less conservative use of tool stone in some residential sites (see Chapter 4), but also in the manufacture of large formal grinding tools (e.g., saddle querns, polished adze/axes, knobbed rollers or pestles) in the East Gobi. Polishing can be accomplished over time, as smaller tools are transported from site to site, but it is very time consuming. Large grinding stones are difficult to transport at all without domesticated beasts of burden. As such, sufficient “down-time” is required for their manufacture. Pottery manufacture also requires some amount of down-time since mixing clays, building pots, drying, and firing are all time-consuming tasks that need to be undertaken before pottery is transported (Arnold, 1985; Brown, 1989).

Although pottery manufacture does imply occasional periods of at least short-term sedentism (a week or two might be sufficient), transport costs probably do not reflect on mobility. Studies of pottery-use amongst late Holocene hunter-gatherers in the western Great Basin indicate that the pottery was used primarily for boiling seeds and levels of pottery production were not related to residential mobility (Eerkens, 2003). Eerkens (2003) suggests that pots were cached in low elevation wetlands, where they were returned to and regularly used. As such, an increase in the importance of pottery during

Oasis 3 does not necessarily imply a progressive decrease in residential mobility. During Oasis 3, the decline of formal grinding technology in the East Gobi, and the use of highly portable "rubbing stones" across the Gobi Desert, suggests an increase in residential mobility (i.e., a trend towards more portable technology).

It is not known if Gobi Desert groups transported pottery from site to site, but the possibility that they could have cached them for return visits, as East Gobi groups almost certainly would have done with large grinding stones, is intruiging. Investment in processing technology and caching of site equipment indicates that hunter-gatherers were at least seasonally tied to specific predictable resources rather than foraging on an encounter basis (Binford, 1979, 1982). Cached grinding stones and pottery at dune-field/wetland locales implies that hunter-gatherers were heavily invested in the low-ranked foods that they were processing.

At the same time, the persistence of microblades and projectile points is consistent with a focus on high residential mobility and the exploitation of unpredictable high-ranked resources (e.g., large-game). Microblade cores best exemplify highly portable, flexible core-tools, which produce standardized components for easily-maintained composite tools (see Elston and Brantingham, 2002). Maintainable and flexible hunting equipments are associated with "search and encounter" procurement – where tools can be maintained and employed on a daily basis and in whatever capacity required – rather than with specialized and predictable use (Bleed, 1986; Ellis, 2008). Reduction strategies represented in Gobi Desert assemblages make conservative use of raw materials, suggesting limited access to tool stone associated with persistently high residential mobility (see Chapter 4). Taken together, the use of grinding stones, pottery, microblade cores, and biface technologies indicate that hunter-gatherers strategically targeted both seasonally reliable (typically low-ranked), and more unpredictable (typically high-ranked) prey.

The organization of foraging strategies based on reduced seasonal mobility is reflected in lithic assemblages. Informal cores are common in Gobi Desert assemblages and are often associated with reduced mobility since they represent a less conservative approach to flake production. While higher relative frequencies of microblade cores should be more commonly associated with high residential mobility, informal cores are expected to occur in relatively higher frequencies with increasing sedentism. Table 6.2 demonstrates the relationship between the frequency of informal core types and site type. Residential B sites have significantly fewer informal cores types and notably higher frequencies of microblade cores than Residential A sites. Task sites are similar in core type frequencies to Residential A sites. When dune-field/wetland sites are removed from the sample, there is no significant variation in the relative frequencies of core types between any types of sites. All sites outside of dune-field/wetland habitats have lower frequencies of informal cores and higher frequencies of microblade cores.

Site type	Residential A	Residential B	All task sites
Mean % informal cores (all zones)	33.5	16.6	31.8
Mean % microblade cores (all zones)	58.1	74.7	60.6
Mean % informal cores (outside wetlands)	29.5	29.0	45.8
Mean % microblade cores (outside wetlands)	60.3	49.0	45.5

Table 6.2a Mean percentage of core types according to site type for Oasis 2 and Oasis 3, all Gobi Desert sites.

	Mean % informal cores	Mean % microblade cores
All site types (all zones)	0.0929	0.1761
Residential site types (all zones)	0.0453	0.0812
All site types (outside wetlands)	0.894	0.437
Residential site types (outside wetlands)	0.4249	0.6518

Table 6.3b *P*-values associated with Table 6.2a.

Non-wetland Residential B sites have higher frequencies of informal cores and lower frequencies of microblade cores than is typical of wetland-based Residential B sites. Decreased access to raw materials may suggest Residential B sites within dune-field/wetland environments are part of a higher mobility strategy, perhaps more focused on search and encounter foraging than was typical for Residential A occupations or non-wetland task sites. Such sites, indicative of more intensive raw material conservation, might be related to unprovisioned field camps radiating from Residential A type habitations. Task sites and Residential A sites show comparable access to raw materials, suggesting that they are related to either raw material procurement or that the groups were well-provisioned by associated residential sites, being so short term that raw material conservation was of little consequence.

Lack of variation in the frequency of core types outside of wetland environments is telling, particularly in the case of Residential A and B sites. Within dune-field/wetland environments the larger multipurpose Residential A sites indicate better access to raw materials and more variety in on-site activities. The few residential sites outside lowland dune-field/wetland zones appear to have more limited access to raw materials. They were probably not provisioned for reoccupation and may have been related to shorter-term seasonal occupation of habitats that supported smaller populations (i.e., fewer people for a shorter length of time).

Table 6.3 further illustrates that food processing technologies like pottery and grinding stones were more common in wetland environments, where vegetative biomass was most concentrated. The exception to this is that task sites with grinding stones were always located outside wetlands. Milling activities within wetlands were likely carried out at residential sites. It is also clear that pottery and grinding stones were not always associated with residential sites in wetlands: 5% of Residential A wetland assemblages and 12% of Residential B wetland assemblages contained neither pottery nor grinding stones (Table 6.4). The use of grinding stones and pottery was restricted to wetlands in Oasis 2, but use expanded beyond areas of primary plant productivity during Oasis 3 (Table 6.5).

Site type	Sites with pottery N = %	Sites with grinding stones N = %
Residential A (all) Total = 25	18 72%	14 56%
Residential A (in wetlands) Total = 19	15 79%	12 63%
Residential A (outside wetlands) Total = 6	3 50%	2 33%
Residential B (all) Total = 21	17 81%	6 29%
Residential B (in wetlands) Total = 17	15 88%	5 29%
Residential B (outside wetlands) Total = 4	2 50%	1 25%
Task site (all) Total = 31	7 23%	3 10%
Task site (in wetlands) Total = 11	4 36%	0 0%
Task site (outside wetlands) Total = 20	3 15%	3 15%

Table 6.3 Number of Gobi Desert Oasis 2 and Oasis 3 sites with pottery and grinding stones according to site type.

Site type	Sites without pottery or grinding stones N = %
Residential A (all) Total = 25	3 12%
Residential A (in wetlands) Total = 19	1 5%
Residential A (outside wetlands) Total = 6	2 33%
Residential B (all) Total = 21	3 14%
Residential B (in wetlands) Total = 17	2 12%
Residential B (outside wetlands) Total = 4	1 25%
Task site (all) Total = 31	22 71%
Task site (in wetlands) Total = 11	7 64%
Task site (outside wetlands) Total = 20	15 75%

Table 6.4 Number of Gobi Desert Oasis 2 and Oasis 3 sites with neither pottery nor grinding stones according to site type.

Period/ Tool type	Lowland dune-field/wetland N =	Lowland river N =	Lowland dry N =	Upland N =	Upland dry N =
Oasis 2					
Pottery	11	1	0	0	0
Grinding	11	1	0	0	0
Oasis 3					
Pottery	29	2	1	3	3
Grinding	8	3	0	2	1

Table 6.5 Number of Gobi Desert sites with pottery and grinding stones according to ecozone and period.

Core reduction strategies and the distribution of pottery and grinding stones both support a pattern of land-use characterized by provisioning of dune-field/wetland bases, which were occupied for longer periods of time and related to the intensified use of low-ranked resources. These data indicate significant differences between Residential A and Residential B type sites and strongly support, as do the data presented in Chapter 4, the probability that a pattern of radiating mobility was practised at least on a seasonal basis. According to Binford’s (1980) original definition, this type of land-use would be characterized by both short-term task groups (task sites) and longer term field camps (Residential B sites), where select members procured resources for a larger group associated with a central base camp (Residential A sites). Such a pattern of resource exploitation is based on the movement of goods to consumers (Binford, 1980). The scarcity of residential sites outside dune-field wetland environments suggests that that primary habitation occurred in wetlands year round with varying degrees of mobility according to the season. In seasons of lowered productivity, the larger group may have dispersed and followed a pattern of circulating high residential mobility still based in dune-field/wetlands and characterized by task sites and short-term residential bases (Residental B sites).

Inferred distribution of various plant and animal resources across environmental zones give us some indication of possible variability in seasonal land-use. Based on the ubiquity of grinding stones and pottery, Residential A sites in the East Gobi appear to have been focused on intensive plant processing, suggesting a possible late summer/early fall aggregation coinciding with seed and tuber harvesting. Berries and fruit would also have been available around dune-field/wetlands in the late summer. Nearby lowland steppes would have been ideal locales for the procurement of mammals such as fattened marmots and herd ungulates. According to modern herd behaviour, the aggregation of human groups could have corresponded with enormous increases in *Procapra gutturosa* herd sizes[24], though it is not known how similar herd behaviour was in comparison to modern times. A distinct decline in the diversity of plant and animal resources occurs in the winter and spring months, and hunter-gatherers may have needed to increase mobility to take advantage of more dispersed resources.

Conversely, a decline in residential mobility might also have occurred throughout the winter months with a return to high residential mobility during the spring and early summer. Dune-field and wetland foods would have been less readily available in winter months (see Table 6.1), while some large ungulates like khulan, horses, ibex, and argali tend to aggregate in the steppes and foothills during the fall and winter (Batsaikhan et al., 2010). Extremely cold winter conditions might have limited mobility, although precipitation is greatly reduced in this season and the cold would have been more of a hindrance to travel than snow. In this case, longer-term seasonal occupation could have commenced in the late summer, with abundant summer resources being harvested, processed, and stored for consumption during cold winter months. Logistical habitation of wetland sites may also have been favoured with return of fatty waterfowl to wetlands

[24] Herd sizes of up to 250,000 individuals have been reported (Olson et al., 2009).

in April[25]. Advantages to high mobility during the spring and summer would include greater ease of mobility, predictable availability of low-ranked resources around dune-fields and wetlands, and the ability to procure a wide array of resources across environmental zones.

Archaeological sites typified by a lack of middens and residential structures do not necessarily preclude prolonged seasonal occupations. Modern nomadic pastoralists in the region live in organic portable dwellings (*gers* or yurts) and leave little refuse upon their departure. High density sites would probably have accumulated only after many successive occupations. Neolithic/Eneolithic lithic reduction strategies do indicate the importance of technologies suitable for high residential mobility and unpredictable foraging situations, which supports the probability that even seasonal sedentism was limited. Although periods of reduced mobility are suggested, high residential mobility should be considered characteristic of post-LGM Gobi Desert hunter-gatherers.

6.3. Oasis 3 and the rise of nomadic pastoralism

Land-use and subsistence in the Gobi Desert during Oasis 3 should inform our understanding of the processes leading to the rise of nomadic pastoralism, including developments like the construction of burial monuments and the widespread adoption of domesticated herd animals. The end of Oasis 3 is contemporaneous with the earliest

[25] Decreased body fat in ungulate species during spring can be a severe problem in high latitude environments. Fats and carbohydrates needed to metabolize meat proteins are especially difficult to procure this time of year and wetland resources like fattened waterfowl, eggs, tubers or stored carbohydrates may play an important role in reducing seasonal stress. See Speth and Spielmann, 1983; and Malainey et al., 2001.

Bronze Age burial structures and monuments in Mongolia, a rise in the symbolic importance of horses in China and Mongolia, and the spread of herd animals throughout the agricultural regions of China (see Chapter 2). By 3.0 kya, nomadic pastoralism was widespread in Northeast Asia. However, only Alashan Gobi lithic assemblages reveal any statistically significant divergence between Oasis 2 and Oasis 3 that might be related to shifts in residential mobility or raw material access (Table 4.13). Alashan Gobi lithic assemblages imply increased residential mobility during Oasis 3. A lack of similar evidence in the East Gobi and Gobi-Altai does not preclude shifts in land-use or subsistence. High residential mobility and the centralized use of dune-field wetlands appear to have continued in all three target regions until the end of Oasis 3. Despite some intriguing finds such as clay spindle whorls, painted pottery (with very similar motifs to those used by agropastoralist groups farther east), and copper slag, a lack of conclusive evidence for early pastoralism limits our ability to model the transition from Oasis 3 hunter-gatherers to Bronze Age pastoralists.

Nevertheless, there were a number of widespread shifts in material culture during Oasis 3. Residential sites in the East Gobi less often contain the large formal grinding tools that characterize Oasis 2 settlement. Surface treatments on pottery were more varied and pottery was more widespread during Oasis 3. These two developments might be related to a decline in the importance of milling or a preference for seed boiling. Grinding stones and pottery were also dispersed across a wider range of environments in Oasis 3 than in earlier periods, suggesting that extensive food processing was less spatially constrained. Other aspects of material culture exhibit variation from earlier styles, including: fully and finely polished adzes/axes; the introduction of high-fired pottery[26], along with more extensive variation in decorative finishes and vessel forms; the increased visibility of bead-making on both ostrich eggshell and stone[27]; the more frequent use of specialized hafted microblade tools like shouldered drills and endscrapers on microblades; and the introduction of end-hafted bifacial curved knives on bladelets or thin, elongated chalcedony nodules that may have replaced side-hafted bifacial inset knives.

One of the most striking aspects of technological change in Oasis 3 is the emphasis on decorative elements. Manufacture of finely polished adze/axes and eggshell and stone beads are especially time-consuming tasks. Burnishing, painting, and creating raised and moulded rims on high-fired Oasis 3 pottery require additional effort, but produce a more striking appearance than that of earlier vessels. Finer tools like shouldered drills and endscrapers on microblades would have been used in more detailed tasks, which may have included some type of decorative work (e.g., drilling holes in beads, engraving, and carving). Though not directly related to mobility and land-use, increased emphasis on decorative arts underscores a shift in time allocation. High-fired pottery and finely polished tools suggest that durability was valued and longer-term curation intended.

A peak in the production of traditional goods has been frequently witnessed in situations of new contacts between hunter-gatherers and food producing groups (see

[26] Painted pottery and hard red-wares were probably fired at temperatures between 900-1000^{o}C, based on estimates by Palmgren (1934) of Chinese Neolithic Majiayao Banshan-type pottery.
[27] As exemplified by Alashan Gobi assemblage K: 13230 (Maringer, 1950: 109-110).

examples in Sadr, 2005), and the shift in production of material culture might be related to contact with neighbouring herding groups as their influence in the region increased. Though there is currently insufficient evidence to support a claim for trade between Gobi Desert hunter-gatherers and nearby groups, it is not unusual for hunter-gatherers to trade local products with food producing neighbours (Lukacs, 1990; Spielmann and Eder, 1994; Junker, 1996, 2000; Zvelebil, 1996; Sadr, 2005). Furs, feathers, skins, tool stone, clay, wild meat, turquoise, raw copper, chalcedony beads (such as those being manufactured at cave site K: 13230 on the Ukh-tokhoi Plateau), and seasonal labour (see Paterson, 2005) are all products that might have been appealing to contemporary pastoralist, agro-pastoralist, and even agriculturalist neighbours. Products like grain/flour, pottery, bronze tools or ornaments, milk products, spun hemp, wool, and even domesticated animals might have been valued items among hunter-gatherer groups. Such interactions could have facilitated initial introduction of domestic herd animals into the Gobi Desert (although some might argue that camels may have already been domesticated during Oasis 3 as outlined in Chapter 2).

Few habitation sites can be reliably attributed to the Bronze Age. Most assemblages from Gobi Desert collections are consistent with Oasis 2 and Oasis 3. The scarcity of recognizable Bronze Age habitation sites suggests a decline in population density after Oasis 3, a substantial shift in material culture and/or settlement that made Bronze Age sites more ephemeral, or simply the absence of clear differences between Oasis 3 and early Bronze Age sites. Increased mobility and a decline in the use of lithic technology, both of which are expected to have occurred with the rise of pastoralism, could have contributed to reduced visibility in the archaeological record.

Dottore-namak (K: 13248; Maringer 1950: 127) is the only dated Bronze Age site in this sample and is no later than 2.5 ka (see Table 3.1). The pottery is a high-fired red-ware tempered with coarse sand and decorated with a moulded band on the shoulder (Figure 6.1). Two fragments of pottery with copper slag melted into the exterior surface were recovered from the same site around a spring in the Goitso valley (the oasis-lined southern edge of major depression, along the northern edge of which Yingen-khuduk and many other such sites were discovered). Dottore-namak exhibits the same microblade core reduction technology used during the Neolithic/Eneolithic. The presence of slag and a distinct pottery type are defining features. Core rejuvenation spalls were the only evidence of microblade cores in the assemblage so core morphology was not clear. The assemblage is significant in that it represents a very low density (98 artefacts recovered [Maringer, 1950: 127]) pottery-bearing site from a valley near a spring, as opposed to a dune-field/wetland environment. Dottore-namak exemplifies the trend towards more even dispersal of specialized food processing equipment across ecozones that appears to have begun in Oasis 3.

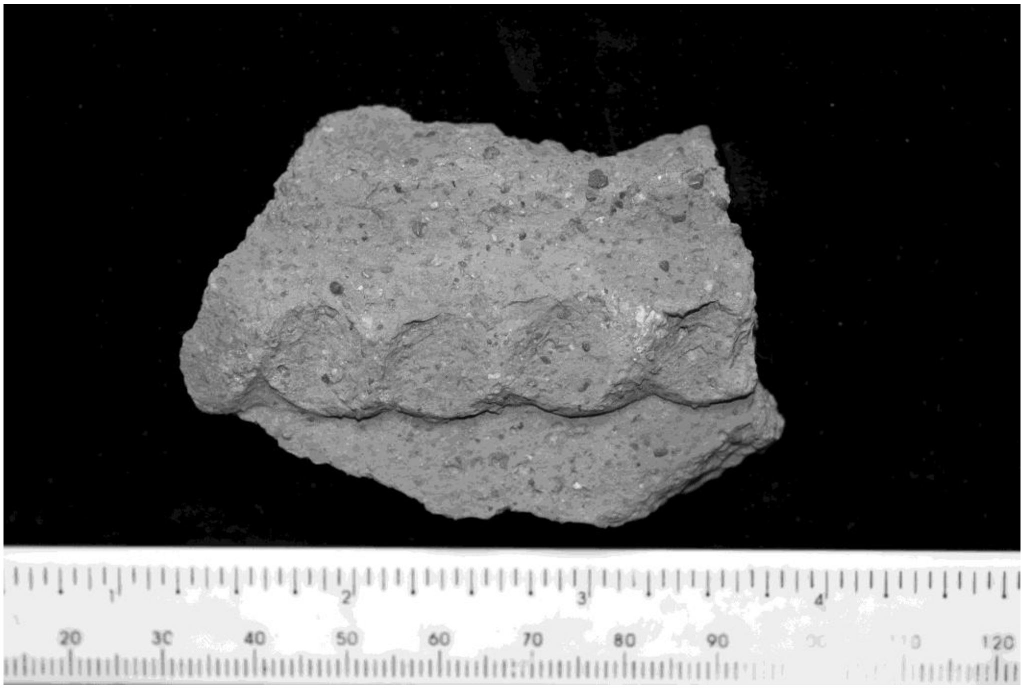


Figure 6.1 High-fired red-ware from the Bronze Age site, Dottore-namak.

New transportation aids could be responsible for this pattern. Beasts of burden such as horses or camels could have allowed groups to travel more easily between distant foraging patches, resulting in the higher residential mobility characteristic of Alashan Gobi. The Alashan Gobi is notable in that Oasis 3 is characterized by increased mobility, and dune-field/wetland use intensified during a relatively more arid phase than had been experienced in the preceding millennia. Lake levels were still high and wetland vegetation still abundant, however, desertification was probably occurring across the lowland plains. This may have led to an intensification of dune-field/wetlands that was less sustainable for longer-term habitation. Contacts with neighbouring pastoralist or agropastoralist groups might have contributed to local solutions such as the adoption or local domestication of horses or camels. A lack of distinct non-mortuary material culture associated with the local Bronze Age may support such a model of indigenous development. Since the use of domestic herd animals for transport would allow all belongings to be transported during moves in a manner similar to modern pastoralists, increased ubiquity of pottery and a decline in caching behaviour would be possible signatures of early Bronze Age sites. Changes in the distribution of pottery and grinding stones during Oasis 3 may represent the early presence of such elements.

If dune-field/wetland sites were still regularly exploited during the early Bronze Age, the Oasis 3 signature could easily overlap with and obscure evidence for early nomadic pastoralism. Sites like Dottore-namak could be confused with Neolithic/Eneolithic assemblages, particularly in the absence of pottery. Residue analysis of pottery vessels (Evershed et al., 2008) and sediment micromorphology from habitation sites (Shahack-Gross et al., 2004) are two methods of recognizing herding signatures in the archaeological record.

6.4. Conclusion

Despite the last century of heightened archaeological inquiry in East Asia, little work has been done with the vast collections of archaeological remains from the Gobi Desert. The dominance of surface assemblages and the inaccessibility of contextual data have inhibited research. The primary goal of this study has been to mine the extensive existing collections for a broad comparative sample of cross-regional data in order to provide a strong interpretative foundation for post-LGM prehistory of the Gobi Desert. Museum collections are shown to hold a diverse wealth of information that could not be replicated under the contemporary logistical, political, and financial constraints of fieldwork. Most importantly, the resulting observations of chronology and land-use among Neolithic/Eneolithic Gobi Desert hunter-gatherers form a basis from which interpretive investigation of field work and collections analysis can proceed.

Currently, we can assert the following:

1. Beginning around 8.0 kya, Gobi Desert hunter-gatherers began practicing a mode of subsistence and land-use that diverged greatly from earlier periods.
2. The shift in land-use was related to widespread forestation by 8.0 kya in the East Gobi and 6.0 kya in the west, along with the stabilization and increased productivity of lowland habitats.
3. After about 8.0 kya, organizational strategies were centred on the logistical exploitation of lowland dune-field/wetland and neighbouring ecozones. Habitation was centred within dune-field/wetlands, while task groups procured resources from a range of environments. Some locales were provisioned for longer-term occupation. This pattern of land-use continued until 3.0 kya.
4. The use of dune-field/wetlands between 8.0-3.0 kya is related to the complementary exploitation of both unpredictable high-ranked species like large ungulates, and reliable low-ranked dune-field/wetland foods.
5. Post-LGM hunter-gatherers maintained high residential mobility, but residential mobility did decline slightly, at least seasonally, after 8.0 kya.

6. Due to increased effective moisture and shifts in vegetational distribution, periodic seasonal reductions in residential mobility almost certainly occurred by 8.0 kya in the East Gobi, and by 6.0 kya in the Gobi-Altai and Alashan Gobi.
7. East Gobi sites represent an early intensive focus on milling during Oasis 2 (8.0-5.0 kya) that appears not been replicated in the Gobi-Altai or Alashan Gobi, and did not continue into Oasis 3.
8. Alashan Gobi sites reflect decreased access to tool stone (either due to a differential pattern in land-use or more uneven natural dispersal of raw materials) that seems to have been accentuated during Oasis 3.
9. Oasis 3 represents a period of increased emphasis on decorative elements and perhaps on the functional durability of certain artefact types such as pottery and adze/axes.

Several avenues of future research would be highly desirable for testing this new outline of chronology and land-use systems. First, collections research is necessary to improve sample size and enable a more refined reconstruction of regional chronology and organizational systems. Such research should include the integration of additional chronometric dating. Second, residue analysis on pottery and grinding tools can allow for a more direct understanding of subsistence and artefact functions, while compositional analysis of clays (and complementary in-field sourcing studies) can suggest patterns of transport or trade. Conscientious and conservative use of museum collections should continue to be an integral part of such research. Third, more holistic approaches to excavation are necessary and should include elements largely absent in Mongolian archaeology, including flotation for palaeobotanical analysis, systematic collection of sediments for soil micromorphology and luminescence dating, landform geomorphology, and coring of nearby lake/playa sediments for complementary palaeoenvironmental data. Finally, a tool stone sourcing studies would contribute greatly to our understanding of regional procurement strategies, as would a generally more detailed understanding of regional and local landscapes.

Due to both a unique geographic and cultural setting, the Gobi Desert region has great potential for illuminating our understanding of human adaptational and behavioural processes. This study is intended to lay a foundation for future research on post-LGM Gobi Desert hunter-gatherers, and to contribute ideas and knowledge to a budding interest in the transition to nomadic pastoralism in Mongolia (Wright, 2006; Houle, 2010). I have attempted to address the findings and hypotheses of past research; however, limitations on language and the availability of certain publications might have, on occasion, inadvertently thwarted my ability to be inclusive. It is my hope that the models outlined here for chronology, land-use, and subsistence will be refined – corrected and enriched – as more data becomes available and multiple voices emerge.

APPENDIX A – RESULTS AND CONTEXT OF DATED SITES

A.1. Dated Samples

REGION	SITE NAME/#	ORIGINAL CATALOGUE #	MATERIAL	METHOD
Alashan Gobi	Jabochin-khure	MFEA K.13203: 5	ceramic	Luminescence
	Gashun	MFEA K.13207: 1	ceramic	AMS
	Yingen-khuduk	MFEA K.13212: 6	ceramic	Luminescence
		MFEA K.13212: 123	ceramic	Luminescence
		MFEA K.13212: 128	ceramic	Luminescence
		MFEA K.13212: 184	eggshell	AMS
	Dottore-namak	MFEA K.13248: 5	ceramic	Luminescence
		MFEA K.13248: 6	ceramic	Luminescence
	Mantissar 4	MFEA K.13290: 44	eggshell	AMS
	Mantissar 7	MFEA K.13293: 29	eggshell	AMS
	Mantissar 12	MFEA K.13298: 15	ceramic	Luminescence
		MFEA K.13298: 25	ceramic	Luminescence
		MFEA K.13298: 55	eggshell	AMS
		MFEA K.13298: 60-01	eggshell	AMS
		MFEA K.13298: 60-02	eggshell	AMS
		MFEA K.13298: 60:03	eggshell	AMS
Gobi-Altai	Shabarakh-usu 1	AMNH 73/648 A	eggshell	AMS
		AMNH 73/648 B	eggshell	AMS
		AMNH 73/655 A	ceramic	AMS
		AMNH 73/655 A	ceramic	AMS
	Shabarakh-usu 2	AMNH 73/763-01	eggshell	AMS
		AMNH 73/763-02	eggshell	AMS
		AMNH 73/764-01	eggshell	AMS
	Shabarakh-usu 2 *in situ*	AMNH 73/790-01	eggshell	AMS
		AMNH 73/790-02	eggshell	AMS
		AMNH 73/790-03	eggshell	AMS
	Shabarakh-usu 4	AMNH 73/887 A	ceramic	AMS
		AMNH 73/894 A	eggshell	AMS
		AMNH 73/984 A	eggshell	AMS

Gobi-Altai (continued)	Shabarakh-usu 4 (continued)	AMNH 73/998 A	eggshell	AMS
	Shabarakh-usu 7	AMNH 73/1034-01	eggshell	AMS
		AMNH 73/1034-02	eggshell	AMS
		AMNH 73/1034-03	eggshell	AMS
		AMNH 73/1035-01	eggshell	AMS
	Shabarakh-usu 10	AMNH 73/1189 A	ceramic	AMS
		AMNH 73/1194 A	ceramic	AMS
	Ulan Nor Plain	AMNH 73/1609 A	ceramic	AMS
		AMNH 73/1609 C	ceramic	AMS
	Barun Daban	AMNH 73/1702 A	ceramic	AMS
	Orok Nor	AMNH 73/1790 A	eggshell	AMS
		AMNH 73/1790 B	eggshell	AMS
		AMNH 73/1792 A	ceramic	AMS
East Gobi	Shara Kata Well	AMNH 73/466A	ceramic	AMS
	Baron Shabaka Well (Site 19)	AMNH 73/2229 A	ceramic	AMS
		AMNH 73/2231 A	ceramic	AMS
		AMNH 73/2231 C	ceramic	AMS
		AMNH 73/2236 A	ceramic	AMS
		AMNH 73/2237 B	ceramic	AMS
		AMNH 73/2225-01	eggshell	AMS
		AMNH 73/2225-02	eggshell	AMS
	Shara Murun Crossing (Site 3)	AMNH 73/2303 A	eggshell	AMS
	Ta Sur Heigh (Site 7)	AMNH 73/2403 A	eggshell	AMS
	Spring Camp (Site 16)	AMNH 73/2526 A	ceramic	AMS
	Alkali Wells (Site 26)	AMNH 73/2646 A	eggshell	AMS
	Chilian Hotoga (Site 35)	AMNH 73/2796 B	ceramic	AMS
		AMNH 73/2796 C	ceramic	AMS
		AMNH 73/2797 A	ceramic	AMS
		AMNH 73/2797 A	ceramic	AMS
		AMNH 73/2800 A	Eggshell	AMS
		AMNH 73/2800 C	Eggshell	AMS

A.2. Context of Dated Sites

REGION	SITE NAME	# OF SAMPLES	MATERIALS	METHODS	NOTES
Alashan Gobi	Jabochin-khure	1	ceramics	L	Plains/basin, near square ruin, diagnostic pottery, evidence of microblade cores, probably cohesive
	Gashun	1	ceramics	AMS	Dunes/basin, paddled bowl, microblade tools, cohesive
	Yingen-khuduk	4	ceramics, eggshell	L, AMS	Dunes/basin, many small sites, diagnostic shards, grinding stone, polished stone, mixed
	Dottore-namak	2	ceramics	L	Dunes/basin, associated with copper slag, evidence of microblade cores, cohesive
	Mantissar 4	1	eggshell	AMS	Painted pottery, textile pottery, small microblades, probably cohesive
	Mantissar 7	1	eggshell	AMS	Painted pottery, incised pottery, bifaces, small microblades, probably cohesive
	Mantissar 12	6	ceramics, eggshell	L, AMS	Painted pottery, diagnostic pottery (textile, engraved, handles, etc.), microblade cores, mixed
Gobi-Altai	Shabarakh usu 1	4	ceramics, eggshell	AMS	Dunes, partially excavated, higher than S-u 2, few microblade/cores, mostly white chalcedony, bird bone artefact, small/large bifaces, cohesive
	Shabarakh-usu 2	6	ceramics, eggshell	AMS	Dunes, partially excavated, below high water lines, adze/axes, bifaces, stamped pottery, grinding stones, cohesive?
	Shabarakh-usu 4	5	ceramics, eggshell	AMS	Dunes, hearths, several small sites, diagnostic pottery (paddled, comb, net, engraved, moulded, channeled), barrel-shaped microblade cores, small bifaces, cohesive?
	Shabarakh usu 7	4	eggshell	AMS	Dunes, below high water line, one small shard, rough small bifaces, small cobbles, eggshell beads, probably cohesive

REGION	SITE NAME	# OF SAMPLES	MATERIALS	METHODS	NOTES
Gobi-Altai (continued)	Shabarakh usu 10	3	ceramics	AMS	Dunes, promontory, above high water line, partially excavated, few lithics, diagnostic pottery (paddled, stamped, channeled), few microblades/cores, cohesive
	Ulan Nor Plain	4	ceramics	AMS	Several hearths, sand, near raw material source, many test pieces, small bifaces, diagnostic pottery, mixed pottery, probably cohesive
	Barun Daban	1	ceramics	AMS	Dunes, many hearth sites around lakes, above lake deposits with possible exception of two, one from later period, small bifaces, polished stone, some mixing
	Orok Nor	4	ceramics, eggshell	AMS	Dunes near lake, hearths, several small sites, diagnostic pottery (paddled, incised), small bifaces, copper ore, some mixing
East Gobi	Shara Kata Well	1	ceramics	AMS	Mountains near river, excavated, fibre-tempered shards with light cording, wedge-shaped microblade cores on chalcedony, cohesive
	Baron Shabaka		ceramics, eggshell	AMS	Dunes, hearths, many small sites, many diagnostics, formal grinding stones, small bifaces, mixed
	Shara Murun Crossing	1	eggshell	AMS	Dunes near river, mostly debitage, no pottery, microblades, possibly mixed
	Ta Sur Heigh	1	eggshell	AMS	Mesa/hill near river, stamped pottery, cowry shell, small biface, microblades/cores, probably cohesive
	Spring Camp	1	ceramics	AMS	Mesa, grinding stone fragment, microblades/cores, stamped pottery, small bifaces, mixed
	Alkali Wells	1	eggshell	AMS	Hills with dunes, grinding stones, polished stone, microblades/cores, small bifaces, bronze arrowhead

REGION	SITE NAME	# OF SAMPLES	MATERIALS	METHODS	NOTES
East Gobi (continued)	Chilian Hotoga	6	ceramics, eggshell	AMS	Dunes, hearth, diagnostic pottery (textile, string, toothed), ochre, formal grinding stones, faunal remains, fox canine ornaments, bone tools, small unifacial points, microblades/cores, probably cohesive

A.3. Results of Chronometric Dating

LAB. NO.	CAT. NO. (K.13 OR 73/)	SITE	MAT.	$\delta^{13}C$	^{14}C AGE BP $\pm$ 1σ/ ka $\pm$ 1 σ	KYA (CAL. TO 68% RANGE)
UW2361	203: 5	J-k	C		3500 $\pm$ 300	3.20-3.80
AA91693	207: 1	G	C	-32.4	3385 $\pm$ 40	3.59-3.68
UW2358	212: 6	Y-k	C		3910 $\pm$ 300	3.61-4.21
UW2357	212: 123		C		5690 $\pm$ 350	5.34- 6.04
UW2360	212: 128		C		3910 $\pm$ 230	3.68-4.14
AA87198	212: 184		E	-2.4	41,900 $\pm$ 1500	44.04-47.25
UW2856	248: 5	D-n	C		3540 $\pm$ 1060	2.48-4.60
UW2355	248: 6	D-n	C		2740 $\pm$ 200	2.54-2.94
AA87197	290: 44	M 4	E	-11.8	14,857 $\pm$ 85	17.92-18.44
AA87200	293: 29	M 7	E^+	-9.1	>49,900	discarded
UW2362	298: 15	M 12	C		6460 $\pm$ 700	5.76-7.16
UW2359	298: 25	M 12	C		3840 $\pm$ 340	3.50-4.18
AA87201	298: 55		E^+	-8.1	>49,900	discarded
AA87202	298: 60-01		E^+	-8.1	>49,900	discarded
AA87199	298: 60-02		E^+	-8.8	>48,500	discarded
AA87203	298: 60:03		E^+	-9.2	>48,800	discarded
AA89869	648 A	S-u 1	E	-10.4	7483 $\pm$ 47	8.23-8.36
AA89870	648 B		E	-8.4	8522 $\pm$ 50	9.49-9.54
AA89872	655 A		C	-20.9	4308 $\pm$ 40	4.85-4.95
AA89872	655 A		C*	-7.3	10,039 $\pm$ 57	discarded
AA76420	763-01	S-u 2	E	-10.3	8159 $\pm$ 43	9.04-9.20
AA76421	763-02		E	-9.6	8184 $\pm$ 44	9.06-9.23
AA76419	764-01		E	~ -9.3	7969 $\pm$ 37	8.75-8.95
AA76416	790-01	S-u 2 (in situ)	E	-9.0	8396 $\pm$ 52	9.34-9.48
AA76417	790-02		E	-11.1	8268 $\pm$ 44	9.17-9.37
AA76418	790-03		E	-10.7	30,490 $\pm$ 780	34.05-35.50
AA89873	887 A	S-u 4	C^+	-21.9	3680 $\pm$ 76	3.92-4.13
AA89874	894 A		E	-10.0	7589 $\pm$ 47	8.37-8.42
AA89875	984 A		E	-10.0	8473 $\pm$ 64	9.44-9.52
AA89876	998 A		E	-10.0	8254 $\pm$ 47	9.15-9.34
AA76422	1034-01	S-u 7	E	-11.3	8054 $\pm$ 43	8.82-9.02

LAB. NO.	CAT. NO. (K.13 OR 73/)	SITE	MAT.	$\delta^{13}C$	^{14}C AGE BP $\pm$ 1σ/ ka $\pm$ 1 σ	KYA (CAL. TO 68% RANGE)
AA76423	1034-02	S-u 7	E	-11.6	38,600 $\pm$ 1000	42.20-43.85
AA76424	1034-03		E	-10.7	8439 $\pm$ 60	9.41-9.51
AA76427	1035-01		E	-11.0	8081 $\pm$ 49	8.89-9.08
AA89877	1189 A	S-u 10	C	-24.6	3595 $\pm$ 41	3.86-3.96
AA89878	1194 A		C	-23.4	3246 $\pm$ 39	3.42-3.54
AA89879	1609 A		C	-23.1	5116 $\pm$ 41	5.78-5.91
AA89880	1609 C		C	-23.3	5061 $\pm$ 49	5.75-5.88
AA89881	1702 A	BD	C	-27.5	1661 $\pm$ 42	1.53-1.62
AA89882	1790 A	ON	E	-9.5	8307 $\pm$ 56	9.22-9.41
AA89883	1790 B		E	-9.5	8307 $\pm$ 56	9.29-9.43
AA89884	1792 A		C^+	-26.8	10,030 $\pm$ 140	discarded
AA89868	466A	SKW	C	-24.4	8604 $\pm$ 51	9.54-9.63
AA89885	2229 A	BS 19	C	-25.7	5609 $\pm$ 47	6.34-6.44
AA89886	2231 A		C	-24.3	5954 $\pm$ 52	6.73-6.86
AA89887	2231 C		C*	-3.8	1173 $\pm$ 58	discarded
AA89887	2231 C		C^+	-22.5	5825 $\pm$ 85	discarded
AA89888	2236 A		C^+	-23.2	1445 $\pm$ 86	discarded
AA89889	2237 B		C	-24.0	3115 $\pm$ 47	3.28-3.38
AA76426	2225-01		E	-12.0	12,509 $\pm$ 59	14.53-15.13
AA76427	2225-02		E	-10.7	12,450 $\pm$ 74	14.38-15.05
AA89890	2303 A	SMC 3	E	-12.3	12,497 $\pm$ 70	14.56-15.12
AA89891	2403 A	TSH 7	E	-11.4	14,129 $\pm$ 80	17.13-17.61
AA89892	2526 A	SC 16	C	-20.1	866 $\pm$ 51	0.74-0.88
AA89893	2646 A	AW 26	E	-10.4	9562 $\pm$ 51	10.79-11.05
AA89895	2796 B	CH 35	C^+	-26.7	1866 $\pm$ 88	discarded
AA89896	2796 C		C^+	-27.6	17,120 $\pm$ 220	discarded
AA89897	2797 A		C*	+0.6	33,160 $\pm$ 540	discarded
AA89897	2797 A		C	-25.5	6728 $\pm$ 45	7.56-7.64
AA89898	2800 A		E	-7.2	10,586 $\pm$ 56	12.42-12.68
AA89899	2800 C		E	-6.9	10,103 $\pm$ 55	11.49-11.90

* indicates that sample was taken on carbonate fraction of ceramic without pretreatment, using selective dissolution; $^+$ indicates that the date may be unreliable due to a carbon yield of under 0.10 mg C or the sample produced an infinite date.

APPENDIX B – DETAILED SUMMARY OF DATED SITES

East Gobi

Baron Shabaka Well, Site 19

The Baron Shabaka locality, or Site 19, was located near a well in a narrow valley covered with weathered sand dunes. The vegetation was considerable relative to the rest of the region. “Camel sage” and a tough wire-like grass were most plentiful. Pond (nd: 90B) reports that they were led to the site by a Mongol hunter with a flint-lock gun, who claimed that the place yielded large quantities of material suitable for gun flints. The site stretched over an area of about 0.4 x 1.2 km. Archaeological remains were recovered 3 km south of a mesa and about 3 km west of a well. The majority of artefacts were found in blown out wind hollows, but smaller quantities were collected from the top of the valley sides and the tops of the dunes. The latter are probably related to historic use of the locale, but were mixed during curation.

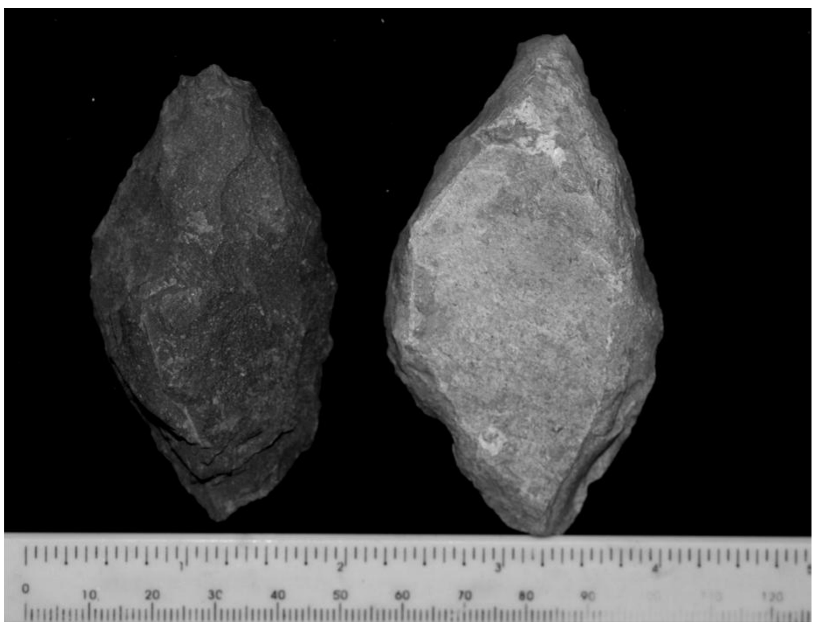
The dunes were partially solidified and then weathered into many hollows by aeolian activity. Many distinct hearth sites were reported but the integrity of these sites was not maintained during curation as they were for the Shabarakh-usu locality in the Gobi-Altai (see below). Pond described two of the sites. At Site 1, fire-cracked rocks suggested a hearth site, forming a loose group near a partially buried adze/axe. They were partially embedded in a dark grey soil that might have been so coloured due to the inclusion of ash in the sediment. A broken rectangular metate was also found next to a knobbed grinding bar or pestle. At Site 2, a broken rectangular metate was also found next to a knobbed grinding bar or pestle. Several small groups of lithics, all made of the same material, and sometimes “very crude pottery,” were found in a small area of less than a square meter. Elsewhere fine microlithic and coarser chipped implements were mixed and found together.

The archaeological assemblage is extremely diverse and includes some historic emains (including fragments of iron cookware), as is typical of many larger dune field sites. Ostrich eggshell fragments and unfinished beads from Baron Shabaka Well date to between about 14.5-15.0k cal yr BP (Janz et al., 2009). Radiocarbon dating produced three good dates from both Oasis 2 and the end of Oasis 3: 6.8k cal yr BP (5954 $\pm$ 52 BP [AA89886, AMNH #73/2231A]), 6.4k cal yr BP (5609 $\pm$ 47 BP [AA89885, AMNH #73/2229A]), 3.3k cal yr BP (3115 $\pm$ 47 BP [AA89889, AMNH #73/2237B]). The collection of artefacts and associated dates illustrates the reuse of dune-field/wetland sites over many millennia. Pond’s description of the site indicates that several of the collected scatters were probably temporally coherent. A similar situation is recognized at the Shabarakh-usu locality (Nelson, 1925).

Almost 7000 artefacts were recovered and curated from the Baron Shabaka locality, including: 402 ceramic shards, a stone spindlewhorl or circular disk, fragments of an iron cooking vessel, fragments of a mollusc shell, beads and fragments of ostrich eggshell, a partially drilled piece of talc, red paint stone, a fragment of a stone ring, 116 grinding stones (e.g., grinding slabs, hand stones, saddle querns, pestles, stone vessels/mortars), chipped and/or partially polished adze/axe/gouges, hammerstones, unifacial and bifacial points, bifacial knives, perforators, drills, burins, a diverse array of endscrapers, microblade cores, microblades, rough flake cores, and flakes. Cores and endscrapers are especially numerous which is probably partially due to collection bias, but still illustrates the nature of the site as a center of production. Pottery from Baron Shabaka was dated to both Oasis 2 and Oasis 3, and the range of artefact types indicates that the locality was used intermittently during both periods. Due to the temporal range of habitation, clear chronological distinctions are difficult to assess within the assemblage.

Microblade tools were often steeply retouched and several examples of unifacially retouched projectile points and perforators were recovered. Blade tools (2 to 2.5 cm wide) with lightly retouched distal ends are unusual and not typical of the Neolithic period. Likewise, several examples of unifacial tools made on large flakes (3 to 9 cm long and up to 4 cm wide) or flat-backed cobbles may be related to earlier Palaeolithic or Epipalaeolithic occupations, as they have no clear parallel in the Neolithic/Eneolithic. They are oval shaped and steeply retouched on all edges (Figure B.1). Large flakes and blades struck from prepared cores were also found, though some may have been retouched more recently. Artefacts that are most closely aligned with Oasis 2 assemblages include semi-lunar knives or thick bifacial preforms, short bifacial blades with parallel edges that were probably used as insets, and low-fired corded brown ware. The wide range of pottery types suggests intermittent use of the site throughout the Neolithic.

a.



b.

Figure B.1 Macrotools from Baron Shabaka Well.

Certain other artefact types are likely to have been associated with Oasis 3 habitations. One pottery shard produced a date of 3.3k cal yr BP (Table 3.1). This shard is very hard and was probably fired at a higher temperature than is typical of Oasis 2 pottery. The shard is uniformly coloured – grey on the exterior surface and light brown/buff on the interior surface. Some coarse sand or gravel temper was used, but organics were also included, as indicated by the porous and spongy texture of the fabric as seen in a cross-section of the interior paste (Figure 3.9). Manufacture by coiling and slow turning on a wheel are suggested by the undulating interior surface with fine, parallel striations. The type of temper used is not known, but is common in later East Gobi pottery. Although the surface was eroded, traces of the decorative finish show the use of a roller stamp, resulting in widely (~1.5 cm) and evenly spaced rows of square punctates – “toothed” impressions (Figure 3.8e). Similar shards recovered from other East Gobi sites indicate a tall, cylindrical vessel with a flat bottom.

Other examples of pottery from Baron Shabaka show the frequent use of coarse sand temper, large quantities of very fine sand temper, unidentified organics, mica or nacre, and possibly shell. Red, grey and brown wares were all found in high numbers at Baron Shabaka. Undecorated shards made of untempered homogeneous paste, or very lightly sand-tempered red-ware, are reminiscent of those from the Alashan Gobi. Coarser red-ware is usually sand-tempered and fired at a lower temperature. One shard is a sand-tempered red-ware with faint traces of string-paddled markings. The exterior surface was darkened, suggesting use over fire. Another fragment of sand-tempered red-ware shows possible traces typical of geometric-incised pottery recovered from western sites (Figure

3.8c, d). One shard of brown-ware resembles a shard from Chilian Hotoga, dated to 20.5k cal yr BP (AA89896, AMNH #73/2796C). The shard appears to be unfired and is porous, with a high content of extremely fine sand particles. The radiocarbon date for the Chilian Hotoga sample is almost certainly much too old and probably resulted from contamination of the porous unfired shard.

Surface treatments show parallels with other Gobi Desert collections, as well as some unique styles. The majority of shards are undecorated. Common finishes include stamped, string-paddled, and textile impressions. A smeared net impression made on buff clay was noted on several shards having heavily blackened interior surfaces. Textile impressions make up about 9% of this collection. Many of these shards are of thick grey ware with the spongy textured paste (Figure 3.9). Parallel and intersecting rows of cord impressions, like those found at Mantissar 12, were also recovered from Baron Shabaka. Several examples of incised designs included linear and checked patterns. Slightly diagonal vertical scraped incisions were identified on several shards and are reminiscent of paddle markings. As in the western Gobi Desert sites, moulded rims are also present. High-fired grey ware with angular punctate impressions is included in the collection and was typical of Mongolian pottery during the Khitan Period/Lao Dynasty.

As at other Gobi Desert sites, shards are very small and vessel form difficult to ascertain. One fragment of a round, thick drilled clay disk is probably a spindle whorl. Similar artefacts were recovered from the Alashan Gobi collections. As at other Gobi Desert sites, drilled fragments may indicate mending and curation. Discernable examples include one brown shard with a finely finished outward projecting rim which was thick and rounded. The vessel was decorated with vertical scraped incisions. Handle fragments and miniature lugs were found, supporting evidence from the western sites of a new type of vessel design and perhaps function. The latter were attached to low-fired spongy ware with incised patterns or smeared paddling. Flat bottomed vessels are evidenced by some fragments. One fragment indicates the use of a pedestal bottom with blackened patches near the bottom on the exterior surface.

Polished and chipped macrotools and grinding stones occurred in high frequency. Grinding slabs of many different shapes and sizes are numerous (at least 116 examples were retained in the AMNH collections for this site alone), and include pestles or knobbed/ball-headed rollers. The labour invested in their manufacture underscores the importance of milling tools. Such tools are associated with Oasis 2 assemblages such as Chilian Hotoga and Jira Galuntu. Two examples of what might be construed as hoes were also found. Such artefacts were also found in the west at Yingen-khuduk and Gashun Well. They were crudely chipped into semi-circular shapes. A large pick (~30 cm x ~5 cm wide) was partially flaked from an oblong stone is another unique artefact that does not have any parallel in more western Gobi Desert sites. Fragments of thick polished stone rings are also included in the assemblage and might be similar to artefacts in other regions described as “counter-weights.”

Macrotools were mostly made on basalt. Some are roughly chipped adze/axe preforms, occasionally exhibiting localized patches of light polishing. Polished versions of similarly shaped tools were also recovered, including a broken axe with a bulbous proximal end that was roughly polished, with numerous deep striations. There are also large bifacially flaked tools with one purposely flattened end for hafting. One such biface is a leaf-shaped point on basalt. The others are on flint and somewhat spatulate in shape, but with an angled distal end (Figure B.1). Some unifacial specimens may be blanks for such tools. Small bifacially flaked adze/axes (N = 8) on fine quality flints are notable for this collection and are probably associated with Oasis 2 occupations.

Other bifacially flaked tools include rough thick bifaces, microadze/axes, projectile points, and blade knives or inset knife blades. Fine bifacially retouched awls or drills with thin points were made on chalcedony microblades and have parallels with examples from other Oasis 3 Gobi Desert sites. Knife blades at Baron Shabaka are short and have parallel edges rather than the curved blades of western sites. Such artefacts are common in Oasis 2 assemblages and were probably used as inset knife blades. Fine bifacially flaked points or arrowheads exhibit concave, convex, and straight bases.

The wide variety of core types is typical of both Oasis 2 and Oasis 3. Many different sorts of raw materials were used and there is little evidence of the red jasper that is common in the Gobi-Altai and Alashan Gobi. Wedge-shaped cores are more common here than is typical of Oasis 3 sites. Some wedge-shaped cores might have been made on prepared bifaces. This group is similar to those from the Oasis 1 site of Shara KataWell in that some of the cores were prepared by initial unifacial retouch on a flat cobble. A long spall was then removed to form the platform, resulting in a D-shaped perform. Microblades were struck from the platform without further preparation.

Scrapers are typical of Neolithic/Eneolithic assemblages from the Gobi Desert. Many are heavy-duty, thick specimens, and there are several large rectangular scrapers with a squared distal end. Most scrapers are on amorphous microlithic flakes (35%), but a high frequency (20%) were made on amorphous blocks, chips, or cobbles. Scrapers on the ends of microblades or thick elongated flakes are characteristic of Oasis 3 assemblages. One large macroflake is reminiscent of Epipalaeolithic assemblages.

Many archaic forms are recognized within assemblage and may support an undated Early Epipalaeolithic or Oasis1 occupation. At the same time, long term stockpiling of raw materials could simply have resulted in less emphasis on microlithic tool types. Closer comparison of the Baron Shabaka collection with dated Epipalaeolithic assemblages from Northeast and North China should be undertaken in order to offer a better assessment of this situation.

Baron Shabaka South, Site 21

Site 21, or Baron Shabaka South, was found in weathered dunes on a hillside almost 5 km south of Baron Shabaka Well (Pond, n.d.: 91) and appears to be a temporally coherent occupation site with less than 500 recovered artefacts. Artefacts from the site were not dated, but the presence of diagnostic artefacts indicates an early Oasis 2 occupation. No pottery was found at this site. A unifacial point made on a microblade and a very finely retouched bifacial flake point with light fluting on one face were collected. Formal grinding stones are limited to one handstone or mano. Two roughly chipped bifaces, small and thick, may have been used as adzes. The core assemblage comprises 57% microblade cores. All are of the wedge-shaped variety and made on small nodules of chert and chalcedony. Other artefacts include one finished ostrich eggshell bead, endscrapers, flakes, microblades, and a perforator on a microblade. Raw materials included chert, chalcedony, and various other metavolcanic rocks. Based on the transitional form of the unifacial and bifacial points, an age of about 8.0-7.5 kya is proposed.

Chilian Hotoga, Site 35

Textile-impressed pottery from Chilian Hotoga, or Site 35 was dated to 7.6k cal yr BP (Figure 3.4c). The site was found near a well among dunes in a large wind hollow. On south side of hollow, worked bone, pierced teeth, and shells were found at foot of an escarpment. On surface, loose sand was mixed with small artefacts. The site was excavated to reveal a hearth site about 2.5 m in diameter, containing burned stone, bone fragments, charcoal, and one roller for grinding. Artefacts were found all over the eastern half of the large wind hollow around the well, but no other artefacts were embedded.

Aside from the bifacial and unifacial points, a bifacially-flaked bladelet knife was recovered. This specimen is typical of bifaces found in many Neolithic sites and resembles a large microblade or bladelet that was completely retouched in order to create a parallel-sided tool suggestive of a knife blade. Such artefacts are typical of Oasis 2 and may have been used as inset blades for composite knifes. One edge usually shows usewear. The remainder of the lithic assemblage included chipped and partially polished adzes, a lightly flaked bifacial semi-lunar knife, rough cores, flakes, sidescrapers, numerous and varied endscrapers, perforators, microblade cores (subprismatic, conical, cylindrical), microblades, endscrapers on microblades, and a stone pendant. A fragment of "red paintstone", ostrich eggshell fragments, drilled bivalve shells, drilled fox canines, fragments of avian long bones (one of which was incised with transverse grooves), and fragments of a bone awl and two bone needles are also included. Faunal remains are from rabbit (MNI = 6), equid (including teeth, long bone fragments, phalanges, an astragalus, and a sesamoid), frog (Ranidae), and some type of small Galliformes (identified by spur). Possible Oasis 3 elements include several shards of reddish-brown, low-fired pottery decorated with toothed or roller-stamp punctate impression and endscrapers on microblades.

Jira Galuntu, Site 18

Jira Galuntu was a large site yielding 6,340 artefacts. Artefacts from this site were not dated, but the site is assigned to the beginning of Oasis 2 based on the presence of diagnostic artefacts. There is evidence of intrusive pottery from later occupations. Pond (n.d.: 90A) wrote that the site was discovered in a wind hollow on a hillside with some sand (perhaps a former dune), near a wash that drained into the nearby lake bottom. Some of the associated pottery was clearly intrusive – high-fired grey ware with a punctate design typical of the Khitan period/Liao Dynasty (AD 911-1125). Pond suggested that the site was composed of remains from two distinct periods – one representing a microlithic component and the other characterized by coarsely chipped material.

The majority of pottery at this site is coarse sand-tempered red-ware with organic inclusions. Formal grinding stones, including a pestle or ball-headed/knobbed roller, are typical of Oasis 2. Microblade cores include wedge-shaped, conical, and sub-prismatic core, made on a variety of poor quality raw materials that were probably local. The remainder of the lithic assemblage comprises a massive chipped and finely polished adze/axe fragment, hammerstones, various types of endscrapers, fragmentary biface blanks, microblades, burins, perforators, drills on microblades, and unused amorphous flakes. Decorated pottery includes fragments of a straight-walled, wide-mouthed vessel with an undulating moulded rim and vertical cording. These shards are not typical of Oasis 2 sites and could be intrusive elements from Oasis 3. Jira Galuntu is assigned to the earlier period of the unifacial point phase at about 8.0-7.6 kya.

Gobi-Altai

Shabarakh-usu 1

Shabarakh-usu 1 was found largely deflated from an eroded dune. Artefacts were scattered along the surface of the valley floor, continuing to a spot in the base of a low escarpment, where some artefacts were still in place (Nelson, 1925: 33). Neither hearths nor the firecracked rocks typical of other Shabarakh-usu sites were found in the vicinity. The site is presumed to have been a workshop for lithic production. Over 7000 artefacts were recovered including a some pottery, a small metate or “rubbing stone”, a crudely chipped adze/axe, an incised fragment of shale, many lithics (about 85% of which were of white chalcedony), a worn and polished bird bone, weathered mammal phalanges, angular fragments of ostrich eggshell, pendants made on bivalve shells, and a perforated shell. Only a small portion (N = < 1000) of that total assemblage was removed from the site and included in the museum collections. According to Nelson’s (1925) description and the abundance of white chalcedony used as a raw material, the assemblage should be considered temporally coherent.

One potshard from Shabarakh-usu 1 (AA89872, AMNH #73/655A) was dated using radiocarbon analysis to the Oasis 2-Oasis 3 transition (4.9k cal yr BP [4308 ± 40 BP]). It is a piece of roughly paddled light reddish-brown ware. The interior portion of the paste is blackened and shows darkened pits where organic inclusions were carbonized. Sand grains are present in the paste, though not in a quantity suggestive of intentional tempering. The surfaces of the shard are cracked and appear friable, perhaps due to erosion. Ostrich eggshell from this site was dated to 8.3 and 9.5k cal yr BP. The former date is so far the latest date yet recorded for ostrich in East Asia, suggesting that the species might still been present in the Gobi-Altai region at the beginning of Oasis 2. The dates do not reflect the age of the archaeological assemblage (see Chapter 3).

Several distinctly decorated pottery shards are associated with the site, but some of the pieces may be intrusive, judging from the style of manufacture. One of these fragments is from a finely made and relatively high-fired sandy pottery. It refits with a larger repaired section of the same vessel recovered by other researchers in the general vicinity of Shabarakh-usu 1 and 2. The shard features a dispersed diagonally slanted stab and drag pattern, each based on two sets of four lines (see Figure 26.b’. in Fairservis, 1993: 51). Another conspicuous shard features moulded curvilinear designs and is from an unusually large, thick-walled, high-fired vessel that was made on a sand-tempered paste of very homogeneous character (see Figure 64.i, Fairservis, 1993:154). Another thick, high-fired shard is stamped with a curvilinear design similarly inconsistent with the mid-Holocene date. As such, we must consider the possibility that these artefacts were from the dune surface and may have been mixed during deflation. Despite evidence of intrusive elements, the consistency of lithic raw material and collection context support a strong temporal coherency.

Most of the pottery from Shabarakh-usu 1 is reddish-brown and string-paddled (some may have been cord-marked). The blackened interior paste characteristic indicates low firing and the use of organic temper (or highly organic clay). Only some of the shards appear to have been sand-tempered. One partially reconstructed sand-tempered vessel with a raised band of moulded clay placed in an undulating pattern along the rim, and string-paddled on the lower section is reminiscent of decorated pottery from Jira Galuntu, though the design is less developed. The shape suggests straight walls and there is a thick, flat handle. Other shards have raised clay bands below the rim, moulded and pressed, with some evidence of vertical string-paddling on the exterior surface below. Two additional Oasis 3 shards appear to have been fired at higher temperatures. One is decorated with incised slanting lines reminiscent of a pattern recovered at Site 10 that will be referred to as “geometric incised” (see Figure 8.d). The other is a tiny dark red shard with a raised band incised with vertical troughs at regular intervals (see Figure 8.f). In general, this pottery is similar to that from Oasis 2 sites, but with distinct additions like raised moulded bands and handles.

The lithics from this site also represent a continuation of Oasis 2 reduction strategies. A series of finely made projectile points are included in the sample of bifacially flaked points (N = 26), as are some large rough bifaces which might be unfinished blanks. All were made on either jasper or chalcedony. New biface forms include stemmed, leaf-shaped with a deeply concave or fishtail base, and a tear-drop shaped point (see Figure 3.11). A variety of sizes are represented and small projectile points may have been reworked from larger damaged specimens. Bifacial straight or slightly curved blades with rounded ends were also found (N = 6), and are similar to specimens from Ulan Nor Plain (see Figure 3.10). One large adze/axe of brown and black mottled silicified sandstone was recovered. One end had been modified for hafting.

Thick microblades or elongated flakes often possess steep retouch along parallel vertical edges. Many were clearly being formed into minimally retouched perforators or completely retouched drills, including forms with expanded bases, which are common in many Oasis 3 sites but absent from Oasis 2 assemblages. Several of the finely finished awls on microblades are probably more typical of Oasis 2 tool kits. Some large elongated flakes show steep retouches and may have been used as scrapers or knives. Many other elongated flakes and microblades were used without retouch and discarded. Some have possible evidence of hafting at the distal or proximal end. A few very slender, pointed – almost needle-like – microblades were recovered. Some have signs of light use along the lateral edges. Uniformity and consistency of edge damage distinguishes usewear from post-depositional chipping.

Only 12 cores are included in the Shabarakh-usu 1 assemblage. This number may not accurately reflect the actual number of cores at the site since almost 90% of the assemblage was discarded (Nelson, 1925: 51c-51d). Still, judging from the high number of unused debitage flakes (N = 469) retained in the collection, it is probable that few cores were present in the original site. The relatively higher number of bifacial points (N = 26) is significant and probably related to site function, since microblade cores and bifaces are expected to be equally favoured during collection.

The assemblage includes two examples of each of the following core forms: amorphous cores, informal bladelet or elongated flake cores, unsuccessful microblade cores of unknown type, unknown microblade cores, and flat-backed conical cores with blunt angled distal ends. One wedge-shaped and one flat-backed funnel shaped core are also included. There are twenty-two scrapers: ten on microlithic flakes; five on the ends of microblades or elongated flakes; four on blocks, chips, or cobbles; two reworked from thick elongated flakes; and one formal thumbnail scraper. From a chronological perspective the most important characteristics to consider are the use of endscrapers on elongated flakes or microblades, the high number of finely worked projectile points, the occurrence of curved bifacial blades, and the importance of bifacial retouch in the preparation of formal tools.

Shabarakh-usu Site 4

The Shabarakh-usu 4 assemblage (see also Janz, 2006: Appendix A) is comprised of several distinct concentrations that were deflated or in the process of deflating from the dune matrix. Some of the spots were partially excavated. According to Nelson (1925: 37), the lithics from subsite 4E were separately grouped, but the museum assemblage does not include the one potshard reported by Nelson. The majority of pottery was found in a separate area about 9 m in diameter. Faunal remains were not analyzed, but included an ungulate metapodial, a possible tarsal, and a rib fragment. Additional bone fragments were reported but not retained for the museum collections. The distribution of these sites, spread out over about 920 m^2, suggest clusters of task sites related to the primary hearth group of 4A and 4B. Nelson believed that what remained of the *in situ* artefact groups lay at about the same stratigraphic level.

Despite low carbon yields (0.04%), one shard from Shabarakh-usu 4 (AA89873, AMNH #73/887A) produced a radiocarbon date of 4.0k cal yr BP (3680 $\pm$ 76 BP), which is contemporaneous with the earlier date from Shabarakh-usu 10 (see below). As low carbon yields regularly produce erroneously old dates, the shard could actually be more similar in age to the slightly later date from Shabarakh-usu 10. The sample had a visibly darkened interior paste suggestive of carbonaceous remnants from organic inclusions. The piece is thick-walled, heavily sand-tempered, and light reddish-brown. Curvature is suggestive of the lower portion of a globular vessel. From the same site a lightly net-impressed shard of similar material, though lacking a darkened interior paste, was dated using luminescence (AMNH #73/890A) and should provide a comparative date range when dates are available. Three dates on ostrich eggshell from this site yielded ages of 8.4, 9.5, and 9.2k cal yr BP, suggesting prehistoric scavenging from multiple sources. These dates do not reflect the age of the site. Dated pottery shows contemporaneity with Shabarakh-usu 10 – about a thousand years younger than Shabarakh-usu 1.

Many pottery types from the site are reminiscent of those from Shabarakh-usu 1. One dark grey, thick-walled, high-fired shard with a curvilinear stamp decoration is similar to a shard found at Shabarakh-usu 1 and may be intrusive. Some undecorated brown, red and grey shards, heavily tempered with sand, show evidence of carbonized organic residues in the interior paste. Reddish-brown string-paddled wares with raised clay bands are common, making up almost 75% of the total pottery sample. They are sand-tempered and many show evidence of possible organic temper. Two groups of such ceramics can be distinguished – those with narrow raised bands and those with thicker raised bands that were moulded or incised. The latter often have wider ridges on the body suggestive of cord paddled marks rather than string-paddling. Again, they are comparable to the majority of pottery found at Shabarakh-usu 1. String-paddled shards are reminiscent of the ceramic bowl found in the Alashan Gobi at Gashun (MFEA #K.13207:1), dated to about 3.6k cal yr BP.

Other shards are similar to those recovered from Shabarakh-usu 10. A larger reconstructed rim fragment of sand-tempered ware is decorated with "stamped bands of parallel corrugations" (AMNH catalogue) that is similarly made to other examples of channelled ware from Shabarakh-usu 10 (Figure 30.d. in Fairservis, 1993:59; this volume, Figure 3.8a). One small bead-like lug is attached to the fragment near the rim.

Another tiny shard is marked with a series of short rows made up of diagonal circular punctuates, which is a decorative technique also represented at Shabarakh-usu 10 (see Figure 30.i in Fairservis, 1993: 59). Finally, a very interesting reconstructed fragment of a large vessel with distinctive decorations was recovered. The shard is sand-tempered and the paste is reminiscent of that used in the stab-and-drag decorated vessel from Shabarakh-usu 1. Two fragments, probably from the same vessel, show a pattern of geometric incision (linear and triangular designs) common in late Gobi Desert sites. Along the rim are diagonally angled almond-shaped indentations placed in a band just below rim (see Figure 30.a, 30.b in Fairservis 1993: 59, Figure 3.6.). In view of the date on pottery from this site and from Shabarakh-usu 10 (see below), these shards should all be considered representative of the later phase of Oasis 3.

Chalcedony was the most common raw material used in tool manufacture. Core types include amorphous cores, a variety of informal microblade cores, wedge-shaped, wedge or flat-backed funnel-shaped, conical, and massive barrel-shaped cylindrical cores. The latter are more common in Alashan Gobi Desert sites and are sometimes characterized by opposed platforms. At Shabarakh-usu 4, barrel-shaped cores were made on coarser-grained cryptocrystallines. These microblade cores have only one platform, and probably represent nuclei discarded at an early stage of use. Endscrapers on microblades and thick elongated flakes, drill points, larger sidescrapers, and a bifacially flaked adze made on jasper were also contained in the site assemblage. Bifacial tools include points and knives. Points include the fragmentary base of the concave/fish-tailed type and the teardrop shape with a convex base. Two bifacial blades, one finer bladelet-sized version, and a larger reconstructed one (2.5 cm at the base and about 7.5 cm long) were collected. Both were curved with straight bases. The range of lithic types is similar to Shabarakh-usu 1, which suggests the continuation of earlier reduction strategies.

Shabarakh-usu 10

Shabarakh-usu 10 is the last dated site for this locality and produced two dates: 3.9k cal yr BP (3595 ± 41 BP [AA89877, AMNH #73/1189A]); and 3.5k cal yr BP (3246 ± 39 BP [AA89878, AMNH #73/1194 A]). The distinction of surface and subsurface components at the site is probably arbitrary. Nelson (1925: 47) reported that the pottery at this site was found in a streak of charcoal under the point of a small finger-like bluff. His diagram shows that surface artefacts were found scattered around site. As tends to be the case at the Shabarakh-usu locality, the site was probably temporally coherent and deflated from the same layer of the original matrix.

The difference in dates between the two radiocarbon samples is about 400 years. This divergence may be related to differences between the date of manufacture as recorded by the date on the interior paste and the last burning episode as recorded in the subsurface sample. The difference in dates might also be accounted for by the use of clay heavily impregnated with decomposed organics (represented by samples with darkened interior paste), which could have been much older than the date of manufacture. The lack of decomposed organics in the later sample might reflect a more accurate date for the site. In any case, Shabarakh-usu 10 dates to between about 3.9 and 3.5k cal yr BP.

The shard dated to 3.9k cal yr BP (AMNH #73/1189A) is light greyish-brown with a thick corded impression, perhaps created by a cord-wrapped paddle. The interior paste is heavily blackened. More sparse sand inclusions suggest either incidental mixing or a light sand temper. Judging from the interior surface, the fabric of the shard is smoother and more homogeneous than the sample from Shabarakh-usu 1 and was probably fired at a higher temperature. Another shard, dated to 3.4k cal yr BP, is from the excavated component of the site (AMNH #73/1194A) and produced a slightly younger date than the surface sample of about 3.5k cal yr BP (3246 $\pm$ 39 BP). The interior paste suggests an original colour of light reddish-brown, but carbonization on the exterior and interior surfaces gives the artefact a grey hue. Incidental traces of darkened hollows associated with combusted organic remains are visible, but the interior paste does not show darkening associated with organic temper. The clay on the interior surface is heavily infiltrated with carbonaceous residues. The exterior surface of the vessel shows a smoothed thick corded impression overlain with striations that suggest light scraping prior to firing. Aside from this smoothing or scraping, the cord pattern is similar to that from the sample dated to 3.9k cal yr BP.

Another brown or buff shard from the same surface component was dated using luminescence (AMNH #73/1190A), but dates are not yet available. The exterior surface is somewhat haphazardly impressed with a distinct pattern of raised ridges surrounding indented squares (referred to by Nelson in the original catalogue as “checker-stamped”) (Figure 3.8b). The interior paste is slightly darkened and small holes throughout the fabric are indicative of combusted organic particles or perhaps weathered minerals.

Indentations from some type of fibre (e.g., grass, thread, or hair) are plainly visible on the exterior surface. Fibres resembling clumps of hair were found in the temper of several other Gobi-Altai shards. Sand inclusions are visible, but probably incidental. Additional diagnostic pottery types are identified from Shabarakh-usu 10. The rim fragment of heavily blackened channelled ware is similar to shards from Shabarakh-usu 4, further suggesting broadly contemporaneous habitation episodes (compare Figure 37 in Fairservis, 1993: 68; Figure 3.8a). Other pottery displays decorations of incised raised bands, both string and cord paddling, linear designs made with circular punctuates and thin diagonal troughs. Clay fabrics are highly variable and included sand-tempered red-ware, high-fired dark grey or black ware, light reddish-brown wares, and dark red-brown wares that were heavily tempered with very fine sand grains resulting in a surface texture reminiscent of coarse sand-paper. Some pieces exhibited the remnants of combustion of long, narrow organic elements that might have been small clumps of fibres or hairs. Blackened interior pastes are common, though high-fired wares are more homogeneous and sometimes exhibit hollow impressions of fibres or other possible combusted organics which left no traces of carbon residue.

The few lithics from Shabarakh-usu 10 clearly exemplify the continuation of post-LGM microblade reduction sequences complemented by the use of amorphous flakes. One small (2001-5000 cm^3) sandstone metate or “rubbing stone” was recovered. Two chalcedony cylindrical microblade cores and one chert (probably silicified volcanic ash) conical microblade cores were recovered, along with a chalcedony test piece (AMNH #73/1172, catalogued as a rough core). Microlithic scrapers were made on the end of elongated flakes and microblades (N = 2), or other amorphous microlithic flakes (N = 3), including one on a spall derived from a microblade core. One formal thumbnail scraper is also included. As in other Gobi Desert assemblages, there is a variety of debitage and used microblade and amorphous flakes. The lithic assemblage is typical of other Oasis 3 sites, although the cores are smaller and more heavily reduced than is typical of Gobi-Altai assemblages.

Ulan Nor Plain

Pottery from the Ulan Nor Plain site was dated to about 5.8k cal yr BP (5116 ± 41 BP [AA89879, AMNH #73/1609A], 5061 ± 49 BP [AA89880, AMNH #73/1609C]). The assemblage appears to be relatively temporally coherent. Decorated potsherds were limited to the upper level and distinctly located at the eastern extent of the site (Nelson, 1925). These decorated pieces, along with high-fired scraped red ware, can be associated with the Turkic Period (AD 552-630). The assemblage was recovered from stabilized reddish sand dunes (characteristic of Gobi-Altai Oasis 2 and 3 finds and referred to by Nelson as a "Shabarakh-usu deposit") in a hollow of the Ulan Nor-Artsa Bogdo plain. The hollow was just over 1 km in diameter, bow shaped, and drained by an east flowing stream. The main deposit was central to the hollow and most densely concentrated on the western front, stretching over 275 m north to south and 185 m east to west. Several fireplaces were found with ashes already exposed. The Ulan Nor-Artsa Bogdo plain was a major raw material procurement locality during the Palaeolithic and Neolithic, and the abundance of raw materials in the vicinity is reflected in the numerous test pieces (Nelson, 1925; AMNH catalogue).

The assemblage is consistent with other Oasis 2 sites, but includes slightly curved bifacial blade knives and one endscraper on a microblade. Both are more typical of Oasis 3 tool kits and probably represent the early use of such tools. The site was rich in high quality materials and discarded test pieces. Finely made and heavily reduced microblade cores as well as more expedient forms were collected. The high frequency of unknown core fragments (48%) and informal elongated flake and microblade cores (15%) is indicative of raw material abundance. Of the seventeen formal microblade cores seven are wedge-shaped cores, six cylindrical, and four conical. Of the seventeen scrapers, eight are on amorphous microlithic flakes, seven on blocks, chips or cobbles, and one on the end of a microblade. Bifaces include a large semi-lunar knife, a poorly formed and rather large bifacial point, and a curved bladelet knife.

The pottery is also representative of Oasis 2 types and is a coarse brownish-grey ware. Many of the shards show extensive exfoliation on the interior and exterior surfaces. The clay contains sand grains and organic temper. In some pieces, individual fibres are evident, including what appear to be coarse black hairs. The two radiocarbon dates are essentially identical and dated shards are probably from two pieces of the same vessel.

Alashan Gobi

Gashun Well (K. 13207)

The Gashun collection is listed in the MFEA catalogue as K.13207. Artefacts were picked up from the surface near a well 10 km northeast of Hoyar-amatu, an archaeological locality and stopping point on the caravan route. The location is near the border between Mongolia and the Inner Mongolia Autonomous Region. It appears to have been a workshop site with many large lithic specimens, probably unfinished adze/axes, all made on the same brown jasper (Maringer, 1950: 129). Similar specimens are included in collections from Abderungtei (K.13209: 128) and Mongol (K.13210: 132), slightly farther west.

The dated shard, which places the site assemblage at 3.6k cal yr BP (3385 ± 40 BP; AA91693, MFEA #K.13207: 1), is from a partially reconstructed sand-tempered bowl with very thin walls and string-paddled markings on the exterior surface. The bowl is uniformly blackened on the interior surface and has several darkened patches on the exterior. What appears to be a short (0.5 cm long) raised band of clay may have been applied near the rim as a sort of miniature or decorative lug, but might also be incidental. Four pieces of higher-fired, thicker, and heavily sand-tempered shards (MFEA #K.13207: 2) are similar to the Shabarakh-usu 4 shard radiocarbon dated to 4.0k cal yr BP. They are reddish- and greyish-brown and darkened on the interior surface.

The lithic assemblage is consistent with Gobi-Altai assemblages in both the range of raw materials and tool types. Microblade cores include the same type of barrel-shaped cores found at Shabarakh-usu 4, as well as wedge-shaped, conical, and cylindrical forms. Core reduction strategies appear biased towards the cylindrical form and many of the wedge-shaped specimens are more cylindrical with round bases. Raw material used in the manufacture of microblade cores and microblades is highly consistent, suggesting that microblades were detached and discarded at the same site with parent cores. Brown and yellow jasper are most common, followed by red jasper similar to the kind found in Gobi-Altai sites. Perforators include fine unifacially retouched specimens and one perforator/point on a thick, steeply retouched microblade. One scraper is on the end of a microblade or elongated flake, while the other four are on microlithic flakes, a large amorphous flake, and a chip or cobble.

Bifacial macrotools are notable. There are five unfinished implements made on the same brown jasper and retouched primarily along the edges. The other two forms are one plane-like tool and one large, thin unfinished biface that may have been an axe preform. The similarity to macrotools from Abderungtei (K. 13209) and Mongol (K. 13210) is notable. Curved bifacial blade knives were found at all three sites. This association further supports the chronological association of curved blade knives with Oasis 3 tool kits. Steeply retouched microblade tools and endscrapers on microblades are also consistent with Oasis 3 assemblages.

Jabochin-khure (K. 13203)

Jabochin-khure was dated using luminescence on pottery to about 3.5 ka (3490 $\pm$ 285 ka), making it broadly contemporaneous with Shabarakh-usu 4 and 10, as well as Gashun Well (K: 13207). A wide range of error is unavoidable because we were unable to control for external dose rates, but it does not preclude a solid Oasis 3 date. This group of artefacts was found near an unidentified square ruin just over 40 km south of Hoyar-amatu. The dated pottery (MFEA #K: 13203: 5) is decorated with a geometric incised design that is diagnostic of Oasis 3 sites (Figure 3.8c, d). The paste is sand-tempered and low-fired. While the exterior surface was light brown with darkened patches, the interior paste is dark grey and somewhat porous, indicating the organic content of the clay. Sand-tempered plain-ware manufactured from a similar paste may be from an undecorated portion of the same vessel, or from another undecorated pot. Debitage flakes include microblade platform core rejuvenation and preparation spalls made of yellowish-brown and red jasper. Cores include one wedge-shaped microblade core and one test piece.

Mantissar 12 (K. 13298)

Mantissar 12 was one of many small sites located in the Gurnai (Gurrunai) Depression, a large erosion basin bounded by the Ruoshui/Heihe (Etsin-gol) drainage system to the west and the Badain Jaran Desert in the east. The depression extends about 50 km from west to east. The most deeply eroded regions reach ground-water level and are overgrown with reeds. Aeolian deposition has resulted in sand from the depression being redeposited on the southern and eastern border of the basin in the form of a dune belt almost 40 m high, which intermittently juts out in a spur-like formation. This stretch was reported to be about 100 km from north to southwest, along which a “nearly uninterrupted series of small prehistoric sites” was discovered within the scrub and reeds or along the reed-saxual transitional zone (K. 13277-13319) (Maringer, 1950: 151-152).

Many of the collected sites were found within about 10 km of a small lake or playa feature called Ulan Nor. Current conditions suggest that the area was once occupied by extensive dune-fields and marshland, complemented by a small freshwater lake. Gurnai Depression sites are notable in the high frequency of ostrich eggshell fragments associated with bead manufacture. Radiocarbon dates on ostrich eggshell artefacts verify that inhabitants were collecting and modifying Pleistocene ostrich eggshell, most of which provided infinite-age radiocarbon dates (Appendix A.3).

Two shards were selected from Mantissar 12 for luminescence dating, including one cord-marked (K. 13298: 15, described as having "vigorous textile impressions" – Maringer, 1950: 160; see Figure 3.8d) and one plain brown burnished shard (K. 13298: 25). The first produced a date of about 6.5 ka (6460 ± 700; UW2362, MFEA #K. 13298: 15). The second shard was dated to 3.9 ka (3870 ± 340; UW2359, MFEA #K. 13298: 25). About 22% of the 169 shards from this site are high-fired and untempered or lightly sand-tempered red-ware with traces of painted black lines, including a checkered or lattice design. Amongst the untempered shards, the striking homogeneity of the fabric, including uniform coloration revealed in cross-sections of the interior paste, indicate that before use the clay was probably cleaned of impurities and then fired in a kiln under controlled conditions (compare to descriptions of Banshan pottery manufacture in Palmgren, 1934: 1, 3-4 and *contra* 5-6).

There is a high range of error in the two dates, but they securely date occupation of the Gurnai Depression to both Oasis 2 and Oasis 3. The first date is broadly contemporaneous with Yangshao sites of the middle Neolithic in China (Chang, 1987;

Liu, 2004). The later Oasis 3 date spans both the Qijia (4.2-3.8 ka – after Debaine-Francfort, 1995) and Siba (3.7-3.6 ka – after An, 1992b) archaeological cultures. Qijia pottery is characterized by fine red-ware, coarse reddish-brown ware, and some grey-ware. Surface treatments include rare occurrences of burnishing, smoothing, white slip, cord impressions, and basket-impressions. Painted pottery is rare, but designs include lines and checks (An, 1992b). Siba pottery is less well known, but noted as characteristically poorer in quality and less diverse than that of contemporaneous groups in the region, or preceding periods. Sand- and gravel-tempered plain-ware is most typical. Occasional finds of painted pottery show very simple and repetitive patterns. Red and black paints were applied in thick layers. Impressed "N" and "Z" patterns and wedge shapes are most the most frequent type of surface design (Yang, 1998).

The majority of painted pottery from Mantissar 12 is consistent with either Qijia or Majiayao pottery. Majiayao (4.7-4.3 kya [2700-2300 BC] – after An, 1992a) pottery is usually red, and painted in black with zoomorphic or geometric designs in delicate lines, curves, dots, triangles, and impressed checks. Cord-impressed and moulded surface decorations were also used (An, 1992a). Since the shards recovered from the Gurnai Depression are small, it is difficult to compare them with the wealth of complete Chinese Neolithic vessels. The pottery from Mantissar 12 is most consistent with either Majiayao or Qijia ceramic traditions. Luminescence dates coincide best with Qijia, but indicate that the Gurnai Depression was probably inhabited throughout both periods.

In general, the Mantissar 12 assemblage is characterized by red and reddish-brown pottery. Fabric types include an untempered ware with only a few incidental inclusions, light sand temper, and some heavily sand-tempered shards. Evidence of organic inclusions is extremely rare. Even sand-tempered shards show a paste that is very uniform. Most pottery fragments are consistent with a higher firing temperature than is common at other Gobi Desert sites, though a few shards appear to have been fired at lower temperatures. One shard exhibits a heavily blackened core, despite appearing to have been fired at a high temperature. One rim fragment of a fine, high-fired black-ware was also recovered from this site, but is atypical. Some indications of vessel design are evident in this group. Handle fragments found at Mantissar 12 are typical of Oasis 3 and were also recovered from Shabarakh-usu. Some handles are from painted red-ware and others from a heavily sand-tempered dark red-ware. Another heavily sand-tempered fragment of greyish-brown plain-ware is from a flat-bottomed vessel. A third fragment of sand-tempered dark red-ware is from a globular vessel with constricted neck and flared rim. Well-rounded thicker rims are characteristic and, based on the appearance of fine uniform striations, may have been smoothed using a slow wheel (as described for Banshan [Panshan] pottery by Palmgren, 1934: 3). Drill holes are rather common in sites from this region and suggest curation by extensive pot repair.

Surface treatments are highly variable for such a small site. Plain-ware is most common, making up 36% of all shards. Vessel surfaces are often smoothed. There are a few examples of burnished brown-ware, including one of the dated shards. Decorative treatments include intersecting and parallel incised lines, hand-moulded undulating rims (beneath which several shards are ringed by distinct vertical clusters of small circular punctates), intersecting rows of parallel rolled cord impressions, faint textile impressions (including on low-fired, drilled, brown-ware), textile or basket impressions, and cord-paddled. One shard is decorated with parallel rows of rectangular grooves subtly reminiscent of channelled ware from Shabarakh-usu. Pottery types are indicative of both Oasis 2 and Oasis 3 occupations.

The lithic assemblage from Mantissar 12 is representative of Gurnai Depression sites, showing both similarities and notable divergences from other Gobi Desert Oasis 3 sites. Chalcedony (either yellow and white, or translucent) is the main raw material, along with some poor quality jasper or siliceous sandstone and quartzite. The lithic assemblage includes cores and core fragments, unused and retouched flakes, perforators on microblades, drills on microblades, scrapers, and two small splinters of polished stone implements. Drills were very extensively retouched and there are distinctive forms like the double-ended drill. Only six scrapers are included in this collection, four from amorphous microlithic flakes, one is on the end of a microblade and the other on a thick elongated flake. No bifaces were recovered from Mantissar 12, but fragments of blade knives and bifacial projectile points were collected in other Gurnai Depression sites, including one stemmed point and one with a straight base.

The six cores from Mantissar 12 are particularly notable in form and manufacture. They are unusually small, with a mean approximate volume of 33.7 cm^3, in comparison to the overall Alashan Gobi mean of 179.1 cm^3 (see Chapter 4). The smallest of these is 0.4 x 1.4 x 1.1 cm, while the largest measures 3.2 x 2.1 x 1.4 cm. Keel flakes from initial core preparation range in length from between about 2.5 cm to under 1.0 cm, further suggesting high variability in the size of the original prepared cores. The range of raw materials used at Gurnai Depression sites suggests a similar source – perhaps the use of small locally available pebbles. The diminutive size may be related to small nodule size and/or intensive conservation of raw material due to limited access. Only three of the 25 cores analyzed from the Gurnai Depression retain any cortical remnant. Cores are indicative of typical Neolithic/Eneolithic Gobi Desert reduction sequences that result in flat-backed conical and cylindrical specimens. Less formal types were also made on small cobbles. They were reduced in a similar sequence to standard wedge-shaped microblade cores, but lacked a bifacial wedge opposite the striking face.

Yingen-khuduk (K. 13212, 48)

The Yingen-khuduk locality includes both MFEA site collections K. 13212: 1-186 and 48: 1-100. The locality was particularly rich and comprised numerous site groups collected from the desert surface. Yingen-khuduk sits on the Mongolian border and was an oasis of scrub with a few isolated trees, where drift sand had come to form dunes. The locality was situated in a vast dune-filled basin, just north of an ancient lake bottom and lined on the north with red cliffs (Bergman, 1945: 158; Montell, 1945: 367; Maringer, 1950: 127, 130). Folke Bergman, the Sino-Swedish Expedition archaeologist, reported encountering the carcass of a large web-footed bird along the road and a flock of swans flying south on the day before arriving at Yingen-khuduk (April 7, 1931) (Bergman, 1945: 158). During wetter periods, the area was rich in avian fauna. The locality is south of a transitional zone of scattered foothills belonging to the Gobi-Altai range, alluvial plains, and open desert plains intersected with drainage channels and small lakes.

Numerous sites scattered across the open territory along the Mongolian border suggest extensive prehistoric occupation. Judging by dates for the Yingen-khuduk assemblage, the region was exploited throughout the Neolithic.

Occupation of the Yingen-khuduk site in the Alashan Gobi, as with Baron Shabaka and Mantissar 12, appears to span Oasis 2 and Oasis 3 (5690 ± 350 ka [UW2357, MFEA #K. 13212: 123], 3910 ± 300 ka [UW2358, MFEA #K. 13212: 6], 3910 ± 230 ka [UW2360, MFEA #K. 13212: 128]). As with the Ulan Nor Plain site, the Yingen-khuduk artefact assemblage is different from early Oasis 2 sites, as represented by Jira Galuntu, Chilian Hotoga, and Baron Shabaka South. It is not clear which artefact types are associated with which date; therefore, it is difficult to identify temporally diagnostic artefacts. Despite this, directly dated “net-impressed” pottery (Figure 3.8a) is considered diagnostic of Oasis 2. There is an abundance of diagnostic Oasis 3 artefacts, but as we have seen with the Ulan Nor Plain site it is possible that many such specimens are transitional technologies, belonging to a late phase of Oasis 2.

Two essentially identical Oasis 3 luminescence dates of about 3.6 ka were derived from Yingen-khuduk ceramic shards. These are consistent with Oasis 3 dates from Shabarakh-usu and other Alashan Gobi sites. The first is from a fragment of red high-fired,string-paddled pottery, the fabric of which was porous and lightly tempered with coarse sand or gravel. The second is from a fragment of high-fired plain red-ware with a homongeneous, untempered paste. Darker patches of red are suggestive of a red slip or paint on the exterior surface. A similar fragment is derived from the same collection and is lightly sand-tempered. Such shards are found in other Alashan Gobi sites as well, including Hoyar-nor (Khoburin-nor, K. 13176). Examples of a similar fabric are found in the Gurnai Depression sites, but often painted in black lines or swirls (Figure 3.7).

Much of the pottery is high-fired. A more porous texture suggests organic temper or highly organic clays, but shard cross-sections show consistent colour and texture throughout. Organic temper appears to have been less favoured in the Alashan Gobi than in the Gobi-Altai or East Gobi. Heavy sand or coarser gravel is a typical temper. Surface finishes at Yingen-khuduk include, in order of descending frequency, textile or basket impressions (often smeared), paddled, plain or slipped, and net-impressed. Some high-fired red-wares have traces of red or black paint. Surface treatments in this group are representative of Oasis 3 Alashan Gobi ceramics. One specimen is from the rim fragment of a large narrow-mouthed jar with a wavy moulded rim and an exterior surface covered in a smeared basket or net impressions (Maringer, 1950: Pl. XXII, 1). The walls are rather thin and the paste untempered. Another partially reconstructed fragment is from the belly of a more globular vessel. The exterior surface shows a smeared cord-marked finish. The shard is thick-walled, brown with reddish patches, and appears to have been more highly fired. The paste is untempered or only lightly sand-tempered. Geometric-incised pottery was also recovered at Yingen-khuduk. Various pieces resemble those from Shabarakh-usu 4 and Jabochin-khure. Other plain-ware shards have darkened interior pastes and are tempered with coarse sand or gravel and rather porous.

Much of the pottery, particularly the high-fired types, probably belongs to the later occupation and can be compared to Oasis 3 shards from other sites. While it is tempting to associate the coarser pieces with the Oasis 2 component, dates from Gashun

Well and Shabarakh-usu clearly indicate that both types of pottery were used in later periods. Several examples are of a coarse, sand-tempered red-ware with miniature lug-like protrusions similar to those on the dated shard from Gashun Well. Thin-walled greyish-brown wares from the site are similarly string-paddled and sand-tempered (K: 13212: 5). Only some of the shards are blackened on the interior surface, but all have darkened patches on the exterior surface. One possible intrusive element is a high-fired, sand-tempered red-ware with a scraped exterior surface, possibly dating to the Turkic Period.

According to dates on pottery from Yingen-khuduk, the lithic assemblage should be considered representative of both Oasis 2 and Oasis 3 occupations. Formal macrotools from Yingen-khuduk likely belong to Oasis 3 and include two fully polished and one chipped specimen. The first of the polished pieces is a shattered and partially reconstructed adze/axe, and another is a thin (0.8 cm), finely polished axe of green, mottled translucent stone similar to jade. The latter shows heavy use on the distal end and was broken about 2.5 cm from the working end. Striations are clearly visible across the surface. Two chips of polished stone implements were also recovered. The third macrotool is expediently and roughly chipped. It is a rounded hoe-like tool narrowing at the neck. A comparable artefact was recovered at Shine-usu (K. 13259), a large surface site lying between Gashun-nor and Sogho-nor in the Juyanze region. One red sandstone hand-stone or runner was found at Yingen-khuduk and another is associated with the collection made by Bergman and Hedin in 1933 (MFEA #48: 1-100). The former shows an elongated oval profile, with one end mostly unfinished and the other heavily used and slightly rounded. Partially finished ostrich eggshell beads and fragments of worked fossil eggshell were also found with the primary assemblage, one of which was dated to 41.9k cal yr BP (41,900 ± 1500 BP [AA87198, MFEA #K. 13212:184]).

Jasper and chalcedony are the most common raw materials at Yingen-khuduk, with red jasper predominating. The majority of cores are of jasper (41%), while bifaces and scrapers are mostly on chalcedony (67% and 40%, respectively). Core types include conical (24%) and cylindrical (19%), as well as wedge-shaped (14%) forms. Both informal amorphous flake cores and formal biface cores are common. Tools are made on amorphous flakes, microblades, and thick bladelets or elongated flakes. Many such flakes were used without retouch or only lightly retouched and used. More formal tool types include scrapers, awls, and drills – including the expanding base variety. Scrapers on amorphous microlithic flakes are most common (46%), followed by those reworked from thick elongated flakes (16%), and scrapers on the end of a microblade or elongated flake (13%). Other scraper types include amorphous scrapers on cobbles or chips (9%), formal thumbnail (6%), elongated thumbnail or tongue-shaped scrapers (6%), one scraper on a macrolithic flake, and one heavy-duty scraper or small plane (2.8 x 2.9 x 1.6 cm). Bifacially retouched flakes or thin, reduced chalcedony cobbles appear to be unfinished preforms or expedient knives. Two blade knives constitute the sample of more formal bifaces.

APPENDIX C – ARTEFACT TYPOLOGIES

C. 1. Artefact summary for each site

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
EAST GOBI						
SKW	O1	N = 2 123 = 2	N = 1 320 = 1		N = 11 1 = 2 12 = 9	Dates Formal wedge-shaped core Chalcedony
3	O1	N = 1 131 = 1	N = 1 330 = 1	N = 1 220 = 1		Large flakes Microblades Chalcedony/lava Ostrich eggshell
6D	O1	N = 22 101 = 8 120 = 5 122 = 2 123 = 4 124 = 1 126 = 1 140 = 1	N = 11 301 = 3 320 = 5 321 = 1 324 = 1 325 = 1			Chalcedony/lava
7	O3	N = 12 120 = 1 122 = 4 126 = 7	N = 38 300 = 1 301 = 10 320 = 24 325 = 3	N = 3 201 = 2 214 = 1	N = 5 1 = 1 4 = 1 6 = 1 10 = 1 12 = 1	Rough wedge-shaped cores Backed microblades Chaldecony Ostrich eggshell Cowry
9	N/A	N = 1 122 = 1				Core preform Lava
9B	P?		N = 1 301 = 1			Rough macrotool Lava
9C	O2/3		N = 8 320 = 4 321 = 1 325 = 3			Lava
9D	O2/3			N = 1 200 = 1		Silicified lava or sandstone
10/10A/10B	O2/3	N = 5 101 = 1 122 = 1 123 = 1 126 = 1 128 = 1	N = 9 301 = 1 320 = 7 325 = 1	N = 10 200 = 4 211 = 6		Lava and chalcedony

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
EAST GOBI						
11/11A	O3	N = 51 101 = 18 120 = 6 122 = 9 123 = 3 124 = 2 125 = 1 126 = 3 127 = 1 129 = 2 130 = 1 140 = 5	N = 32 301 = 14 320 = 14 321 = 1 323 = 1 325 = 1 330 = 1	N = 12 200 = 1 20 1= 3 212 = 1 214 = 1 216 = 1 220 = 2 222 = 1 260 = 1 261 = 1	N = 1 1 = 1	Chalcedony and lava
12	O2	N = 5 101 = 1 120 = 1 123 = 1 126 = 2	N = 4 301 = 3 320 = 1			Chalcedony and lava
12/12A/12B	P, E, O2	N = 19 101 = 9 120 = 2 122 = 2 123 = 3 125 = 1 131 = 1 140 = 1	N = 10 301 = 3 320 = 5 323 = 2			Lava and chalcedony
13	O2?	N = 5 101 = 3 131 = 2	N = 8 301 = 1 320 = 3 321 = 2 325 = 1 330 = 1			Chalcedony, lava, jasper
13A	O2/3	N = 8 101 = 4 120 = 1 123 = 2 124 = 1	N = 8 320 = 6 321 = 1 324 = 1	N = 1 211 = 1		Jasper
14	O1	N = 4 123 = 1 126 = 1 127 = 2	N = 2 325 = 2		N = 2 1 = 1 9 = 1	Chalcedony and lava
15	O2	N = 11 101 = 5 123 = 1 130 = 1 131 = 3 140 = 1	N = 8 301 = 4 320 = 3 321 = 1	N = 1 214 = 1		Chalcedony and lava

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
EAST GOBI						
19	P/E?, O2, O3	N = 509 100 = 1 101 = 17 120 = 94 121 = 1 122 = 52 123 = 99 124 = 33 125 = 21 126 = 85 127 = 31 128 = 9 129 = 9 130 = 2 131 = 27 132 = 10 140 = 18	N = 487 301 = 125 310 = 18 320 = 170 321 = 31 322 = 2 323 = 51 324 = 13 325 = 18 330 = 59	N = 61 200 = 12 211 = 3 214 = 6 215 = 2 216 = 3 222 = 4 241 = 7 260 = 19 261 = 5	N = 323 0 = 4 1 = 166 3 = 31 4 = 36 5 = 4 5/8/10 = 1 8 = 2 8/11 = 1 9 = 29 9/10 = 1 9/11 = 1 10 = 15 11 = 3 12 = 22 14 = 7	Dates Unifacial knives Unifacial points Adze/axes Small adze Pick Gouge Chisel “Hoe” “Whetstones” Ground ring Manos Rollers Pestles Metates Spindle whorls Chalcedony dominant Iron (Historic) Ostrich eggshell
20	O2/3	N = 10 101 = 5 122 = 2 123 = 2 126 = 1	N = 11 301 = 6 320 = 5	N = 9 200 = 2 201 = 2 215 = 3 216 = 1 222 = 1	N = 5 4 = 2 5/8 = 1 12 = 2	Pestle Metate Drill
20A	Various	N = 2 123 = 2	N = 1 320 = 1	N = 3 201 = 1 214 = 1 224 = 1		Mano Ostrich eggshell
21	Early Oasis 2	N = 15 101 = 4 120 = 2 123 = 8 130 = 1	N = 17 301 = 7 320 = 8 323 = 1 325 = 1	N = 5 201 = 2 214 = 2 241 = 1		Unifacial points Formal wedge-shaped core Metate Perforator Ostrich eggshell
23/23A	O3	N = 46 100 = 2 101 = 15 102 = 1 120 = 3 122 = 10 123 = 1 124 = 5 126 = 7 127 = 1 140 = 1	N = 10 301 = 3 320 = 3 325 = 4	N = 2 201 = 1 216 = 1	N = 26 1 = 7 9 = 18 12 = 1	Mano Metate

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
EAST GOBI						
28	O3	N = 42 101 = 28 120 = 3 122 = 2 126 = 3 130 = 2 131 = 1 132 = 1 140 = 2	N = 24 301 = 12 320 = 12	N = 19 200 = 1 201 = 9 211 = 6 261 = 2 263 = 1	N = 3 3 = 1	Unifacial knife Adze/axe Small adze Large axe "Whetstone" Manos Metates Beads
29	O2/O3	N = 24 101 = 9 120 = 2 122 = 5 123 = 1 126 = 2 127 = 1 128 = 1 132 = 1 140 = 1	N = 25 301 = 12 320 = 12 324 = 1	N = 3 201 = 1 222 = 2		Polished adze/axe Mano Roller Handheld mortar? Drills
30/30A	Late O3	N = 22 101 = 7 120 = 5 122 = 2 123 = 5 125 = 1 126 = 1 127 = 1	N = 13 301 = 3 320 = 5 321 = 2 325 = 3	N = 2 200 = 1 201 = 1		Adze/axe Metate
31	O2/O3	N = 75 101 = 18 120 = 14 122 = 13 123 = 17 124 = 2 125 = 1 126 = 2 127 = 5 129 = 1 140 = 2	N = 44 301 = 18 320 = 21 323 = 1 325 = 2 330 = 2	N = 21 200 = 3 211 = 8 214 = 1 215 = 1 217 = 1 220 = 3 222 = 2 241 = 2		"Whetstones" Manos Pestles Metate Small adze Drills Shell bead
34	O3?	N = 19 101 = 14 120 = 5		N = 6 201 = 6		Chalcedony biface blanks Ostrich eggshell
36	O1	N = 5 101 = 3 123 = 1 140 = 1	N = 1 320 = 1			2.5 km north of Chilian Hotoga

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
GOBI-ALTAI						
Cemetery Mesa (CM)	E, O3	N = 2 101 = 2	N = 5 320 = 4 323 = 1			"Whetstone" Camel effigy Vicinity of burials and stone monuments Petroglyphs
Gashuin Bologai Well (GBW)	Early O2	N = 2 123 = 2			N = 2 1 = 2	Lava stone mortar
Barongi Usu Valley (BUV)	O1?	N = 14 101 = 6 120 = 4 123 = 1 129 = 1 130 = 1 131 = 1	N = 4 301 = 1 320 = 1 330 = 2	N = 1 200 = 1		Jasper Intrusive elements, including Chinese glazed shard
Dubshi Hills (DH)	P	N = 1 120 = 1	N = 1 301 = 1			Macroflakes Yellow chalcedony
Ulan Nor Plain (UNP)	O2	N = 139 101 = 67 120 = 3 122 = 18 123 = 7 124 = 1 125 = 1 126 = 3 127 = 3 128 = 2 129 = 1 130 = 31 140 = 2	N = 19 301 = 4 310 = 4 320 = 4 321 = 1 322 = 1 324 = 1 325 = 2 326 = 1 330 = 1	N = 37 200 = 4 201 = 4 216 = 3 222 = 2 224 = 1 260 = 23	N = 42 1 = 4 2 = 23 4 = 1 5 = 1 6 = 3 10 = 10	Dates Mano Curved bifacial knife Jasper
Jichirun Wells (JW)	Early O2	N = 25 101 = 9 120 = 10 122 = 1 127 = 1 128 = 1 130 = 1 131 = 1 140 = 1	N = 8 301 = 4 310 = 1 320 = 1 325 = 1 330 = 1	N = 5 220 = 3 260 = 1 261 = 1		
Jichirun Wells, in situ	Early O2	N = 6 101 = 3 120 = 2 130 = 1	N = 2 301 = 1 320 = 1	N = 3 214 = 1 226 = 1 260 = 1		Bones and equid teeth

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
GOBI-ALTAI						
Sairim Gashoto (SG)	E	N = 3 101 = 1 120 = 1 130 = 1	N = 2 300 = 1 301 = 1			Jasper
Arts Bogd (AB)	O2	N = 4 101 = 1 120 = 2 124 = 1	N = 3 320 = 2 321 = 1	N = 2 211 = 2		Blade tools
Khunkhur Ola (KhO)	Metal Ages?	N = 3 101 = 3	N = 1 301 = 1			Jasper and chalcedony Vicinity of stone monuments
Barun Daban (BD)	O2, O3	N = 13 101 = 1 120 = 1 122 = 1 123 = 5 126 = 3 127 = 2	N = 30 301 = 3 310 = 1 320 = 20 322 = 1 323 = 5		N = 38 1 = 12 3 = 8 4 = 17 9 = 1	Polished adze/axe
Orok Nor (ON)	O2, O3	N = 31 120 = 2 122 = 13 123 = 8 126 = 4 128 = 3 140 = 1	N = 35 301 = 5 320 = 19 322 = 2 323 = 5 325 = 4		N = 62 1 = 25 3 = 28 5 = 3 8 = 3 10 = 1 12 = 2	Perforators Drills Pendant Shell bead Ostrich eggshell Vicinity of stone monuments and burials
Salt Creek (SC)	O 3	N = 7 101 = 3 122 = 1 123 = 1 126 = 1 129 = 1	N = 2 320 = 1 323 = 1			“Whetstone” Bronze arrowpoint Stone structures
Shabarakh-usu 1	O3	N = 12 101 = 2 120 = 2 122 = 4 123 = 1 126 = 2 129 = 1	N = 22 301 = 4 320 = 10 321 = 1 323 = 5 324 = 2	N = 43 200 = 7 201 = 1 211 = 2 212 = 3 214 = 9 215 = 6 216 = 6 220 = 2 221 = 1 222 = 6	N = 72 1 = 12 2 = 2 3 = 48 3/5 = 5 4 = 1 5 = 1 8 = 2 11 = 1	Dates Axe Small metate Perforators Drills White chalcedony Ostrich eggshell

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
GOBI-ALTAI						
Shabarakh-usu 1A	O2	N = 25 101 = 12 120 = 3 122 = 6 123 = 1 126 = 1 130 = 1 140 = 1	N = 58 301 = 4 310 = 1 320 = 39 321 = 4 323 = 6 324 = 1 325 = 2 330 = 1			Grooved slabs Small metate Jasper
Shabarakh-usu 2a	E/O1	N = 2 101 = 2				"Mossy chert" From valley floor - base of dunes
Shabarakh-usu 2b	O1	N = 3 120 = 1 122 = 1 131 = 1				Perforator Ostrich eggshell
Shabarakh-usu 7		N = 40 101 = 9 120 = 14 122 = 3 123 = 6 129 = 1 130 = 2 131 = 3 132 = 2	N = 52 301 = 3 320 = 41 321 = 1 323 = 3 324 = 3 325 = 1	N = 75 200 = 36 201 = 6 211 = 21 216 = 2 220 = 1 221 = 5 222 = 2 260 = 2	N = 1 1 = 1	Shouldered drills Perforators Jasper Tools/cores on very small nodules Ostrich eggshell
Shabarakh-usu 10		N = 3 125 = 2 126 = 1	N = 7 320 = 3 321 = 1 323 = 2 325 = 1		N = 97 1 = 15 2 = 19 3 = 50 4 = 1 5 = 6 5/8 = 1 8 = 1 8/13 = 1 13 = 3	Dates Small metate Jasper
ALASHAN GOBI						
176	O3	N = 15 101 = 1 120 = 1 122 = 5 123 = 1 125 = 1 126 = 1 127 = 4 128 = 1	N = 12 301 = 1 320 = 3 321 = 2 324 = 6		N = 109 0 = 47 1 = 48 2 = 3 5 = 1 7 = 4 10 = 2 11 = 1 14 = 3	Partially polished axe Within 600 m of scatter with "Ordos-style" bronzes

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
ALASHAN GOBI						
179	O3	N = 3 122 = 2 131 = 1	N = 1 301 = 1		N = 13 0 = 5 1 = 7 11/12/13 = 1	Within 600 m of scatter with "Ordos-style" bronzes
183	O3	N = 2 122 = 1 127 = 1			N = 1 6 = 1	Axe Drill Painted pottery
186	O2?	N = 4 122 = 3 128 = 1	N = 22 300 = 1 310 = 1 320 = 18 321 = 1 323 = 1			Large microblades
188	unknown	N = 2 101 = 2	N = 1 320 = 1			Large flakes, cobbles
202	E?	N = 5 120 = 1 131 = 4	N = 12 301 = 4 320 = 5 321 = 2 322 = 1	N = 2 200 = 1 260 = 1	N = 1 10 = 1	Pottery intrusive?
203	O3	N = 4 101 = 1 122 = 2 123 = 1			N = 15 1 = 9 11/14 = 6	Dates
204	E	N = 2 101 = 1 131 = 1	N = 32 300 = 1 301 = 9 310 = 4 320 = 9 330 = 9	N = 1 200 = 1		No microblades
207	O3	N = 17 120 = 1 123 = 3 125 = 1 126 = 5 127 = 3 128 = 1 131 = 3	N = 5 301 = 1 310 = 1 320 = 2 323 = 1	N = 5 260 = 5	N = 5 1 = 4 3 = 1	Dates Adze/axes Perforators
208	O3	N = 11 123 = 1 124 = 2 125 = 4 127 = 3 129 = 1		N = 3 260 = 1 261 = 2		Adze/axe

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
ALASHAN GOBI						
212	O2,O3	N = 88 100 = 1 101 = 3 120 = 2 122 = 12 123 = 17 124 = 7 125 = 3 126 = 14 127 = 5 128 = 9 129 = 1 130 = 1 131 = 1 132 = 5 133 = 5 140 = 2	N = 45 301 = 2 310 = 1 320 = 21 321 = 3 322 = 4 323 = 4 324 = 9 330 = 1	N = 9 200 = 2 222 = 2 260 = 5	N = 52 0 = 3 1 = 6 2 = 5 3 = 14 4 = 1 5 = 2 5/10 = 1 6 = 3 9 = 10 10 = 2 11 = 2 14 = 1 15 = 1 20 = 1	Dates Adze/axes Thin polished axe Mano Drills Ostrich eggshell
213	O2	N = 4 120 = 1 124 = 1 125 = 1 126 = 1	N = 2 320 = 2			Partially polished adze/axe
216	O3	N = 2 126 = 1 127 = 1	N = 8 320 = 6 321 = 1 324 = 1			
218	O3	N = 24 100 = 1 101 = 2 122 = 17 124 = 1 125 = 1 126 = 2	N = 18 300 = 1 320 = 7 321 = 3 323 = 6 324 = 1	N = 1 200 = 1		Perforators Awl
219	P		N = 1 310 = 1			
220	O2	N = 4 101 = 1 127 = 1 131 = 2		N = 1 222 = 1		
222	O3	N = 2 123 = 1 129 = 1	N = 6 301 = 1 320 = 3 323 = 2	N = 1 200 = 1	N = 1 1 = 1	

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
ALASHAN GOBI						
223	O2/O3	N = 23 100 = 1 101 = 5 122 = 7 123 = 3 125 = 1 126 = 2 127 = 2 128 = 2	N = 102 300 = 12 301 = 19 310 = 14 320 = 43 321 = 6 324 = 7 325 = 1	N = 5 200 = 1 230 = 1 240 = 3	N = 6 0 = 1 1 = 2 3 = 3	Spearpoint
226	O1	N = 6 122 = 1 123 = 5				
229	unknown	N = 1 140 = 1				Macro or core tool
230	O3 (Metal Ages?)		N = 2 301 = 1 320 = 1		N = 69 0 = 5 1 = 39 9 = 2 10 = 16 11 = 7	Grooved slab Chalcedony bead-making
231	O2	N = 87 101 = 2 120 = 12 121 = 1 122 = 10 123 = 7 125 = 2 126 = 9 127 = 9 130 = 9 131 = 11 132 = 13 140 = 2	N = 34 301 = 5 310 = 9 320 = 6 323 = 4 324 = 2 330 = 8	N = 13 221 = 1 260 = 9 261 = 3		Axe
237	P?	N = 4 130 = 2 132 = 1 140 = 1	N = 13 301 = 3 310 = 10	N = 3 260 = 2 261 = 1		Handaxe
247	O2	N = 3 122 = 1 128 = 1 132 = 1	N = 2 320 = 2	N = 2 226 = 1 260 = 1		Axe Drills Awls
248	Metal Age	N = 8 122 = 8	N = 3 301 = 1 320 = 2		N = 38 0 = 16 1 = 17 10 = 2 3 = 2 5 = 1	Dates Slag

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
ALASHAN GOBI						
251	unknown		N = 1 320 = 1			
258	O2 or O3	N = 1 125 = 1				
259	O2?	N = 197 100 = 1 101 = 21 120 = 33 122 = 45 123 = 16 124 = 4 125 = 8 126 = 23 127 = 24 128 = 3 130 = 1 131 = 10 132 = 4 140 = 4	N = 93 301 = 10 310 = 4 320 = 54 321 = 10 323 = 4 324 = 8 325 = 2 330 = 1	N = 9 225 = 1 260 = 5 261 = 3		Unifacial knives Adze/axes Chisel “Hoe” Awl Unifacial point (perforator?)
277	O3?		N = 8 301 = 2 320 = 4 323 = 2		N = 7 0 = 3 1 = 3 9 = 1	Slag Ostrich eggshell
287	O3?	N = 2 122 = 2	N = 5 301 = 2 320 = 2 323 = 1	N = 1 222 = 1	N = 1 5 = 1	Unifacial knife Ostrich eggshell
290	O3	N = 6 122 = 1 123 = 2 124 = 1 126 = 1 127 = 1	N = 18 301 = 3 320 = 11 323 = 1 324 = 3	N = 1 222 = 1	N = 13 1 = 5 6 = 2 12 = 5 20 = 1	Painted pottery Polished stone frag. Turquoise frag. Drills Perforators Ostrich eggshell
293	O3	N = 5 122 = 3 126 = 1 140 = 1	N = 14 301 = 2 320 = 9 323 = 3	N = 2 212 = 1 221 = 1	N = 11 0 = 3 1 = 4 4/13 = 1 6 = 1 12 = 2	Painted pottery Drills Perforators Ostrich eggshell
294	O3	N = 1 125 = 1	N = 2 301 = 1 320 = 1		N = 1 6 = 1	Painted pottery Ostrich eggshell

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
ALASHAN GOBI						
298	O2, O3	N = 6 101 = 1 122 = 3 126 = 1 127 = 1	N = 7 301 = 1 320 = 4 323 = 1 324 = 1		N = 169 0 = 10 1 = 61 4 = 1 4/5 = 4 5 = 15 6 = 39 9 = 11 10 = 1 11 = 11 12 = 4 13 = 12	Dates Painted pottery Drills Perforators Ostrich eggshell
303	O3		N = 2 323 = 1 324 = 1			
307	O3?	N = 3 123 = 1 126 = 1 127 = 1	N = 6 320 = 5 323 = 1		N = 3 1 = 2 12 = 1	Slag Ostrich eggshell Mixed stray finds
311	O3	N = 1 126 = 1	N = 4 320 = 2 323 = 1 324 = 1		N = 1 0 = 1	Ostrich eggshell Mixed stray finds
316	O3	N = 1 126 = 1				Mixed stray finds?
321	Early O2	N = 25 101 = 5 120 = 4 121 = 1 122 = 1 123 = 8 126 = 4 127 = 2	N = 9 301 = 1 320 = 5 322 = 1 323 = 2	N = 1 222 = 1		Axe Perforators
322	P	N = 2 101 = 1 131 = 1	N = 8 301 = 4 310 = 1 321 = 1 322 = 1 330 = 1			Macroflake tools
323	E?	N = 2 127 = 1 131 = 1	N = 5 300 = 1 310 = 1 320 = 1 321 = 1 330 = 1			Unifacial knife Blade Drill

SITE	PERIOD	CORES	SCRAPERS	BIFACES	POTTERY	OTHER
ALASHAN GOBI						
324	unknown	N = 1 123 = 1				

* Counts are only of studied artefacts: a percentage of each tool type was selected for analysis in some of the largest assemblages (Baron Shabaka Well, Ulan Nor Plain). Numbers refer to artefact codes listed below.

C.2. Codes for artefact types

<table>
<tr><th>ARTEFACT</th><th>CODE</th><th>ARTEFACT</th><th>CODE</th></tr>
<tr><td rowspan="2">Core type</td><td rowspan="2">100 unknown fragment
101 amorphous/expedient/ test piece
102 reworked tool
110 Levallois-style
120 informal blade/bladelet/ elongated flake
121 blade
122 unknown/unsuccessful microblade
123 wedge-shaped microblade
124 conical microblade
125 cylindrical microblade
126 flat or biface-backed, pointed microblade
127 flat or biface-backed, round bottomed microblade
128 cylindrical microblade with wedge
129 boat-shaped microblade
130 biface
131 scraper core tool (usu. bifacial)
132 formal biface core tool
140 core tool, informal</td><td>Scraper type</td><td>300 unknown scraper
301 amorphous scraper on block, chip, cobble, etc.
310 on macrolithic flake
320 on microlithic flake
321 thumbnail scraper
322 tongue-shaped (extended thumbnail)
323 end of bladelet/elongated flake
324 reworked from thick blade or elongated flake
325 reworked from broken core or tool
330 heavy-duty scraper</td></tr>
<tr><td>Macrotool type</td><td>400 unknown macrotool
410 unifacial knife
420 adze/axe/chisel
421 small knife/adze
422 heavily reduced adze/axe
430 small wedge
440 pick</td></tr>
<tr><td>Biface type</td><td>200 unknown fragment
211 point fragment
212 stemmed point
213 shouldered point
214 concave point
215 convex point
216 straight base point
217 shouldered point
220 unknown knife
221 knife fragment
222 knife – blade
223 knife – leaf-shaped
224 knife – lunate
225 knife – pillow
226 knife - spatulate
230 spear point/knife (large, triangular point)
240 adze/axe
241 small adze/axe
260 large biface
261 semi-lunar</td><td>Pottery finish</td><td>1 none/slipped
2 net
3 paddle
4 stamped
5 moulded
6 painted
7 glazed
8 incised
9 textile
10 brushed/smoothed
11 combed
12 corded
13 punctate
20 other</td></tr>
</table>

APPENDIX D – ASSEMBLAGE CHARACTERISTICS

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
EAST GOBI						
Shara KataWell Shara Murun River	Oasis 1	11-100	4	Cooking Manufacturing Lithic Reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: S, W % microblade: 100	Residential B
3 Shara Murun River	Oasis 1	101-1000	1	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, K, CT % microblade: 0	Task site
6D Shara Murun River	Oasis 1	11-100	4	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, W, CT % microblade: 36	Task site
7 Shara Murun River	Oasis 3	101-1000	4	Cooking Manufacturing Weaponry Ornaments Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: A Generalized: S % microblade: 92	Residential B
9 Shara Murun River	Unknown	< 10	4	Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: no % microblade:100	Task site
9B Shara Murun River	Palaeo.	< 10	5	Manufacturing	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S No cores	Task site
9C Shara Murun River	Oasis 2 or Oasis 3	11-100	2	Manufacturing	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S No cores	Task site

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
EAST GOBI						
9D Shara Murun River	Oasis 2 or Oasis 3	< 10	5	Weaponry Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: A Generalized: S No cores	Task site
10A Southwest	Oasis 2 or Oasis 3	11-100	4	Manufacturing Weaponry Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: A Generalized: S, W % microblade: 80	Task site
11/11A Southwest	Oasis 3	101-1000	1	Cooking Manufacturing Weaponry Ornaments? Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: A Generalized: S, K, B, CT, W % microblade: 42	Residential A
12 Southwest	Oasis 2	11-100	2	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, W % microblade: 60	Task site
12/12A/12B Southwest	Palaeo., Epipalaeo., Oasis 2	11-100	4	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, W, CT % microblade: 32	Task site
13 Southwest	Late Oasis 2?	11-100	4	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, CT % microblade: 0	Task site
13A Southwest	Oasis 2 or Oasis 3	101-1000	4	Manufacturing Weaponry Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: A Generalized: S, W % microblade: 38	Task site

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
EAST GOBI						
14 Southwest	Oasis 1	101-1000	4	Manufacturing Lithic reduction Bone	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, W % microblade: 100	Task site
15 Southwest	Oasis 2	101-1000	4	Manufacturing Weaponry Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: A Generalized: K, B, W, CT % microblade: 9	Residential B
19 Shara Murun River	Oasis 2, Oasis 3	1001-5000	1	Cooking Manufacturing Woodworking Weaponry Ornaments Lithic reduction	Pottery: yes Grinding: F/I, Sm-L Adze/Axe: both Specialized: A, P, D Generalized: S, K, B, W, CT % microblade: 67	Residential A
20 Shara Murun River	Oasis 2 and/or 3	11-100	1	Cooking Manufacturing Weaponry Lithic reduction	Pottery: yes Grinding: I, Sm Adze/Axe: no Specialized: A, D Generalized: S, K, W % microblade: 50	Residential B
20A Shara Murun River	Various	11-100	1	Cooking Manufacturing Weaponry Lithic reduction	Pottery: no Grinding: I, Small Adze/Axe: no Specialized: A Generalized: S, K % microblade: 100	Residential B
21 Shara Murun River	Early Oasis 2	101-1000	1	Cooking Manufacturing Woodworking Weaponry Ornaments Lithic reduction	Pottery: no Grinding: Small Adze/Axe: chipped Specialized: A Generalized: S, K, B, W % microblade: 53	Residential A
23/23A Shara Murun River	Oasis 3	101-1000	4	Cooking Manufacturing Weaponry Lithic reduction	Pottery: yes Grinding: I, S-M Adze/Axe: no Specialized: A Generalized: S, W, CT % microblade: 52	Residential A

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
EAST GOBI						
28 Great Lake Basin	Oasis 3	101-1000	1	Cooking Manufacturing Woodworking Weaponry Ornaments Lithic reduction	Pottery: yes Grinding: F/I, S-M Adze/Axe: both Specialized: A Generalized: S, B, CT % microblade: 12	Residential A
29 Great Lake Basin	Late Oasis 2 or early Oasis 3	101-1000	5	Cooking Manufacturing Woodworking Lithic reduction	Pottery: no Grinding: F, S-M Adze/Axe: ground Specialized: D Generalized: S, K, B, W, CT % microblade: 46	Residential A
30/30A Great Lake Basin	Late Oasis 3	101-1000	2	Cooking Manufacturing Woodworking Lithic reduction	Pottery: no Grinding: I, L Adze/Axe: chipped Specialized: N/A Generalized: S, W % microblade: 45	Residential B
31 Great Lake Basin	Late Oasis 2 or early Oasis 3	1001-5000	1	Cooking Manufacturing Weaponry Ornaments Lithic reduction Bone	Pottery: no Grinding: F/I, S-M Adze/Axe: both Specialized: A, D Generalized: S, K, B, W, CT % microblade: 55	Residential A
34 Great Lake Basin	Oasis 3?	101-1000	4	Lithic reduction (includes 1 biface blank)	Pottery: no Grinding: no Adze/Axe: no Specialized: N/A Generalized: no % microblade: 0	Task site
36 Great Lake Basin	Oasis 1	11-100	1	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, W, CT % microblade: 20	Task site

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
GOBI-ALTAI						
Cemetery Mesa (CM) Shabarakh-usu Region	Epipalaeo., Oasis 3	11-100	4	Manufacturing Lithic reduction Camel effigy Burial monuments	Pottery: no Grinding: whetstone Adze/Axe: no Specialized: no Generalized: S % microblade: 0	Task site
Gashuin Bologai Well (GBW) Arts Bogd – Ulan Nor	Early Oasis 2	< 10	2	Cooking Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: W % microblade: 100	Task site
Barongi Usu Valley (BUV) Arts Bogd – Ulan Nor Region	Oasis 1?	11-100	1	Manufacture Weaponry (or knife?) Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: N/A Generalized: S, B, W, CT % microblade: 14	Residential B
Dubshi Hills (DH) Arts Bogd – Ulan Nor Region	Palaeo.	11-100	2	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S % microblade: 0	Task site
Ulan Nor Plain (UNP) Arts Bogd – Ulan Nor Region	Oasis 2	101-1000	1	Cooking Manufacture Weaponry Lithic reduction	Pottery: yes Grinding: F, Med. Adze/Axe: no Specialized: A Generalized: S, K, B, W, CT % microblade: 26	Residential A
Jichirun Wells (JW) Arts Bogd – Ulan Nor Region	Early Oasis 2	101-1000	1	Manufacture Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, K, B, CT % microblade: 12	Residential B
Jichirun Wells, in situ Arts Bogd – Ulan Nor Region	Late Oasis 2	101-1000	1	Manufacture Weaponry Lithic reduction Bone	Pottery: no Grinding: no Adze/Axe: no Specialized: A Generalized: S, B % microblade: 0	Task site

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
GOBI-ALTAI						
Sairim Gashoto (SG) Arts Bogd – Ulan Nor Region	Epipalaeo.	11-100	5	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, B % microblade: 0	Task site
Arts Bogd (AB) Arts Bogd – Ulan Nor Region	Oasis 2	11-100	4	Manufacturing Weaponry Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: A Generalized: S % microblade: 25	Task site
Khunkhur Ola (KhO) Arts Bogd – Ulan Nor Region	Metal Ages?	11-100	4	Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S % microblade: 0	Task site
Barun Daban (BD) Arts Bogd – Ulan Nor Region	Oasis 2 and Oasis 3	101-1000	1	Cooking Manufacturing Woodworking Weaponry Lithic reduction Bone	Pottery: yes Grinding: no Adze/Axe: ground Specialized: A Generalized: S, W % microblade: 85	Residential B
Orok Nor (ON) Valley of the Lakes Region	Oasis 2 and Oasis 3	101-1000	1	Cooking Manufacturing Weaponry Ornamentation Lithic reduction Bone	Pottery: yes Grinding: F, Med. Adze/Axe: no Specialized: A, P, D? Generalized: S, W, CT % microblade: 90	Residential A
Salt Creek (SC) Shabarakh-usu Region	Oasis 3	11-100	2	Manufacturing Lithic reduction	Pottery: no Grinding: I? Adze/Axe: no Specialized: no Generalized: S, W % microblade: 57	Task site
Shabarakh-usu, Oasis 2 Shabarakh-usu Region	Oasis 2	5000+	1	Cooking Manufacture Weaponry Ornamentation Lithic reduction Bone	Pottery: yes Grinding: I/F, Small Adze/Axe: N/A Specialized: A, P, G Generalized: S, K?, B, W, CT % microblade: 1a = 32, 8 = 71, 11 = 18	Residential A

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
GOBI-ALTAI						
Shabarakh-usu, Oasis 3 Shabarakh-usu Region	Oasis 3	5000+	1	Cooking Manufacturing Woodworking Weaponry Ornaments Lithic reduction Bone	Pottery: yes Grinding: I, Med. Adze/Axe: both Specialized: A, P, D, G Generalized: S, K, B, W, CT % microblade: 1 = 67, 2 = 34, 4 = 89, 7 = 25, 10 = 100	Residential A
S-u 2a Shabarakh-usu Region	Epipalaeo. or Oasis 1	11-100	1	Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: no % microblade: 0	Task site
S-u 2b Shabarakh-usu Region	Oasis 1	11-100	1	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: P? Generalized: CT % microblade: 33	Task site
ALASHAN GOBI						
176 Eastern Alashan	Oasis 3	101-1000	1	Cooking Manufacturing Woodworking Lithic reduction	Pottery: yes Grinding: no Adze/Axe: ground Specialized: no Generalized: S, W % microblade: 87	Residential B
179 Eastern Alashan	Oasis 3	11-100	1	Cooking Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: S, CT % microblade: 66	Task site
183 Eastern Alashan	Oasis 3	11-100	1	Cooking Manufacturing Woodworking Lithic reduction	Pottery: yes Grinding: no Adze/Axe: ground Specialized: no Generalized: no % microblade: 100	Residential B
186 Eastern Alashan	Oasis 2?	11-100	1	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S % microblade: 100	Task site

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
ALASHAN GOBI						
188 Eastern Alashan	Unknown	< 10	3	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S % microblade: 0	Task site
202 Galbain Gobi	Epipalaeol. ?	11-100	3	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, K, B, CT % microblade: 0	Residential B
203 Galbain Gobi	Oasis 3	11-100	3	Cooking Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: W % microblade: 75	Task site
204 Galbain Gobi	Epipalaeo.	< 10	3	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, CT % microblade: 0	Task site
207 Galbain Gobi	Oasis 3	101-1000	1	Cooking Manufacturing Woodworking Lithic reduction	Pottery: yes Grinding: no Adze/Axe: chipped Specialized: P Generalized: S, B, W, CT % microblade: 76	Residential A
208 Galbain Gobi	Oasis 3	11-100	1	Cooking Manufacturing Woodworking Lithic reduction	Pottery: yes Grinding: no Adze/Axe: ground Specialized: no Generalized: B, W % microblade: 100	Residential B
212 Galbain Gobi	Oasis 2 and Oasis 3	101-1000	1	Cooking Manufacturing Woodworking Ornaments Lithic reduction	Pottery: yes Grinding: F, Small Adze/Axe: both Specialized: D, Aw? Generalized: S, K, B, W, CT % microblade: 78	Residential A

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
ALASHAN GOBI						
213 Galbain Gobi	Oasis 2	11-100	1	Manufacturing Woodworking Lithic reduction	Pottery: no Grinding: no Adze/Axe: ground Specialized: no Generalized: S % microblade: 75	Task site
216 Ukh-tokhoi/ Khara Dzag	Oasis 3	11-100	3	Manufacturing Weaponry Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: A Generalized: S % microblade: 100	Task site
218 Ukh-tokhoi/ Khara Dzag	Oasis 3	101-1000	4	Cooking Manufacturing Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: P, Aw? Generalized: S, K? % microblade: 88	Residential A
219 Ukh-tokhoi/ Khara Dzag	Palaeo.	< 10	5	Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S No cores	Task site
220 Ukh-tokhoi/ Khara Dzag	Oasis 2	11-100	4	Manufacturing Woodworking Lithic reduction	Pottery: no Grinding: no Adze/Axe: chipped Specialized: no Generalized: K, B % microblade: 25	Task site (workshop)
222 Ukh-tokhoi/ Khara Dzag	Oasis 3	11-100	5	Cooking Manufacturing Weaponry? (or knife) Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: N/A Generalized: S, K?, B, W % microblade: 50	Residential B
223 Ukh-tokhoi/ Khara Dzag	Late Oasis 2 or early Oasis 3	101-1000	5	Cooking Manufacturing Woodworking Weaponry Lithic reduction	Pottery: yes Grinding: no Adze/Axe: chipped Specialized: D, Sp Generalized: S, K, W % microblade: 74	Residential A

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
ALASHAN GOBI						
226 Ukh-tokhoi/ Khara Dzag	Oasis 1	11-100	2	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: W % microblade: 100	Task site
229 Ukh-tokhoi/ Khara Dzag	Unknown	< 10	1	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: CT % microblade: 0	Task site
230 Ukh-tokhoi/ Khara Dzag	Oasis 3	11-100	5	Cooking Manufacturing Ornaments Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: G Generalized: S No cores	Task site (bead-making)
231 Ukh-tokhoi/ Khara Dzag	Oasis 2	101-1000	4	Manufacturing Woodworking Lithic reduction	Pottery: no Grinding: no Adze/Axe: chipped Specialized: D Generalized: S, K, B, W, CT % microblade: 42	Residential A
237 Ukh-tokhoi/ Khara Dzag		11-100		Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S, K, B, CT % microblade: 0	Residential B
247 Goitso Valley	Oasis 2	101-1000	1	Manufacturing Woodworking Lithic reduction	Pottery: no Grinding: no Adze/Axe: chipped Specialized: D, Aw Generalized: S, K, B % microblade: 67	Residential B
248 Goitso Valley	Metal Ages	11-100	1	Cooking Smelting Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: S % microblade: 100	Residential B

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
ALASHAN GOBI						
251 Juyanze	Unknown	< 10	3	Manufacturing (1 scraper)	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: S No cores	Task site
258 Juyanze	Oasis 2 or 3	< 10	1	Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: no % microblade:100	Task site
259 Juyanze	Oasis 2?	1001 - 5000	1	Manufacturing Woodworking Hoes? Lithic reduction	Pottery: no Grinding: no Adze/Axe: both Specialized: P, Aw Generalized: S, K, B, W, CT % microblade: 62	Residential A
277 Gurnai Depression	Oasis 3?	11-100	1	Cooking Manufacturing Smelting Ornaments Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: S No cores	Residential B
287 Gurnai Depression	Oasis 3?	101-1000	1	Cooking Manufacturing Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: S, K % microblade: 100	Residential B
290 Gurnai Depression	Oasis 3	101-1000	1	Cooking Manufacturing Ornaments Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: P Generalized: S, K, W % microblade: 100	Residential B
293 Gurnai Depression	Oasis 3	101-1000	1	Cooking Manufacturing Weaponry Ornaments Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: A, P, D Generalized: S, K, CT % microblade: 80	Residential B

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
ALASHAN GOBI						
294 Gurnai Depression	Oasis 3	11-100	1	Cooking Manufacturing Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: S % microblade: 100	Task site (related to 293?)
298 Gurnai Depression	Oasis 3	101-1000	1	Cooking Manufacturing Ornaments Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: P, D Generalized: S % microblade: 83	Residential B
303 Gurnai Depression	Oasis 3	11-100	1	Manufacturing Ornaments (?) Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: P Generalized: S No cores	Task site
307 Gurnai Depression	Oasis 3?	11-100	1	Cooking Manufacturing Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: S, W % microblade: 100	Task site
311 Gurnai Depression	Oasis 3	11-100	1	Manufacturing Ornaments (?) Lithic reduction	Pottery: yes Grinding: no Adze/Axe: no Specialized: no Generalized: S % microblade: 100	Task site
316 Gurnai Depression	Oasis 3	< 10	1	Lithic reduction (1 core)	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: no % microblade: 100	Task site
321 Black Gobi	Early Oasis 2	101-1000	3	Manufacturing Woodworking Lithic reduction	Pottery: no Grinding: no Adze/Axe: chipped Specialized: P Generalized: S, K, W % microblade: 60	Residential A

SITE	PERIOD	SITE SIZE	ECO-ZONE	ARTEFACT CATEGORIES	ARTEFACT TYPES	SITE TYPE
ALASHAN GOBI						
322 Black Gobi	Palaeo.	< 10	3	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: CT % microblade: 0	Task site
323 Black Gobi	Epipalaeo.	11-100	5	Manufacturing Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: D Generalized: S, Bl, CT % microblade: 50	Residential B
324 Black Gobi	Unknown	< 10	5	Lithic reduction	Pottery: no Grinding: no Adze/Axe: no Specialized: no Generalized: W % microblade: 100	Task site

*Grinding: I = informal, F = formal, S = small, M = medium, L = large. Specialized and generalized tools: A = arrowpoint, D = drill, Aw = awl, P = perforator, G = grooved slab, S = scraper, K = knife, B = large biface, Bl = blade tool, CT = core tool, W = wedge-shaped microcore.

APPENDIX E - SUMMARY OF MEANS AND FREQUENCIES

SITE	CORE VOLUME (CM^3) AND CV	CORE PLATFORM (CM^2)	REMNANT CORE CORTEX	REMNANT SCRAPER CORTEX	MEAN t/T	CORE REDUCTION TYPE
East Gobi* means	188.2 1.32	43.4	29% none 36% > 25%	58% none 12% > 25%	0.50	46% F 54% I
SKW	117.5 0.27	47.5	low	low	0.50	100% F
3	1,360.8 N = 1	216.0			0.00	100% F
6D	103.5 0.80	34.1		low	0.52	36% F 64% I
7	62.6 0.74	22.8	low	low	0.48	91% F 8% I
9	77.3 N = 1	27.6		N/A	N/A	100% F
9B	N/A	N/A	N/A	high	0.64	N/A
9C	N/A	N/A	N/A	low	0.42	N/A
9D	N/A	N/A	N/A	50% 50%	0.73	N/A
10/10A/10B	165.3 1.25	40.7		low	0.62	80% F 20% I
11/11A	186.2 0.92	49.6		low	0.46	43% F 57% I
12	104.5 0.74	45.0		low	0.59	71% F 28% I
12A	159.0 0.60	48.4		N/A	N/A	100% I
12B	290.6 0.79	84.4		N/A	N/A	100% I
12/12A/12B	127.3 1.32	34.1		low	0.16	41% F 58% I
13	326.6 1.08	67.3	low	low	0.40	40% F 60% I
13A	242.8 2.06	47.3		low	0.59	38% F 62% I
14	79.8 0.37	26.1	low	low	0.21	100% F
15	93.3 0.74	29.6			0.37	45% F 54% I
19	155.3 1.27	41.6		low	0.61	74% F 25% I
20	82.0 0.93	30.3		low	0.55	70% F 30% I
20A	42.6 0.14	21.0			0.00	100% F

SITE	CORE VOLUME (CM^3) AND CV	CORE PLATFORM (CM^2)	REMNANT CORE CORTEX	REMNANT SCRAPER CORTEX	MEAN t/T	CORE REDUCTION TYPE
East Gobi* means	188.2 1.32	43.4	29% none 36% > 25%	58% none 12% > 25%	0.50	46% F 54% I
21	109.5 0.97	33.3	low 47% none	low	0.61	60% F 40% I
23/23A	96.4 0.78	30.7	high 44% > 25%	low	0.46	52% F 43% I 4% other
28	494.2 0.86	92.6	high		0.53	22% F 78% I
29	141.2 1.30	36.8			0.55	50% F 50% I
30/30A	119.3 0.55	37.8	high 49% > 25%	low	0.58	45% F 54% I
31	152.9 1.08	38.2		low	0.50	54% F 45% I
34	262.8 0.82	63.0	high		N/A	100% I
36	511.1 0.98	75.6			0.75	20% F 80% I
Gobi-Altai means	327.3 0.96	68.0	21% none 46% > 25%	51%none 16% > 25%	0.54	50% F 50% I
C. M.	952.8 1.23	113.6	high	low	0.48	100% I
G. B. W.	88.2 N/A	24.8		N/A	N/A	100% F
B.U.V.	266.4 0.67	61.6	high	high	0.10	29% F 71% I
D. H.	338.4 N/A	72.0	high	high	0.0	100% I
Ulan Nor Plain	408.5 0.76	81.5	high		0.36	48% F 52% I
J. W. surface	442.3 0.66	86.5		high	0.47	17% F 83% I
J. W. in situ	270.0 0.69	58.5		high	0.0	20% F 80% I
Sairim Gashato	385.1 0.42	85.3			0.25	33% F 66% I
Arts Bogd	205.3 0.96	47.1		low	0.80	25% F 74% I
Kh. O.	155.2 0.36	40.5	high	high	0.55	100% I
Barun Daban	101.1 0.70	30.1	low	low	0.63	85% F 15% I
Orok Nor	122.6 1.62	34.0	low (48% none)	low	0.62	90% F 10% I
S. C.	382.4 1.15	79.6	low	low	0.37	57% F 43% I

SITE	CORE VOLUME (CM^3) AND CV	CORE PLATFORM (CM2)	REMNANT CORE CORTEX	REMNANT SCRAPER CORTEX	MEAN t/T	CORE REDUCTION TYPE
<u>Gobi-Altai means</u>	<u>327.3</u> <u>0.96</u>	<u>68.0</u>	<u>21% none</u> <u>46% >25%</u>	<u>51%none</u> <u>16% > 25%</u>	<u>0.54</u>	<u>50% F</u> <u>50% I</u>
S. U. 1	165.5 0.65	43.8	high	low	0.45	67% F 33% I
S. U. 1A	442.7 0.88	99.4			0.60	36% F 64% I
S. U. 2a in situ	498.7 0.03	95.9	low	N/A	N/A	100% I
S. U. 2b in situ	717.7 0.50	133.8		N/A	N/A	66% F 33% I
S. U. 7	141.0 0.76	40.4		low	0.53 (average)	42% F 58% I
S. U. 10	34.0 0.55	11.5	low	low	0.54 (average)	100% F
<u>Alashan Gobi means</u>	<u>179.1</u> <u>1.57</u>	<u>44.3</u>	<u>53% none</u> <u>21% > 25%</u>	<u>63% none</u> <u>20% > 25%</u>	<u>0.60</u>	<u>80% F</u> <u>20% I</u>
176	85.3 1.42	25.2	low	low	0.62 average	93% F 7% I
179	5.1 0.70	4.1	low	high	0.14 low N=1	100% F
183	35.9 0.65	15.4	low	N/A	N/A	100%F
186	23.6 0.62	7.6	low	low	0.54 low	100%F
188	352.3 0.46	91.5	50% none 50% 51-90%	low	0.25 low N=1	100% I
202	290.1 0.40	71.4	high	high	0.53 low	80% F 20% I
203	66.7 1.01	45.0	low	N/A	N/A	75% F 25%I
204	683.6 0.07	112.2	high	high	0.44 low	50% F 50% I
207	218.8 0.95	42.3		low	0.49 low	94% F 6 % I
208	130.0 1.20	28.8	low	N/A	N/A	100% F
212	91.2 0.98	28.6	low	low	0.62 average	90% F 9% I
213	187.0 1.02	48.6	low	low	0.84 high	100% F
216	154.8 0.46	30.3	low	low	0.48 low	100% F
218	67.9 1.86	26.9	low	low	0.56 low	87% F 8% I
219	N/A	N/A	N/A	low	0.18 (N = 1) low	N/A

SITE	CORE VOLUME (CM^3) AND CV	CORE PLATFORM (CM^2)	REMNANT CORE CORTEX	REMNANT SCRAPER CORTEX	MEAN t/T	CORE REDUCTION TYPE
Alashan Gobi means	179.1 1.57	44.3	53% none 21% > 25%	63% none 20% > 25%	0.60	80% F 20% I
220	606.1 0.30	129.4		N/A	N/A	75% F 25% I
222	443.8 1.05	79.7	low	low	0.61 average	100% F
223	171.8 0.57	54.5	low	low	0.59 average	74% F 22% I
226	226.4 0.65	53.5	low	N/A	N/A	100% F
229	387.1 N=1	75.9		N/A	N/A	100% I
230	N/A	N/A	N/A	low	0.32 low	N/A
231	362.3 1.09	79.1			0.59 average	82% F 18% I
237	1,852.5 0.30	227.1	high	low	0.39 low	75% F 25% I
247	37.2 0.62	14.9		low	0.42 low	100% F
248	14.1 1.22	10.0	low	low	0.39 low	100% F
251	N/A	N/A	N/A	high	0.33 low N=1	N/A
258	38.9 N/A	16.9	low	N/A	N/A	100% F
259	147.1 1.51	39.6	low	low	0.67 high	70% F 29% I
277	N/A	N/A	N/A	low	0.88 high	N/A
287	19.0 0.08	12.7	low	low	0.58 average	100% F
290	15.7 0.69	10.9	low	low	0.73 high	100% F
293	19.6 0.71	12.9	low	low	0.75 high	80% F 20% I
294	15.4 N=1	15.4	low	low	0.56 average	100% F
298	33.7 1.09	23.0	low	low	0.68 high	83% F 17% I
303	N/A	N/A	N/A	low	0.55 average	N/A
307	8.4 0.44	4.7	low	low	0.76 high	100% F
311	13.0 N=1	5.4	low	low	0.43 Low	100% F

SITE	CORE VOLUME (CM^3) AND CV	CORE PLATFORM (CM^2)	REMNANT CORE CORTEX	REMNANT SCRAPER CORTEX	MEAN t/T	CORE REDUCTION TYPE
Alashan Gobi means	179.1 1.57	44.3	53% none 21% > 25%	63% none 20% > 25%	0.60	80% F 20% I
316	15.8 N=1	8.8	low	N/A	N/A	100% F
321	130.5 0.54	39.4		low	0.99 high	72% F 28% I
322	161.7 0.24	50.3	high	high	0.36 low	50% F 50% I
323	96.1 1.25	25.5	low	low	0.41 low	100% F

*Due to the relatively high number of artefacts from Baron Shabaka Well (over 500 each of cores and scrapers), the site was excluded from calculation of regional mean.

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