SHABARAKH-USU AND THE DUNE DWELLERS OF THE GOBI: EXPLANATIONS FOR LITHIC ASSEMBLAGE VARIABILITY IN THE GOBI DESERT, MONGOLIA

by

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STATEMENT BY AUTHOR

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ABSTRACT

Early post-glacial archaeological assemblages in the Gobi Desert of Mongolia have been identified by the presence of microlithic tools and are seen as chronologically separate from the later “Neolithic” assemblages, which are defined by the presence of artifacts such as pottery, grinding stones, bifaces, and adze/axes. Although chronometric dates are currently unavailable, differences in the distribution of these artifacts indicates that their presence or absence is not necessarily dependent on a single cross-regional chronology. While technological complexes in the dune-playa regions appear to have undergone a transition in tool kits that incorporated Neolithic technologies, microlithic technologies in the desert-steppes and foothills of the adjacent Gobi-Altai range continued to be used without the addition of those elements. Differing exploitation strategies of separate ecological zones is the most likely explanation for this inter-regional variation, but a current lack of knowledge about the nature of technological change in either region complicates our understanding of how these environments were used. By focusing upon one series of artifact assemblages, those from the dune-playa Shabarakh-usu site in the South Gobi province, it is possible to use inter-assemblage variation in raw material use and artifact types to suggest explanations for this suite of differential adaptations and gain a better understanding of what aspects of variation are related to chronological change rather than site function.

INTRODUCTION

Corresponding to rapid changes in climate following the end of the Last Glacial Maximum (LGM), there was such a worldwide florescence of technological innovation, that Holocene warming trends, following the rapid climate change that occurred during the terminal Pleistocene, are often thought to have driven humans along a trajectory of adaptation and innovation that, for many cultures, resulted in agriculture and modern human civilization (Burroughs 2005; Brooks 2006; Fagan 2004; Liu 1996; Richerson et al. 2001). At the Shabarakh-usu site (Figure 1.1, 1.2), in the Ömnögov' aimag (South Gobi province) of Mongolia, hunter-gatherers adopted broad-spectrum foraging strategies that appear to have utilized both playa and steppe resources. Despite the lack of chronometric dates for this series of occupations, traces of technologies typical of Neolithic communities in North China suggest that this post-glacial foraging economy was contemporaneous with early Neolithic villages in the Chinese Central Plains (Cohen 2003; Cybiktarov 2002; Elston et al. 1997; Fairservis 1993; Linduff et al. 2002/2004; Madsen et al. 1996; Shelach 2000).

Although the use of the term "Neolithic" tends to have connotations of food production and village life in much of Europe and Asia, in the Soviet archaeological literature of Northeast Asia it refers primarily to a stage of cultural development that is generally associated with the first appearance of pottery (Chard 1974). This is especially true in regions like Japan and Siberia, where the florescence of Neolithic technologies – including pottery, grinding stones and adze/axes – was not necessarily contemporaneous with an economic transition to food production (Kuzmin 2003). An marked increase in dependence upon Neolithic technologies is more commonly related to the beginnings of food production and the adoption of millet agriculture in north and northeastern China by around 8,000-7,000 BP exemplifies this pattern (Cohen 2003). This situation, related to the adoption of agriculture, is quite different from that evidenced among archaeological habitations in more northern regions (see Figure 1.1). Here, frequencies of Neolithic artifact types remain low and spatially restricted (Cybiktarov 2002). In the Gobi Desert, early Holocene complexes that contain Neolithic technologies, like the Shabarakh-usu collections, are only found around playas and in dune formations.

In the adjacent desert-steppes and foothills of the Gobi-Altai mountains, these Neolithic technologies are largely absent. Since it is unlikely that this whole region was uninhabited while foragers focused exclusively on small playas, the presence or absence of Neolithic technologies is certainly related to patterns of land-use, as well as chronology. The presence or absence of certain artifacts, even in the South Gobi province where dune-playa formations are more common, may be related as much to site function and seasonality as to relative age. On a larger scale, just as the dune-playa habitations can not be said to necessarily predate the more technologically "advanced" Neolithic communities on the Central Plains, the Neolithic technologies in the dune-playa region are not necessarily of a later date than aceramic assemblages in the Gobi-Altai region, or on the steppes around playas and dune formations. Considering the unique ecology of dune-playa zones in relation to the desert-steppes and foothills (Nicholas 1998), it is likely that a different set of technological adaptations were required to properly exploit the range of highly localized plant and animal resources that existed at the playa margins.

Since Neolithic technologies were incorporated into an existing tool kit used in the dune-playa regions, it is probable that the ecological variability existing between desert-steppes and dune-playa zones influenced how far such technologies spread. In the same way, the adoption of Neolithic technologies at a regional scale may be related to shifts in the local environments. Dune-playa sites are then significant because they offer a noticeable shift in land-use strategies that is not as apparent in more chronologically uniform technological suites. Excavations of dune-playa sites are particularly rewarding because they retain a higher level of stratigraphic integrity than the deflated surface of the desert-steppes where collections are composed exclusively of surface scatters, many containing a mixture of artifacts straddling both the Pleistocene and Holocene periods. Although the stratigraphy of dune-playa sites has not been carefully studied, inter-assemblage variability at sites like Shabarakh-usu are seen as resulting from occupations from several distinct ages (Cybiktarov 2002; Derevianko and Dorj 1992; Fairservis 1993; Maringer 1963; Nelson 1925). Through a more careful study of these assemblages, particularly the examination of possible chronological differences, a better understanding of the factors contributing to technological change is possible.

Despite the importance of these assemblages, the lack of published data (but see Berkey and Nelson 1926; Fairservis 1993; Gábori 1962, 1963b; Okladnikov 1962; Spock 1934) detracts from our understanding of how inter-assemblage variation. In 1993, Fairservis published a largely descriptive volume on all archaeological sites investigated during the Central Asiatic Expeditions in Mongolia. Regardless, no interpretative analyses of the artifacts from Nelson's sites have been published since Spock's 1934 petrological analysis.

Thus, in combination with a study of paleoenvironment and a consideration of material remains from neighboring regions, it is necessary to conduct an in-depth study of the artifacts themselves. The immediate goal of this endeavor is to provide data by which to better understand variation among sites, whether that variation is due to chronology or site function. Since chronometric dates and detailed information on the stratigraphic relationship between site assemblages is unavailable, a wholly chronological relationship can not be assumed. The assumption of such a relationship also detracts from our understanding of variation in site function, without which it is impossible to understand ecological adaptations. Though not mutually exclusive, other explanations for variation in assemblages include: spatial differences in activity areas, differences in seasonal exploitation, or the use of the same region by more than one cultural group.

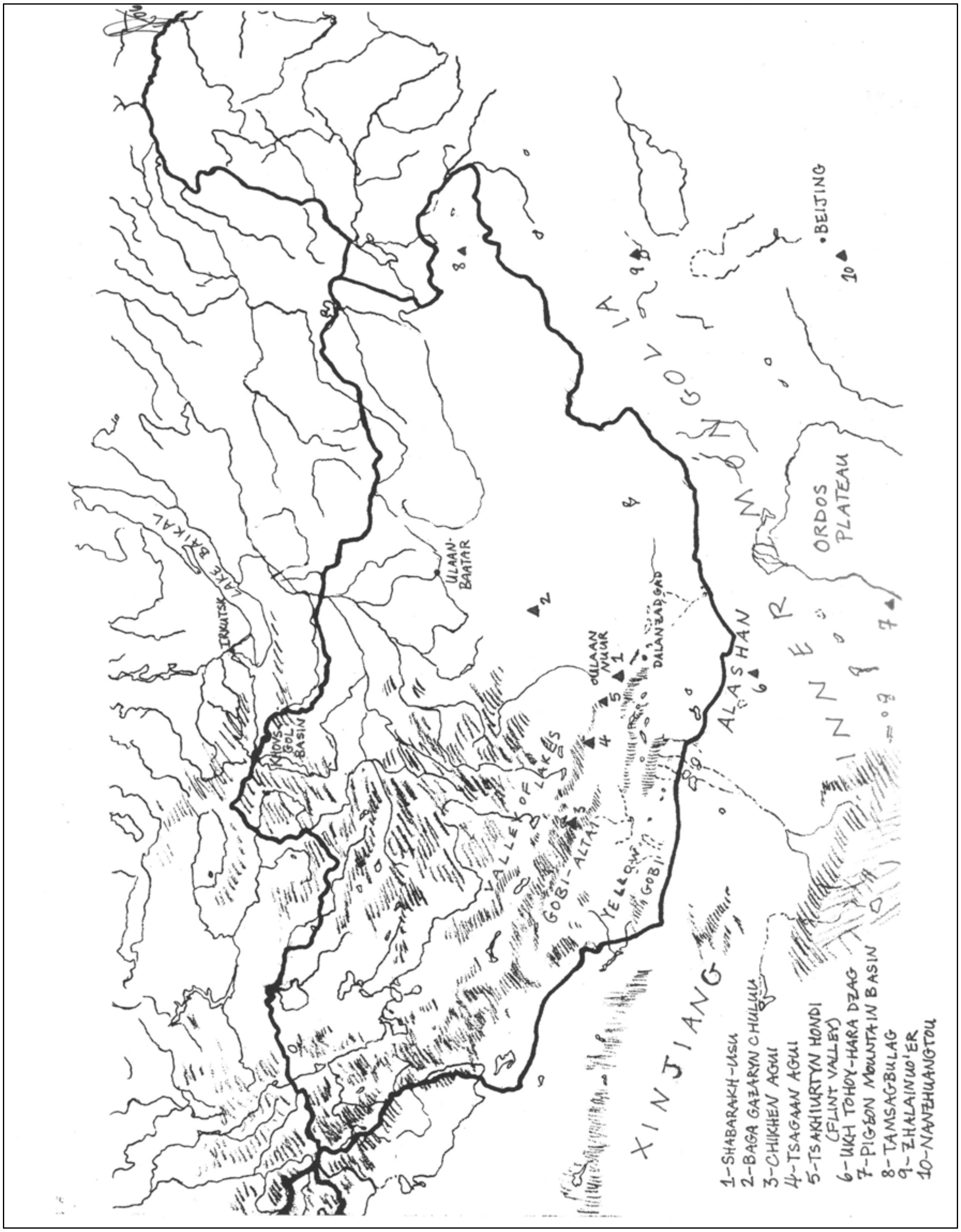

Figure 1.1: Map of Mongolia, North China and southeastern Siberia. Sites and regions mentioned in the text are marked, along with major cities.

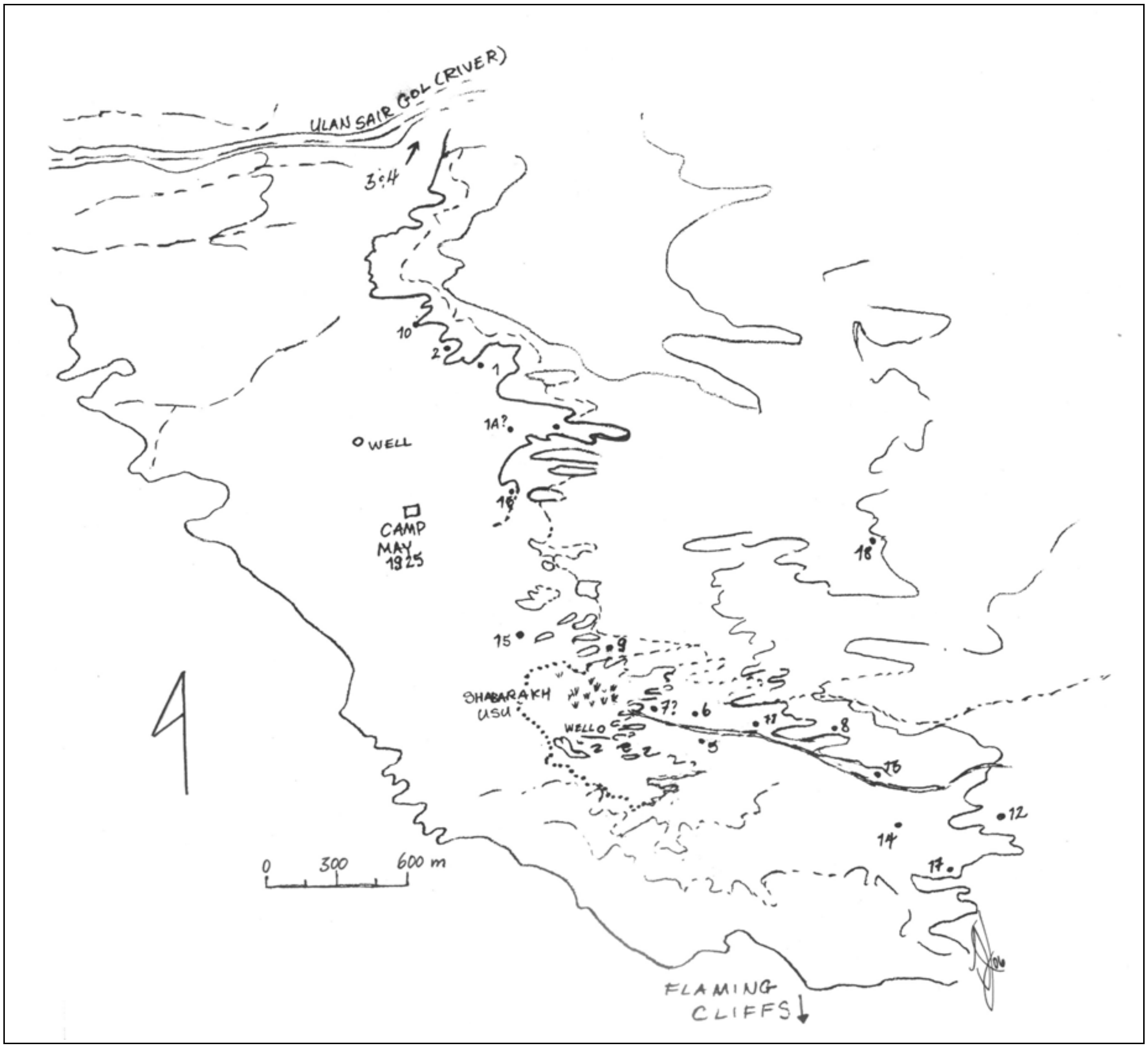

Figure 1.2: Illustration of Bayan-dzak as it was in 1925, indicating locations where each site assemblage was found. The solid line represents inactive dunes, the dotted lines active dunes, and the stippled line represents the low point of the basin, which may have been filled with water at one time. The extent of the current marsh is also indicated. Reconstructed from redrawn map in Fairservis 1993, and personal observation (June 2005).

PALEOENVIRONMENT AND LAND-USE

Landscape and paleoenvironment of Bayan-dzak

Throughout the twentieth century, the popular image of the Gobi was that of camels trailing along the ridges of shifting sand dunes, their silhouettes black against the setting sun. In actuality, unvegetated dune fields are rare even today, a period of increasing aridity. The Gobi Desert region includes various types of arid steppe environments, including grasslands capable of supporting herds of wild and domestic ungulates, largely barren plains devoid of topsoil and supporting mostly small mammals and birds of prey, and vegetated dune fields. Under more humid climatic regimes, even the more arid regions would have supported a greater diversity of wildlife, making these environments capable of sustaining greater numbers of hunter-gatherers.

Bayan-dzak is an example of a vegetated dune field, now largely isolated by long stretches of gobi-steppe (*gobi* is a Mongolian word meaning “desert”, but refers to heavily deflated plains covered in pebble lag deposits), but once fed by a river and located next to a small playa. Surrounded by plains stretching 8.5 km x 3.2 km at the longest and widest points, the landscape in this basin is typical of the basin-range environments that dominate southern Mongolia and northern China. The vegetated dunes at Bayan-dzak are stabilized by saxual or *dzak* (*Haloxylon ammodendron – bayan dzak* means “rich in dzak” or “abundant dzak”) shrub and other low, desert vegetation. On the southwestern corner lies the remains of a small playa, marked by ancient beach shore lines on the western edge, where the vast plain of gobi-steppe begins and stretches north to the Ulaan Nuur playa and east to Dalanzadgad, the provincial capital.

A few kilometers to the west, a high plateau rises above the plain and provides more suitable pasturage for the few horses that are kept by local herders. A dry, but well-defined, river bed trails across the plateau and down into the dune formations at their northern extent. The bright-red clay walls of the Flaming Cliffs are a part of this plateau which wraps around the southern edge of the plain, intersecting the foothill ranges of the Gobi-Altai mountains, 40-60 km to the west and south. Bayan-dzak represents a low point in the landscape that would have collected drainage from the surrounding mountain ranges during times of heightened humidity, resulting in the formation of well-watered, and thus heavily vegetated sand dune accumulations.

In modern times, the plains around Bayan-dzak are extremely sparse and the small playa is filled only shallowly with turbid water during particularly wet spring seasons (hence the appellation "Shabarakh-usu", meaning "muddy water"). Prehistorically, the present playa feature was probably a pond or small lake, an idea that is supported by the presence of what appear to be ancient beach ridges on the western parameter. Most of the sites investigated by Nelson were located along the northern and eastern parameters of this feature, and along the ravine-like stream bed that runs across the southern end of the dunes and drains into the playa (Figure 1.2; see site descriptions in Appendix A).

Under a regime of increased seasonal drainage and/or precipitation, open grasslands and thicker dune vegetation probably existed at the lowest point of this basin. At the playa margins, wetland habitats may have formed, providing an ideal refuge for numerous bird species (for a list of modern local species see Flint et al. 1984), small mammals (including lagomorphs, insectivores, small canids and variety of rodents) and reptiles (see Allen 1938 for species lists). An increase in effective moisture would also have allowed for a both greater wealth of vegetal resources, including seed-bearing grasses, tubers, leafy vegetables and herbs (Jigjidsuren and Johnson 2003), followed by a range of exploitable ungulate species on the vegetated plains. Even in the early part of the 20th century, the region's desert steppe supported sizable herds of gazelle (including both *Procapra gutturosa* and *Gazella subgutturosa*), *Equus hemionus* (wild ass), and *Equus przewalski* (wild horse) (Allen 1938).

As evidenced by the presence of ostrich eggshells among site assemblages at Bayan-dzak, it is also possible that ostrich eggs provided a rich food resource for foragers. Chronometric dates on these artifacts would be of great use since sensitivity of these animals to specific levels of rainfall and aridity (Manlius 2001; Wendorf et al. 1977) could clarify our understanding of contemporaneous climatic regimes. Bones have not been found, but eggshell from the site of Chikhen Agui in the Bayankhongor province has been dated to about 8,000 BP (Derevianko et al. 2003).

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Large-scale climate change and Mongolian wetlands

The exact nature and specific times of more amiable climates in the Gobi Desert are difficult to ascertain since few paleoenvironmental publications devoted specifically to climate change in southern Mongolia are available (Grunert et al. 2000; Komatsu et al. 2001; Lehmkuhl and Lang 2001). Much of the paleoenvironmental record must be inferred through data from Siberia, northern Mongolia, and China. Nevertheless, climate records from neighboring regions do allow a summary discussion of climate change in Northeast Asia over the past 40,000 years, revealing a series of shifts between warm/wet environments and cold/dry ones.

During the late Pleistocene, the climate in Northeast Asia fluctuated between periods of heightened humidity, during which established wetlands and lakes may have flourished in the Gobi Desert, and periods of extreme cold and aridity, culminating in the LGM, around 18,000 BP (Madsen et al. 1998; Pachur et al. 1995; Rhodes et al. 1996; Tarasov et al. 1999; Yu et al. 2000). Average winter temperatures during the LGM in southern Siberia were likely about 12° C lower than at present, with summer temperatures averaging 6° C cooler (Frenzel 1992). LGM pollen and macrofossil data from the Lake Baikal region suggest that vegetative zones in Mongolia and southern Siberia followed roughly similar patterns of dispersal as in modern times. Steppe environments do seem to have been more pervasive than they were previously, having advanced northward in response to increased aridity (Tarasov et al. 2000).

Conversely, a detailed stratigraphic study from Chikhen Agui, a cave site in the Gobi-Altai range, suggests that during the LGM water percolating through the sediments may not only have continued, along with depositional processes, but effectively increased. Paleoshoreline geomorphology studies support this record, indicating that lake levels in the region may have been higher during the LGM than they are at present (Komatsu et al. 2001). This suggests that the central Gobi Desert may not have undergone a process of aridification as intense as that suggested by proxy data from more northern paleolakes (Grunert et al. 2000; Harrison et al. 1996). It has been suggested that this retention of more humid conditions may have been due to suppressed evaporation resulting from lower year-round temperatures (Komatsu et al. 2001; Lemhkuhl 1998; Yu et al. 2000).

Following the retreat of the northern glaciers at the end of the LGM, lake levels in Baikal and the Khovsgol basin of northwestern Mongolia rose in accordance with associated climatic amelioration. Prokopenko et al.'s (2005) analysis of sedimentation changes in the Khovsgol basin reveal that increased humidity following the LGM resulted in the establishment of Khovsgol lake by no later than 15,400 cal BP. A slightly later date has been suggested for the large-scale ecological shifts that are reflected in pollen samples from the Lake Baikal region (Krigonogov et al. 2004). Increased humidity and warmth during this gradual amelioration would have led to the replacement of periglacial tundra and forest tundra vegetation as post-LGM forest environments resurged in the wake of glacial retreat.

Within a thousand years of this initial detection of climate change in the northern regions, Neolithic technological adaptations linked to the eventual adoption of agriculture were developed (Table 1.1). In the Russian Far East, Japan and South China, these technological developments were accompanied by evidence for the use of nuts, seeds, fish, shellfish, and/or small mammals (Cohen 2003; Keally et al. 2003; Kuzmin and

Shewkomud 2003; Wu and Zhao 2003). The relationship between climatic amelioration and a diversification of technology and subsistence strategies would suggest that intensification or broadening of diet breadth was a reaction to change in the availability of resources (Richerson et al. 2001).

With the exception of an intervening return to glacial conditions during the Younger Dryas, the next 8,000 years were characterized by an increasingly warmer and moister climatic regime (Madsen et al. 1998; Pachur et al. 1995; Rhodes et al. 1996; Tarasov et al. 1999; Wang et al. 2004). The Younger Dryas, lasting from about 12,500-11,500 BP, coincides with the first level of occupation at Zhalainuo'er (Djalai Nor), the only dated playa site in Inner Mongolia. If dates from Zhalainuo'er are representative of other playa occupations throughout Mongolia, it may be that the Younger Dryas episode encouraged foragers to focus seasonal subsistence efforts more intently upon these richer ecological zones, particularly if the surrounding plains were less productive.

Nicholas (1998) discusses the use of wetlands in terms of their distinct role in local environments. Playa margins in the Gobi Desert would have represented zones of relief from the dry, open grasslands that surrounded them. In general, wetlands of all kinds are comprised of a unique set of niches providing substantial diversity of flora and fauna, as well as an extremely high biomass. Salt marshes, for example, fall just above tropical rainforests and cultivated land in biozone productivity, closely followed by freshwater marshes. In addition, these ecozones contribute to the local landscape through water storage and purification (Nicholas 1998:721-723).

All of these qualities make wetlands indispensable to humans living in a semi-arid to arid environment. Still, if wetlands constituted an environment densely packed with low-risk, high-return resources, it seems unlikely that foragers would have needed much encouragement to make use of them. Notably, the Younger Dryas cold/dry episode has also been correlated with agricultural developments in the Middle East, where intensification upon one particular resource resulted from a decrease in alternative choices (Flannery 1969; Munro 2004). Considering the pattern of resource use in western Asia, it is possible that playa wetlands were a source of reliable resources that required intense extractive techniques, as evidenced by the presence of pottery and grinding stones.

The unique characteristics of wetlands suggest that this ecotone was an ideal one in which to employ an economy centered a broad range of resources from both the steppes and playas, with an additional focus on a range of extractive processes. Under what circumstances the use of additional extractive processes emerged in arid North China and Mongolia are still unknown. The desire to utilize low-risk, low-return foods like some vegetables, birds, fish and shellfish, may have been driven by a reduction in the availability of high-return foods, or an increase in risk. Aridification may have played an important role in the increased exploitation of playa margins by limiting the availability of high-return species on the open steppes. Alternately, an increase in the productivity of these wetlands and more corridors between oasis zones would also have made the year-round exploitation of a series of playa systems increasingly appealing. The risk of utilizing more distant resources may also have encouraged foragers to utilize high-investment resources to maintain the sustainability of multi-seasonal rounds in a localized environment. In fact, both types of strategies may have emerged at various points throughout the length human habitation in these regions.

What motivated the adoption of specific Neolithic style technologies may then be related to the climatic regime under which these technologies were developed or became available. Understanding this aspect of technological adaptations is complicated by our lack of knowledge about how long the occupation of these playa margins continued and under what environmental circumstances. Paleoshoreline geomorphology of lakes in central Mongolia, just north of the Gobi-Altai mountain range, indicates an increase in humidity during the early Holocene and around 8,000-7,000 BP country-wide lake expansion appears to have reached a climax (Harrison et al. 1996; Komatsu et al. 2001; Lehmkuhl and Lang 2001). Evidenced by increased dust deposition in the Guanzhong basin in Shaanxi province, North China between 6,000 and 5,000 BP, the Holocene Hypsithermal interrupted this lakeshore expansion and destabilized the evolution of new ecological niches (Huang et al. 2000; Wang et al. 2004). This event also coincides with a reduction of diatom production in Khovsgol Lake by 6,600 cal BP (Prokopenko et al. 2005).

In contrast with records from northern Mongolia and most regions of North China, pollen sequences from the Eastern Juyanze paleolake in the Alashan Plateau suggest that this period was one of heightened humidity in parts of the southern Gobi Desert directly adjacent to Shabarakh-usu. Here, pollen sequences indicate the comparatively late expansion of steppe vegetation and its eventual co-dominance with desert taxa by 5,400 BP (Herzschuh et al. 2004). This humid phase coincides with 6,000 BP, during which time the northern limit of the East Asian Summer Monsoon is proposed to have seen a significant northward shift, resulting in increased summer precipitation. At the same time, a weakening of the Siberian-Mongolian High, which brings cold, dry winter winds from the north, would have contributed to an increase in effective moisture (Winkler and Wang 1993).

Considering the two lines of evidence for humidification in the Gobi Desert, it may be that within the southernmost reaches, dune-playa environments were responding to shifts in monsoonal intensity that negatively affected regions of North China. This highly arid environment may not have undergone an the same increase in effective moisture that is evidenced in more northern regions, where post-glacial drainage may have contributed to the expansion of lake shores. If changes in adaptive strategies were influenced by northward migrating monsoons, ecologically motivated changes in foraging adaptations and technological innovations may have occurred as late as the mid-Holocene. By about 3,000 BP a country-wide lowering of lake levels (Harrison et al. 1996) might have brought an end to the playa adaptations witnessed at sites like Shabarakh-usu, allowing for the successful introduction of Bronze Age herding economies in some regions.

Although agriculture did not develop in the Gobi Desert, an improved understanding of the complexities surrounding environmentally-driven shifts in the use of available resources allow us to test established models of human adaptive mechanisms. Many of these models focus upon relationships between human adaptation and rapid climatic and ecological changes following the LGM (Burroughs 2005; Brooks 2006; Fagan 2004; Flannery 1969; Munro 2004; Richerson et al. 2001). Currently, adaptive trends in technological complexes can be recognized and compared to known climatic fluctuations and as additional chronometric dates and paleoenvironmental data become available, the understanding of adaptive mechanisms in this region can be further refined.

DEVELOPMENTS IN TECHNOLOGY AND SUBSISTENCE

After 15,000 BP the procurement of specific dietary resources among some groups in locales, such as the Middle East and Northeast Asia, appear to have undergone previously unprecedented levels of intensification. This pattern of subsistence was complemented in some regions by a sharp decline in mobility; the best studied of these cases being the Natufian in the west, and the Incipient Jomon in the east (Richerson et al. 2001). In North China, by between 12,000 and 10,700 BP, subsistence strategies like those evidenced at sites such as Nanzhuangtou, Hebei province (Underhill 1997; Shelach 2000) focused on the highly specialized and intensive exploitation of specific grass seeds and suids. These foods, which were later fully domesticated, were complimented by a range of other wild resources that were gathered or hunted.

It is about this time that dates from sites in North China indicate that foragers began utilizing playa margins throughout the basin-range landscape throughout the southern extents of the Gobi Desert and elsewhere in Inner Mongolia (An 1992; Bettinger et al. 1994; Cybiktarov 2002; Derevianko and Dorj 1992; Elston et al. 1997; Fairservis 1993; Madsen et al. 1996). These groups likely focused on both wetland resources and foods from the adjacent steppes. In northeast China, the Zhalainuo'er site has produced faunal remains of mollusks, fish, birds, mammoth, bison, horse, deer, antelope, wolf, rabbit and rat (Wu and Zhao 2003), suggesting that a wide range of animal foods were available to the inhabitants.

Surface finds in these regions are typified by the presence of grinding stones, pottery, polished or chipped adze/axes, and bifaces (Cohen 2003; Bettinger et al. 1994; Fairservis 1993; Wu and Zhao 2003), which appear to have added to the pre-existing microlithic technology evidenced from the lower levels of excavated dune fields in Inner Mongolia (Elston et al. 1997; Madsen et al. 1996). Foragers in the more northern reaches of the dune-playa region seem to have utilized technologies very similar to their pre-agricultural counterparts. It is the relative scarcity of Neolithic style technologies at sites like Shabarakh-usu, as compared to more regular finds throughout the millet producing regions of North China, which suggests that the use of these technologies do not necessarily signal the formation of the emerging agricultural complexes that typify their southern neighbors during the same period. Animal domestication eventually became an important part of some later Neolithic and Bronze Age economies in these regions (Derevianko and Dorj 1992; Cybiktarov 2002), but there is no convincing evidence that cereal agriculture was similarly adopted before the rise of state-level societies (di Cosmo 1994). Instead, foragers in these regions may have simply maintained a heightened focus on extractive techniques, perhaps on only a seasonal scale.

Notably, the introduction of Neolithic technologies throughout larger areas of Northeast Asia occurs immediately before and during the Younger Dryas. Another period of developmental intensification takes place around 8,000 BP, by which time Neolithic technologies appear to have flourished throughout Northeast Asia. Agricultural communities were then being established in the Central Plains while semi-sedentary foragers in Japan settled into a series of adaptations that lasted for a few thousand years. Table 1.1 illustrates the general chronological relationship between technological innovations in Northeast Asia and periods of climatic fluctuation. Although there is no specific paleoclimatic episode recorded for 8,000 BP, it is around this time that Mongolian lakeshores north of the Altai mountain range had probably reached their maximal expansion (Harrison et al. 1996; Lehmkuhl et al. 2001). Coinciding with this date is evidence from the arid to semi-arid transitional of zones of northwest China and Inner Mongolia, suggesting a stabilization of lake shore levels and heightened humidity between 10,000 and 6,000 BP (An et al. 2006; Jiang et al. 2006; Mischke and Wünnemann 2006; Peng et al. 2005; Yu et al. 2006).

As noted, evidence from the Alashan Plateau indicates that under the influence of a change in monsoonal patterns, the southern reaches of the Gobi Desert may have undergone a period of heightened humidity just as neighboring regions were becoming more arid. This climatic event may have encouraged foragers to focus more intensively on increasingly productive playa margins, or the aridification of more southern playa regions could have encouraged northward migration. Still, when comparing the appearance of Neolithic artifacts in Gobi Desert sites with chronometric dates for the use of technologies elsewhere in Northeast Asia, it seems likely that use of Neolithic technologies could have begun much earlier than 6,000 BP (for further discussion see Aseyev 2002; Derevianko and Dorj 1992; Cohen 2003; Keally *et al.* 2003; Weber 1995; Wu and Zhao 2003).

Whenever Neolithic technologies were added to the microlithic tool kits of desert foragers, the use of dune-playa zones almost certainly predate the addition of these technologies. Several series of excavations at Shabarakh-usu have suggested the presence of an aceramic layer below assemblages containing ceramics and other Neolithic technologies (Derevianko and Dorj 1992; Derevianko et al. 2003; Fairservis 1993). The earliest occupations may be contemporaneous with the lower aceramic levels of Pigeon Springs in the Pigeon Mountain basin of North China, dated to 11,620 $\pm$ 70 BP

(Beta 86731) and 12,710 ± 70 BP (Beta 97242) (Elston et al. 1997), where dates for the introduction of Neolithic technologies are similarly elusive. It is known that the use of pottery did not become widespread in China until sometime around 8,000 BP (Cohen 2003; Keally et al. 2003), at about the same time grinding stones appeared in the millet-producing regions in northern China (Cohen 2003). These approximate dates favor a mid-Holocene date for employment of Neolithic technologies in the context of foraging economies further north.

A range of resources was certainly utilized at playa sites during all periods of occupation. The occurrence of projectile points (Figure 2.1, 3.1) and more labor intensive hunting technologies, like shaft straighteners (Appendix A, sites 1A and 2), in some of the Shabarakh-usu site assemblages indicate that the locale may have been important for hunting. The presence of adze/axes (Figure 3.2), pottery (Figure 3.3), and grinding stones also suggest that more strenuous extractive processing techniques were also practiced, although site assemblages containing the highest frequencies of hunting technologies (sites 1A and 11) do not include processing technologies. This range of technologies, resulting from the exploitation of differential resources, implies that dune-playa sites may have been used in several ways depending on the season of occupation.

In contrast to the typical dune-playa surface scatters, microlithic scatters from the steppe zones indicate the use of similar lithic reduction techniques but are not accompanied by heavy, awkward processing tools and shaft straighteners. The variation between tool kits in these neighboring regions demonstrates that the two ecozones were used differentially. Most notable is exclusive presence of extractive processing technologies among dune-playa assemblages, an indication that these technologies did not travel away from the site with foragers, who probably used them on a seasonal basis.

Foragers northwest of Shabarakh-usu, subsisting on a range of resources from the open steppes and the foothills of the Gobi-Altai range were producing similar assemblages to foragers at Shabarakh-usu, but did not adopt Neolithic technologies as a part of their tool kits. Chikhen Agui is an important cave site in the foothills of the Gobi-Altai range and may have been occupied contemporaneously with Shabarakh-usu. Ten radiocarbon dates bracket the occupations in this cave, ranging from 5630±220 (SOAN-3732) to 11,545±75 (AA-31215) years BP (Derevianko et al. 2003). These dates indicate that aceramic microlithic assemblages lacking bifacial projectile points continued to be used north of the playa-rich regions of the Gobi Desert. The Chikhen Agui site was likely formed by the occupation of a winter hunting camp and the high level of preservation revealed that individuals had built hearths around grass sleeping mats. Wooden hafts had been used for the insertion of microblade segments and fragments of what may have been an ostrich eggshell bowl were also recovered (Derevianko et al. 2003).

Chikhen Agui contains lithics of a similar technological tradition to those at Shabarakh-usu (Figure 2.1, 2.2), with both assemblages focused on microblade production and the use of retouched flakes. Some blades were fashioned into what appear to have been projectile points and the same types of high quality cryptocrystalline stone (siliceous sandstone, jasper and chalcedony – see Derevianko et al. 2003) were being utilized. Despite the similarities, these characteristics are common of most lithic assemblages in North China and Mongolia following the LGM. It is the presence of ostrich eggshell that most notably connects the two locales.

The disparity between sites in the north and south is even more apparent in the strong variation in distribution between “Neolithic” and “Mesolithic” sites noted in Appendix C. “Neolithic” sites were restricted to southern reaches of the Gobi, around playas, marshes or springs, while “Mesolithic” sites were more widespread, found on adjacent plains and mountain passes, as well as throughout the more northern stretches of the Gobi Desert, including the foothills of the Gobi-Altai range. This pattern of distribution strongly suggests that the south Gobi was inhabited by a separate groups of foragers. Dates from Chikhen Agui contradict the view that the more northern steppes and basin-ranges were uninhabited during the Neolithic and support the notion that Neolithic technologies remained confined to the playa-rich extents of the southern Gobi Desert. This does not mean that changes in subsistence and technology did not occur in these areas, but there is evidence that microlithic blade reduction strategies of a regular type were retained.

Moreover, since few of these sites have been studied, the mode of seasonal land-use is uncertain. In the south, the seasonal use of specific playas, or playa resources in general, may have been synchronized with the harvesting of vegetable or aquatic resources (although there is no evidence of the latter at Shabarakh-usu). A temporary, but recurrent, occupation of the Shabarakh-usu locale is strongly supported by the presence of artifacts that would have been difficult to transport on long trips. These non-portable items could have been easily cached during times when foragers were involved in other subsistence activities.

Many of the sites at Shabarakh-usu also contain artifacts related to both hunting and processing activities, while other sites are strongly biased towards hunting activities (sites 11 and 1A). These differences in site function suggest that a range of resources were available and that foragers exploited the area for various purposes. Notably, the presence of grinding stones (grinding slabs and hand stones or manos) in this sample is limited to sites with ostrich eggshell fragments and/or beads, which could be coincidental or may indicate that the eggs or their shells were processed with grinding stones. Both grinding slabs and grinding tools or pestles were found.

The lack of evidence for shelters and middens suggesting long-term occupations at Shabarakh-usu implies that the dune-playa sites were inhabited temporarily on a seasonal basis. This might suggest that other resources were exploited in the adjacent mountain and steppe regions. A seasonal variation in the availability of resources may have been responsible. Factors influencing the use of dune-playa zones may have included seasonal variation in ungulate herd ranges and group organization. For example, gazelles birth in June, gathering in herds of up to 8,000 individuals for protection of the young. In July, the males leave the herd until another large-scale aggregation in the late fall (Allen 1938). If resources like seeds were available around playas in the late fall (or ostrich eggs in the spring – Sampson 1994) when gazelle were aggregating on the adjacent plains, this would have provided a perfect situation for the establishment of a temporary base camp. When neither resources was available, occupation of the steppes or nearby foothills might have been more profitable. This type of land-use is suggested by An (1992) to have been common in Xinjiang region among Neolithic pastoralists.

Basin-and-range environments in the southern playa zones would have provided sufficient resources for foragers, thereby discouraging their expansion into the northern steppes and foothills of the Gobi-Altai mountains. This point is important because, unlike the immobility of such technological markers as pottery and grinding stones, more portable technologies like bifaces, or even adze/axes, are also confined to the dune-playa regions. A lack of movement beyond the dune-playa regions supports the idea that there were sufficient resources in the immediate vicinity to support year-round occupation, not necessarily of the playa margins, but certainly of the surrounding basins and ranges. By introducing extractive processing technologies, foragers may have been attempting to either maintain a more localized range. It is unclear whether was a response to a depression in resources resulting from aridification, or a strategy to reduce mobility at the onset of more humid conditions.

Dates	Technology					Climate		Shabarakh-usu Sites		
KYA	Microblades	Polishing	Bifaces	Grinding	Pottery	Warm/Wet	Cold/Dry	Analyzed	Other	
	?							1&2	3	
			?					1	5,7,9	Pottery
								4	10, 10s-s	
5								8, 8s-s	16, 17	
								1&2		
								1	6	
								1A	9	
								2	10	Grinding
								4	12,14	
								8		
									3	
								1	6	
10									5,7,9	
								2		Bifaces
								4	12,14	
								8	15,16	
								11	17	
								1&2		
								1	6	
								1As-s	9	
								2		Polishing
								4Es-s	12,14	
15										
									17	
								1&2	3	
								1	6	
								1A	5,7,9	
								2, 2s-s		Perforator
								4	12,14	
								8, 8s-s	15,16	
								11	17	
								all sites	all sites	Microblades
20		?								

Table 1.1: Chronological relationship between climate and technological innovations since 20,000 BP in Northeast Asia (Cohen 2003; Fairservis 1993; Frenzel 1992; Harrison 1989; Keally et al. 2003; Krigonov et al. 2004; Weber 1995; Wu and Zhao 2003). The dotted line represents regular and widespread use. Approximate timing of warm/wet and cold/dry periods are compared to technological chronologies.

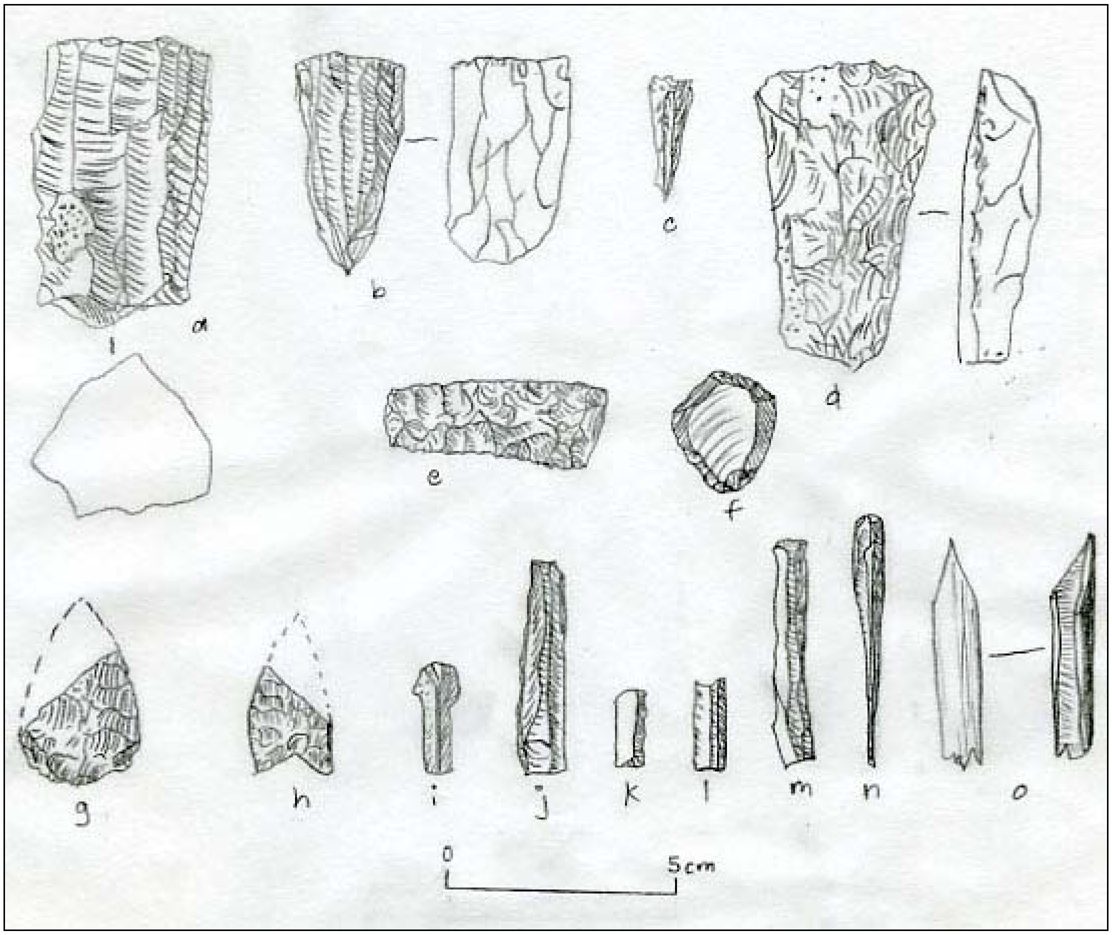

Figure 2.1: Various artifacts from the Shabarakh-usu collection. Cylindrincal (a), typical flat-backed (b), and heavily reduced microblade core (c), all from Site 4; chipped stone adze/axe (d) and bifacially flaked knife (e) from Site 4; typical thumbnail scraper (f) from Site 6; two types of bifacially flaked projectile points (g, h) from sites 11 and 4, respectively; microblade fragments and tools formed on microblades (i-n) from Site 4 (i), Site 1A (j-l), and Site 1 (m, n); unique bone point (o) also from Site 1.

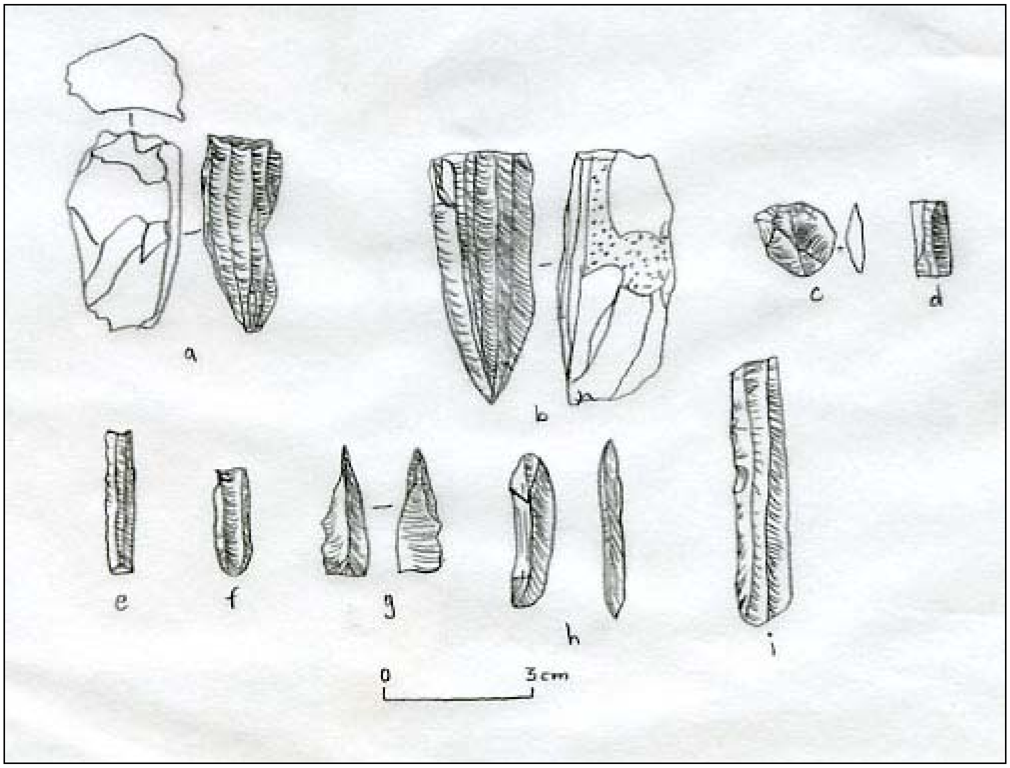

Figure 2.2: Typical lithic artifacts from Chikhen Agui cave site, including two examples of microblade cores (a, b), a thumbnail scraper (c), and various microblades (d-h) and a larger blade (i).

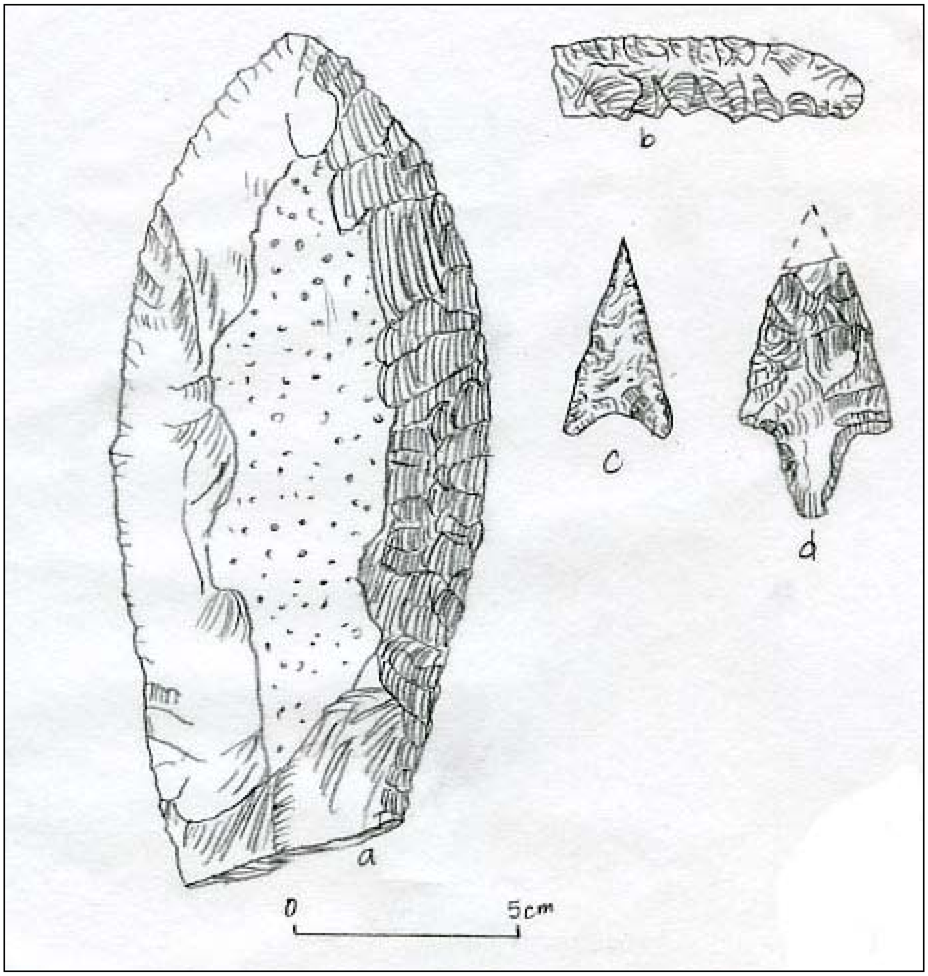

Figure 3.1: Examples of various types of bifaces found at Shabarakh-usu, Site 2.

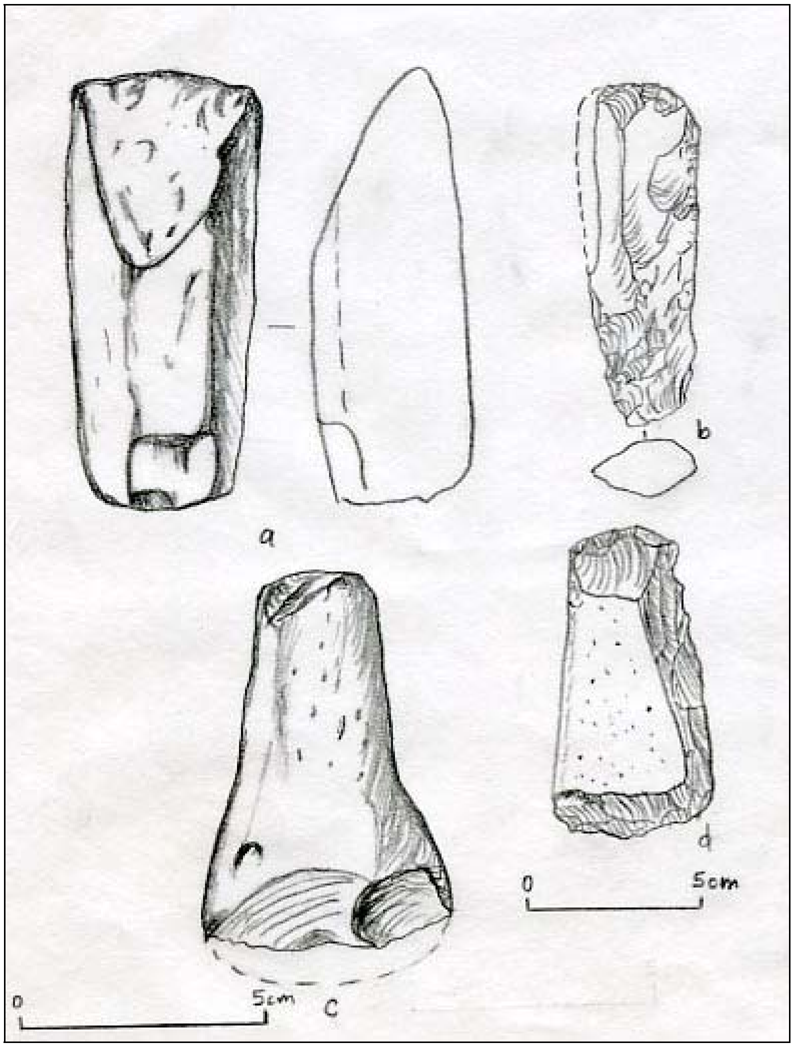

Figure 3.2: Examples of polished (a, c) and chipped stone adze/axes (b, d), from Shabarakh-usu sites 2 (a, b, c) and 6 (d).

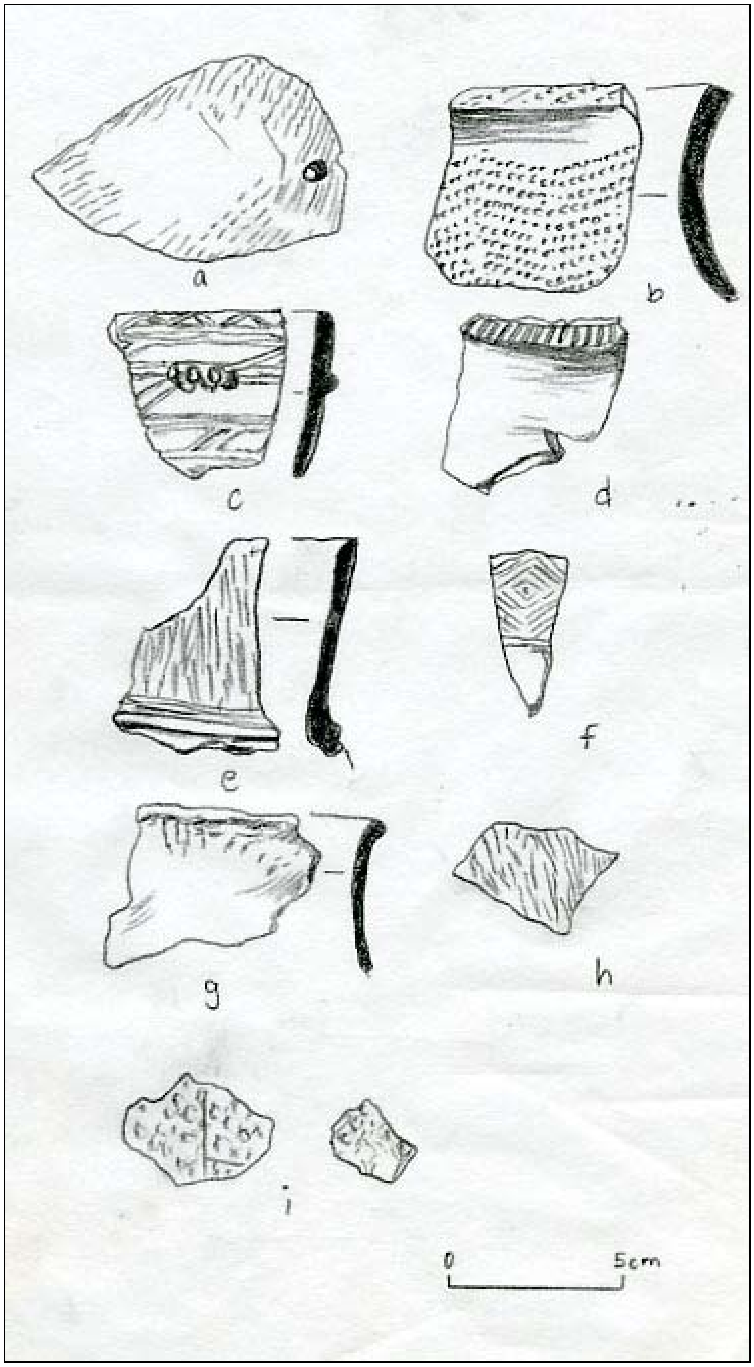

Figure 3.3: Examples of pottery from Shabarakh-usu surface collections, Collection 1&2 (a-h) and Site1A (i).

HISTORY OF THE SHABARAKH-USU COLLECTION

The Shabarakh-usu sites at Bayan-dzak (also Baindzak, Bain-dzak, Bayandzak) were first investigated during the Central Asiatic Expedition in 1925 by Nels C. Nelson, then staff archaeologist for the American Museum of Natural History (AMNH). Led by the intrepid explorer Roy Chapman Andrews, whose gift for storytelling and exaggeration made him a popular adventure writer in the early 1900s, the highly publicized and largely privately-funded Central Asiatic Expedition met with brilliant results in 1923, when the first Mongolian dinosaur and megafaunal fossil deposits were discovered. On July 23, 1923, the expedition's lead paleontologist, George Olson, made the first of these finds at the Flaming Cliffs, only two kilometers south of Shabarakh-usu[1] (Gallenkamp 2001). Although no archaeological remains were found that year, Andrews returned two years later to further investigate the rich fossil beds at the Flaming Cliffs. At this time Nelson's explorations of the vegetated dune fields to the north revealed numerous archaeological remains.

Within the dune formations Nelson found several surface scatters and subsurface accumulations of microlithic tools and other artifacts (Figure 1.2). Each spatially distinct scatter was considered to be a site and sometimes included subsurface components excavated from the intact portions of partially deflated dunes or from ash pits (which Nelson referred to as "hearths") found within site parameters. Many of the surface scatters appeared to have originated from these partially intact dunes, but the relationship

[1] The name "Shabarakh-usu", meaning "muddy water", was used by Nelson to indicate the dune-playa formation in which the archaeological sites were found. Bayan-dzak, the name of the surrounding region, is now more commonly used among Mongolian and Russian scholars to reference the locale. In this paper, "Bayan-dzak" indicates the basin region as a whole, including the Flaming Cliffs immediately south, where many important paleontological finds were made. "Shabarakh-usu" is used as the name of the archaeological locale, but probably refers more correctly to the playa itself.

between artifacts found in ash pits and those on the surface remained unclear. Among these scatters, Nelson identified two types of assemblages: those with pottery and those without. Assemblages without pottery were considered to be older, partially because pottery was found only in surface scatters from higher elevations.

In the years that followed, conflict over this interpretation arose when the Soviet-Mongolian archaeological team, headed by A. P. Okladnikov, conducted excavations at Shabarakh-usu and found no evidence for a distinct aceramic layer (Maringer 1963; Okladnikov 1962). Although later expeditions proved the existence of an aceramic layer (Derevianko and Dorj 1992; Derevianko et al. 2003), it is not clear whether either of these excavations were carried out in the same area of the dunes as those conducted by Nelson. Spatial variation may also have been due to differences in the preservation of ceramics throughout the site. While the presence or absence of grinding stones, bifaces, and adze/axes should not have been affected, information on the distribution of these artifacts is scanty (but see Cybiktarov 2002).

Since 1925, similar sites have been found throughout the southern Gobi Desert, but the Shabarakh-usu sites are still considered to be key collections, especially since Nelson's notes were highly descriptive and the collection itself was carefully curated. Inter-assemblage variation among dune-playa sites is thought to be representative of changes in technology and subsistence-settlement patterns throughout the Gobi Desert. These broad-scale changes could then be recreated based on the stratigraphic integrity of sites excavated directly from the dunes. The published results of international expeditions to Gobi-Altai and Bayankhongor provinces in the 1980s and 1990s (Derevianko 2000; Derevianko et al. 1996, 1998, 2000) suggest that the Neolithic style technologies (Figure 3.1 – 3.3) appearing within the dune-playa context in the south are not characteristic of habitations outside this environmental range (Appendix C).

Therefore, Shabarakh-usu and other dune-playa sites are unique in their range of artifacts. While microblade technology is the prevalent lithic reduction strategy, grinding stones, polished groundstone implements and bifaces are all absent in the northern foothills and arid western steppes. Pottery is extremely rare and poorly preserved[2]. Clearly, variation exists in land-use and site function between these two ecological zones, but the lack of chronometric dates disallows a reconstruction of chronological change over such a large geographic region, thereby complicating comparisons of land-use strategies between environments.

An understanding of each region must be sought individually, focusing first on that region most amenable to tentative chronological reconstruction. The first step in building a chronology for Shabarakh-usu and other dune-playa sites is studying inter-assemblage variation. By understanding which aspects of variation are related to time depth, testable chronological models may then be formulated.

[2] The poor level of preservation in these regions also suggests that ceramic artifacts, if used among pre-pastoral societies, may simply not have survived into the archaeological record.

METHODS

Nelson's Shabarakh-usu collection at the American Museum of Natural History (AMNH) in New York provides the best sample of archaeological collections from the dune-playa regions because it is not only the most accessible, but the most reliably curated. Examining a range of qualitative and quantitative characteristics for each artifact allows for artifacts to be compared in groups based on technological traits or site assemblage. Resulting variation between groups can then be assessed through a consideration of other data, including paleoenvironmental data and a comparison with regional trends in technological development and land-use. While Nelson's work suggests that much of the inter-assemblage variation previously noted supports a linear chronological ordering of site assemblages, other explanations might also be considered.

A cautious approach is required in the compositional analysis of surface collections, but the integrity of these sites should not be immediately discounted. The possibility that many of the individual site collections are sufficiently temporally coherent to be analyzed as such is particularly relevant considering the speed with which sites in dune fields can be deposited, buried and re-exposed. Nonetheless, it is acknowledged that much of the pottery from these collections is discordant with the probable age of the sites and this is suggested not only by the relative abundance of surface collected pottery and the variety of historical periods represented (Figure 3.3).[3]

Furthermore, technologies associated with the Neolithic are not found among the subsurface components collected from ash pits, which suggests that interpretations about

[3]In particular, see descriptions of sites 4, 8 and 13 (Nelson 1925). Many of the illustrations by Jan Fairservis in Fairservis 1993 are fine examples of designs considered by Mongolians to be typical of historic period and late prehistoric periods, including styles typical of Uighur (8th to 9th centuries A. D.) and Kitan (10th to 12th centuries A. D.) periods (Hall et al. 1999; Joshua Wright, personal communication in July 2005).

the relative chronology and corresponding function of these sites is potentially misleading when based on the presence or absence of certain artifact types. The absence of specific types of artifacts in ash pits may be a function of differential utility, perhaps related to discard practices, rather than a means of aging those assemblages. This is especially true when comparing subsurface with surface level components. In general, a simple presence versus absence approach to collections that include surface scatters is too simplistic to be reliable.

Although the analysis of museum collections is often problematic because knowledge of the original collection strategies and the spatial context of each site has often been lost, Nelson kept careful records and curation practices. His meticulous field records also explained which artifacts he culled at each site or which artifacts in an assemblage were from separate, but neighboring, concentrations within the site collection area. Although a lack of screening is also a serious problem for analyses related to flake size and reduction strategies, Nelson made all final decisions about which artifacts were to be collected and curated; therefore, some degree of consistency was retained in the final sample. Due to the availability of Nelson's records, as well as his careful collection and curation, statistical analysis can be employed not only to test his theories, but to examine other possible explanations for variation between the sites.

For this research, almost half of the material from Nelson's collections were analyzed, a group composed of 5,030 pieces from seven (1, 1A, 2, 4, 8, 11, and 13) of the 18 cataloged sites to be analyzed. Collection group 1&2, an assemblage of artifacts collected from the periphery of Site 2, was also analyzed as a distinct group. Tables 2.1 – 2.3, along with site descriptions in Appendix A, summarizes the context and content of each site assemblage analyzed. The suggested site functions in Appendix A are preliminary and were based solely on the frequency of certain artifact categories, such as debitage, recovered from each site assemblage. The sites were chosen to reflect variability in geological context and assemblage content.

Initially, sites with subsurface components were selected on the assumption that the subsurface component was older and could be used to support and test chronological determinations. Chronological concerns, as elucidated in Nelson's interpretations, also motivated the selection of a range of both chalcedony and jasper dominated sites. The presence of what Nelson believed to be hearth features was also a factor in choosing sites because it was hoped that they might be related to site function. Finally, Site 11 was chosen because it contains high frequencies of projectiles and has an unusual range of raw material types. Site 2 was also of interest because it featured two types of subsurface components, neither of which were related to the hearth features. The geographic relationship of between sites is detailed in Appendix A and illustrated in Figure 1.2.

Since chipped stone artifacts are the most common artifact type in all Shabarakh-usu site assemblages, and due to their lowered susceptibility to natural reduction processes such as wind abrasion and water damage, two characteristics of the lithic collections were considered for more focused analysis: raw material type and blade dimensions. Raw material type seemed a valuable avenue for investigation, since previous research on these collections indicated that inter-assemblage variation between the use of chalcedony or agate types versus jasper types was easily observable (Fairservis 1993; Nelson 1925; Spock 1934; see Table 2.2). Blades were considered an important aspect of this collection (Tables 2.2, 2.3) since they are the most common artifact type next to amorphous flakes. Besides being more uniformly quantifiable than amorphous flakes, they also occur in site assemblages in both the dune-playa regions and the steppe and foothill zones. As a result, regular variation amongst Shabarakh-usu site assemblages might provide a relevant unit of comparison for later cross-regional comparisons.

Nelson's field notes were another important source of information about this collection. They contain information for some site assemblages on which artifacts were discarded, with information on the raw materials and artifact type. Although this information was not precise enough to be calculated into the numerical analysis of the collection, it does provide valuable insight into possible problems with quantitative analysis of the museum collections.

Site	1&2	1	1A	1A s-s	2	2a s-s	2b s-s	4	4 s-s	8	8 s-s	11	13
Lithics (N=)	1661	824	447	84	197	68	54	438	35	535	80	523	84
Jasper	56.8	11.1	88.7	89.3	64.2		77.8	46.2	60.0	59.7	70.0	24.1	59.8
Chalcedony	40.6	88.1	7.7	6.0	25.8		9.3	52.4	37.1	38.2	27.5	75.1	31.7
Blades	46.6	5.8	52.1	2.4	23.5	7.5	13.0	29.9	52.9	44.9	26.3	12.2	27.4
% Medial segments	25.5	10.4	34.3	12.5	6.7	20.0		24.0	33.3	39.0	15.0	17.2	26.1
% Artifacts from blade reduction sequences	52.1	6.8	52.9	22.6	28.6	13.2	13.0	31.1	48.6	49.5	26.3	22.0	33.7
Bifaces		6.3			3.0			3.9		1.3		24.2	1.2
Scrapers	15.1	2.7	13.4	7.1	26.4		3.7	13.7	11.4	17.8	3.7	4.4	30.9
% Thumbnail Scraper	15.0	27.3	2.1		13.6			19.2		10.5		30.4	25.0
Blanks	20.7	0.7	13.2	3.6	6.2		5.6	12.7	38.2	22.1	17.5	0.4	
Utilized Flakes	8.4	1.2	1.6	9.5	10.7	4.5	3.7	7.5		9.7	1.3	28.9	4.8
Core	5.7	1.3	6.1	6.0	21.9	2.9	9.3	6.4	51.4	12.5	1.3	15.3	7.2
% Microcore	84.5	54.5	36.4	50.0	34.4		40.0	84.0	100	71.2	100	17.6	60.0
% Blade Core	4.1	9.1	18.2							13.6		8.8	
% Other Core	11.4	36.4	45.5	50.0	65.5	100	60.0	16.0		15.3		73.8	40.0
Debitage	25.4	80.9	29.5	64.3	14.8	85.1	70.4	40.0	32.4	15.7	70.0	9.2	29.8
% Jasper Debitage	58.9	4.2	95.3	94.1	55.6		93.5	35.5	54.5	42.9	77.8	29.2	55.6
%Chalcedony Debitage	41.1	95.8	4.7	5.9	44.4		6.5	64.5	45.5	57.1	22.2	70.8	44.4
Shell or Bone	shell	both		bone	shell		both	both		shell			
Shell (N=)	236	34			55		5	296		11			
Pottery (N=)	105	73			2			168		47	2		9
Grinding Stones (N=)	1	2			2			1		2			
In ash pit?				yes					yes		yes		yes
Multiple collection areas?	yes				yes?		yes	yes					yes

Table 2.1: Summary of site assemblages in relation to the frequency of principal artifact types and subtypes. Subsurface groups are designated by "s-s".

Site	# of Blades		Minimum	Maximum	Mean	CV	Jasper/Chalcedony (%)
1&2	770	length	8	58	25.25	0.268	60.2/38.6
		width	8	28	8.21	0.342	
		thickness	1	10	2.56	0.535	
1	48	length	12	50	30.25	0.306	43.8/56.3
		width	4	19	10.21	0.389	
		thickness	1	12	3.75	0.583	
1A	231	length	11	55	24.46	0.265	91.4/7.8
s-s		width	4	17	8.05	0.264	
		thickness	1	10	2.25	0.552	
1A	16	length	13	92	37.19	0.459	93.8/6.3
		width	5	21	10.62	0.435	
		thickness	1	11	3.81	0.706	
2	45	length	20	58	31.89	0.282	84.4/15.6
		width	5	22	10.22	0.361	
		thickness	1	10	3.69	0.500	
2a	5	length	22	36	26.60	0.210	neither
s-s		width	9	15	12.00	0.212	
		thickness	2	5	3.40	0.395	
2b	7	length	21	44	35.43	0.209	85.7/14.3
s-s		width	4	14	8.14	0.462	
		thickness	1	9	2.71	1.059	
4	129	length	8	54	24.15	0.349	57.3/41.2
		width	3	25	8.49	0.368	
		thickness	1	9	2.42	0.478	
4	18	length	13	38	23.22	0.354	72.2/27.8
s-s		width	2	13	7.83	0.434	
		thickness	1	3	1.94	0.278	
8	240	length	8	60	26.51	0.337	72.1/27.9
		width	3	29	8.10	0.440	
		thickness	1	12	2.43	0.743	
8	20	length	13	48	24.45	0.370	61.9/38.1
s-s		width	4	10	6.70	0.238	
		thickness	1	4	1.85	0.439	
11	64	length	13	51	27.64	0.319	50.0/50.0
		width	5	22	11.23	0.343	
		thickness	1	10	3.95	0.551	
13	23	length	11	52	25.39	0.409	59.8/31.7
both		width	5	26	11.17	0.469	
		thickness	1	16	4.09	0.909	

Table 2.2: Summary of blade measurements and raw material frequencies for all sites analyzed.

Site	Jasper		Mean	CV	Chalcedony		Mean	CV
1&2	465	length	25.25	0.269	296	length	25.19	0.258
		width	8.08	0.356		width	8.35	0.298
		thickness	2.52	0.563		thickness	2.61	0.474
1	21	length	30.43	0.317	27	length	30.11	0.304
		width	9.14	0.420		width	11.04	0.357
		thickness	3.38	0.610		thickness	4.40	0.564
1A	211	length	24.74	0.263	18	length	21.67	0.264
		width	8.07	0.263		width	7.83	0.298
		thickness	2.21	0.496		thickness	2.78	0.860
1As-s	15	length	37.73	0.465	1	length	29.00	
		width	11.00	0.411		width	5.00	N/A
		thickness	3.93	0.697		thickness	2.00	
2	38	length	31.45	0.271	7	length	34.29	0.339
		width	10.45	0.365		width	9.00	0.314
		thickness	3.89	0.496		thickness	2.57	0.208
2b s-s	6	length	24.50	0.222	1	length	41.00	
		width	7.50	0.490		width	12.00	N/A
		thickness	2.67	1.176		thickness	3.00	
4	75	length	24.55	0.336	54	length	23.59	0.369
		width	8.37	0.313		width	8.65	0.431
		thickness	2.31	0.427		thickness	2.57	0.527
4s-s	13	length	23.85	0.323	5	length	21.60	0.473
		width	7.08	0.384		width	9.80	0.459
		thickness	1.85	0.300		thickness	2.20	0.203
8	173	length	25.90	0.346	67	length	28.09	0.310
		width	7.72	0.463		width	9.10	0.368
		thickness	2.23	0.778		thickness	2.97	0.634
8s-s	32	length	26.75	0.277	32	length	28.53	0.354
		width	11.78	0.388		width	10.69	0.274
		thickness	3.69	0.544		thickness	4.22	0.554
11	18	length	24.89	0.380	5	length	27.20	0.530
		width	10.39	0.427		width	14.00	0.527
		thickness	3.83	0.923		thickness	5.00	0.927
13	12	length	24.75	0.285	8	length	24.00	0.500
		width	6.58	0.246		width	6.88	0.239
		thickness	1.92	0.469		thickness	1.75	0.404

Table 2.3: Summary of blade measurements by site according to raw material.

NELSON'S CHRONOLOGICAL SEQUENCE

Explaining inter-assemblage variation at Shabarakh-usu in terms of a chronological sequence was central to Nelson's analysis of the sites. Two lines of evidence should be considered in the discussion of chronology at Shabarakh-usu. The first of these is Nelson's 1925 journal which recorded key facts on site distribution and content, as well as methods of collection. These records indicate that some categorical sites were actually composed from several spatially distinct artifact scatters. In addition, Nelson's immediate impressions about spatial relationships between sites and the differential distribution of raw materials suggest a temporal relationship based partially on the distribution of jasper and chalcedony tools.

Depositional Sequence

The relative absence of information about the geological context of Shabarakh-usu sites has hindered extrapolations on their depositional sequence. This is due mainly to the nature of the sites, which were surface scatters that had been completely or partially exposed through deflation of the dune sediments. Nonetheless, partially-exposed finds originating from disparate depths within the dunes were initially used by Nelson to support his interpretations about the relative chronology of Shabarakh-usu sites.

Sites from the transitional western margins of the dune formation were essential in convincing Nelson of the chronological relationship between the use of jasper and chalcedony. Initially, the higher elevation at which Site 1 was found (1, 108 m a.s.l., 3.65 m above the valley floor) was thought to bolster his interpretation that this chalcedony-rich site was of a more recent age than the jasper-rich Site 2 (1, 105 m, on the valley floor [Nelson 1925:34]). Later, the discovery of Site 1A helped convinced Nelson of the chronological relationship between the uses of jasper and chalcedony: “the stratigraphic relations of Site 1 and 1A [being] very simple and convincing” (Nelson 1925: 40-41).

Site 1A was found 3.65 m below the level of Site 1, spreading out across the compacted “clay” floor of the formation amidst nearly exhausted dunes, and marked by a distinct pit, 12.5 cm deep and 25.5 cm in diameter. Capped with 5 cm of clay and filled with lithics and ashes, Nelson believed the feature to be an undisturbed hearth with which the nearby bunches of fire-cracked rocks and other surface finds would have been associated. The relative absence of both bifaces and chalcedony flakes at the lower elevation seemed to argue favorably for the validity of Nelson’s assumptions.

Further reinforcing Nelson’s conclusions was Site 3, which was found 1.22 m above the valley floor. Over two thirds of the lithics from Site 3 site were made of agate or chalcedony, and technologies considered to be of a later age, such as pottery and bifaces, were only present in small numbers. The subsurface component of Site 3 was found in an ash pit and no Neolithic style technologies were found, which is characteristic of ash pit accumulations. The lack of a clear temporal association between the two components further limits interpretations about the relationship between the surface and subsurface groups.

Finally, Nelson’s understanding of these various temporal horizons was further related to the presence of “a series of levels, one extensive and several small independent ones marking water ponds – some with vegetable matter enclosed” (Nelson 1925: 35). He refers to these as high water lines, but is not clear whether he believes them to be modern or ancient. Using the high water marks as points of comparison between sites, he noted that the occupation surface of Site 2 lay 1.35 m below the high water line (suggesting that Site 1 lay about 2.3 m above it), and that Site 10 (which contained a thick streak of charcoal and pottery sherds) lay at an elevation of 2.4 m above that of the high water line in the valley where sites 1 and 2 were discovered (1925: 35, 48). The "successive lake or pond deposits" on the southwestern side of the formation were all at an elevation higher than the sites (5-9, 11 and 13) in that vicinity (1925: 43). These differences in elevation would suggest that Sites 1 and 10 were closely contemporaneous and much later than the majority of sites at Shabarakh-usu.

Seriously affecting these interpretations is the lack of knowledge about paleotopography and both modern and ancient rates of aeolian deposition and erosion. These older occupations may have occurred on the surface of the valley floor, or been deflated previously from more ancient sediments and then covered with sand. In contrast, the level at which later sites were found would have represented the contemporary living surface. Since we do not currently know when different dunes were formed, it is impossible to verify these assumptions. Still, despite the limits to Nelson's interpretations of the geological content, his field notes are never contradictory. Since they are all that remain of the stratigraphic sequence observable in 1925, they should be carefully considered.

Raw Materials

The lithic artifacts from Shabarakh-usu were fabricated mainly on jasper and chalcedony or agate. Both are sedimentary cryptocrystallines and compositionally identical, but chalcedony and agate have a more fibrous structure (Spock 1934; Odell 2003:19). The raw materials used to make each artifact are grouped based primarily on color. The jasper group includes opaque yellow, red, brown or purple cryptocrystallines. The chalcedony/agate[4] group is recognized primarily by their lighter color and glass-like structure, breaking to produce a thinner, sharper edge. Chalcedony is opaque to semi-opaque and is frequently white or white with veins of pink, orange or grey. Agate is more translucent and is found in a variety of colors including dark grey, pink or nearly colorless. A variety of other materials – including both other cryptocrystalline types and more coarse-grained choices – were also used in small numbers.

Nelson thought of the sites in this collection as belonging to various stages of a temporal sequence bounded on either side by sites 1 and 1A. This interpretation was based primarily on variations in the elevation of assemblages dominated differentially by jasper or chalcedony artifacts. Site 1A was interpreted as the oldest in this sequence, with jasper dominating the sample at over 95%. Nelson believed that Site 1, discovered nearby, was the youngest of the assemblages that he collected, providing a sharp contrast to the former group with more than 85% of the sample made on chalcedony.

These two periods were connected by a transitional phase, represented by sites 3 and 4, as well as many of the sites discovered around the playa margins on the southwestern edge of the dune formations. These sites contained variable frequencies of chalcedony, which were seen to represent the gradual incorporation of this material into

[4] Hereafter this group will be referred to under the label "chalcedony".

the toolkit. Out of the fifteen sites that Nelson mentions in some detail, only sites 1, 3, and 11 contained more than 65% chalcedony (Figure 4.1, Tables 2.1, 2.2). Moreover, Nelson remarked that in the site assemblages with more chalcedony, bifaces were common. Sites containing high frequencies of blades tools were comprised mostly of jasper (1925:34, 43).

Nelson's observation that bifacial projectile points seem more common in these later chalcedony-rich sites probably influenced L. Erskine Spock's later discussion of raw material flaking properties, published in his petrological analysis of the Shabarakh-usu lithics (1934). Unlike Nelson, who originally suggested that this increased dependence upon chalcedony was due to a decline in the availability of jasper, Spock points out that the suitability of certain materials for specific tasks played an underlying role in this supposed transition. In fact, this area of the South Gobi is actually quite rich in high quality materials and several possible quarries within 60 km of Bayan-dzak were reported both by Nelson and by later researchers (Dervianko *et al.* 1996, 1998; Fairservis 1993:78; Nelson 1925; personal communication[5]). For this reason, Spock's argument may be more supportable than Nelson's.

Spock asserted that the chalcedony and agate (herein contained within the chalcedony category) used at the site were more prone to shatter, but produced a very sharp edge. Thus, although they were more difficult to work for the production of blades, these materials were more easily adaptable to pressure flaking (1934). While Spock's studies appear to have focused primarily on the mineralogical composition and grain-size

[5] In June 2005, local residents told me about a location within 20 km that was the source of many precious stones. Since certain types of jasper and chalcedony have traditionally been used for carving snuff bottles and are considered quite valuable, this may have been a quarry for flintknappers in prehistoric times. Unfortunately, we did not have the opportunity to investigate the possible quarry.

of raw materials, his observation that jasper was used more frequently for blades and chalcedony for bifacially-flaked tools is accurate (Figure 5.1, 7.1). Nevertheless, modern experimental studies upon differential fracture characteristics would compliment Spock's mineralogical analysis, but have not been conducted.

This differentiation in raw material use is elucidated by Fairservis (1993: 78-80) in his summary Nelson's and Spock's findings. He restates the possible relationship between the use of chalcedony for specialized technologies, such as finely flaked bifacial projectiles and knives, and the temporal sequence suggested by Nelson. Figure 5.2 further illustrates the relationship between increased frequency of chalcedony use and the presence of bifaces. Sites 1, 1A and 11 best exemplify this relationship.

The most important exception to this anticipated pattern is Site 7, which has yet to be analyzed. Here, examples of bifacial technology are abundant, but many of the bifaces were flaked on jasper, which accounted for 86.1% of the material used at the site. Another notable characteristic of the lithics at Site 7 is that of the 15, 600 artifacts recovered, most were small chips and non-standardized cores; utilized amorphous flakes accounted for 50.6% of the entire assemblage. Most of the tools from Site 7 were flaked on small cobbles, and this may suggest a stress on raw material resources.

Nelson's field notes are representative of his firmly-held belief that the true temporal sequence of these artifacts is attested to by multiple lines of evidence. His reliance on geological evidence is questionable, partly because it is non-replicable. On the other hand, perceived correlations between raw material ratios and the frequency of specific tool types is testable and may ultimately provide evidence to support or reject Nelson's hypothesis.

COMPOSITIONAL ANALYSIS

Raw materials and tool types

The conclusions of Spock's (1934) research, that chalcedony was more suited to biface manufacture and jasper to blade manufacture, was partially supported by preliminary statistical analysis of the raw material distribution among tool types, which showed that chalcedony or agate was used to make 85% (204 out of 240) of all bifaces, and that 66.7% (1081 out of 1624) of blades (including microblades) were made from jasper. According to Nelson's hypothesis, site assemblages with more bifaces and higher frequencies of chalcedony would be later than those containing primarily jasper blades. As illustrated in figures 5.1 and 5.2, as well as Table 2.1, sites with higher frequencies of chalcedony often contain greater numbers of bifaces, although a similar relationship exists between the use of jasper and blades only in the surface collection (compare Table 2.1 to Figure 5.1).

Differences in the use of raw materials between site groups may suggest a difference in the raw material procurement strategies of the site inhabitants. The suggestion that fine bifacial retouch was employed in the production of projectile points and other tools in Mongolia much later than microblade reduction sequences (Derevianko and Dorj 1992) also suggests that site assemblages with bifaces and higher frequencies of chalcedony artifacts (especially sites 1, 4 and 11, see Table 2.1) were of a more recent date. Variation in the use of raw materials between tool types and site assemblages suggests differences between groups utilizing the sites that may be related to changes in raw material procurement and lithic reduction strategies over time – whether on a seasonal or much longer time scale – or to varying uses of the site by different groups.

Among the site assemblages analyzed, the use of chalcedony is related to the relative frequency of bifaces found at each site. Figure 6.1 indicates that there is also a relationship between the use of bifaces and the utilization of amorphous flakes for tools, but this trend is not as clear with an increase in the use of thumbnail scrapers (Table 2.1). Site 1 is an exception, and the high frequency of debitage[6] (81.3%) and lack of wear (9.8%) indicates that the site was formed through the accumulation of knapping by-products and/or the stockpiling of reusable materials. Despite this exception, the relationship between flake tool morphology suggests that the use of bifacial flake reduction is correlated with the use of fewer blades, less jasper, and a heightened dependence in the use of amorphous flakes for tools.

The table below verifies that, using Pearson's correlation:

$$r = \frac{\sum z_x z_y}{N - 1}$$

a positive correlation exists between the use of amorphous flakes for tools and the occurrence of bifaces. Notably, the overall use of chalcedony and chalcedony blades is more weakly correlated with the use of bifaces than with the frequency of thumbnail type scrapers (Figure 5.2 – 5.4; Table 3.1). This associated increase in the use of thumbnail scrapers, rather than the larger endscrapers or sidescrapers, is unexpected and may be related to the introduction of a new tool kit utilizing differing lithic forms. Following

[6] Although Nelson discarded a total of 6495 flints from Site 1, his notes indicate that over 7, 000 of the artifacts found were flakes (1925: 40), the largest group of artifacts, which he later refers to as "ordinary flakes" (1925: 51c). Only 128 of the total artifacts were "prismatic flakes" or worked flakes (1925: 40, 51c). This suggests that the above figures are probably biased in that they actually *under* represent the amount of debitage (amorphous, unutilized flakes) from this site. Since Nelson appears to have kept most of the tools in these assemblages and tended to have discarded mostly debitage (1925: 51c-51m), the frequency of debitage for each site is frequently underrepresented in calculations. Of those site assemblages studied, only sites 1, 1A, 8, and 11 appear to have been affected (1925: 51c-51o).

Nelson's interpretation, this pattern may also suggest that raw materials were more limited, and smaller tools were related to strategies of efficiency. Since the use of small thumbnail scrapers (those < 30 mm at the widest point) coincides with higher frequencies of chalcedony, the relationship might also indicate that chalcedony was obtained in smaller packages than jasper.

Pearson Correlation

Sig. (2-tailed) (N=6)	Bifaces	Thumbnail Scrapers
Chalcedony	0.665 (0.018)	0.806 (0.002)
Jasper	-0.668 (0.018)	-0.834 (0.001)
Chalcedony Blades	0.556 (0.060)	0.658 (0.020)
Jasper Blades	-0.549 (0.065)	-0.658 (0.020)
Chalcedony Debitage	0.380 (0.458)	0.815 (0.001)
Jasper Debitage	0.578 (0.049)	-0.815 (0.001)
Utilized Flakes	0.844 (0.000)	0.519 (0.069)
Thumbnail Scrapers	0.680 (0.011)	1.000 (.)
Bifaces	1.000 (.)	0.680 (0.011)

Table 3.1: Correlation among bifaces, thumbnail scrapers and chalcedony components. Note that jasper debitage is positively correlated with these technologies, while chalcedony debitage is negatively correlated. Variation is significant at the 0.050 or -0.050 level.

Whatever the case, the correlation between raw materials and tool types is indicative of a trend away from the use of jasper among tool kits utilizing bifaces and thumbnail scrapers. Table 2.1 indicates that besides being absent in the subsurface components, thumbnail scrapers were found at the lowest frequency in Site 1A, which Nelson believed to be the oldest of the surface collections. The replacement of blade technology is not evidenced (Figure 6.2) and blades are common in most assemblages, with the exception of Site 1, which has low frequencies of all artifact types other than debitage (Table 2.1).

Despite a lack of evidence for decreased reliance on blades when bifacial technologies and thumbnail scrapers are used, Table 3.1 indicates that the use of jasper for blade making does decline. This observation is logical since an assemblage dominated by chalcedony will reflect this bias in the tool kit (Figure 7.1). What is notable is the continued reliance on jasper materials for the manufacture of blades, reflected in the relatively slight drop in the relative frequency of jasper for blade manufacture in comparison with the overall frequency of jasper in some assemblages (Table 2.2, in particular see sites 1, 4, 11, and 13; Figure 7.1). An increase in the use of utilized amorphous flakes (Figure 6.1) may simply suggest that higher quantities of suitable expedient tools were being produced during biface manufacture. The use of this resource does not seem to have affected the popularity of blade use.

Considering the relationship between raw materials and reduction sequences that has been suggested, an understanding of this relationship may be integral to an understanding of inter-assemblage variation. Out of the entire sample analyzed for this paper, 32.3% of the blades were made from chalcedony, agate or like materials, while 29.8% of the microblade cores were constructed on chalcedony nodules. Chalcedony also accounted for 58.1% of debitage in the sample and was most commonly used for perforators, bifacial knives and bifacial points (Figure 7.1f). Associated with a specific suite of reduction sequences, chalcedony was favored for bifacial knapping techniques, while jasper was preferred in the production of blades and most types of scrapers.

Leaving aside Nelson's assumption that these associations were regulated by a temporally directed shift in technology, a variety of possibilities for this differential focus on raw materials can be suggested. Although other materials, like quartzite, chert and silicified sandstone, were used occasionally, chalcedony and jasper cryptocrystallines were readily available and strongly preferred by the inhabitants of Shabarakh-usu for both biface and microblade production. Nevertheless, Spock's analysis of differential flaking qualities suggests that chalcedony and jasper were not equally suited for all tasks. In addition to this explanation, it might also be relevant to consider the size and quality of nodules that were available for each material, since it is also possible that chalcedony sized nodules were more conducive to the manufacture of bifacially retouched projectiles and knives, while jasper nodules were more suited for larger microblade cores. This issue will be discussed below.

Whatever the reason for specific raw material preferences, little variation in the availability of jasper and chalcedony would have been required to encourage inhabitants to favor a particular raw material, if they chose materials based on intended use. Assuming that Spock was correct and jasper was better for blade production and chalcedony for bifaces, both materials must still have been differently available to the groups that used them since an abundance of specific artifact types does not entirely influence what material was used. For example, the Site 7 assemblage (which was not analyzed in this data set, but is described in Appendix A under the Site 8 description) contained a total of 62 bifaces (or 20.3% of the total curated assemblage collection), 58 (93.5%) of which were made from yellow or red jasper (Nelson 1925: 51k). Observing that much of the assemblages was composed of small ships made on pebbles (see

Appendix A), Nelson believed this to be a transitional site, where the jasper was "running out". Nelson's suggestion can not be disproved, but his understanding of this site as one where the zeal for jasper and distaste for chalcedony drove its inhabitants to use even the tiniest fragments complicates the status of what he believed to be additional transitional sites like sites 4 and 8, where almost equal frequencies of jasper and chalcedony were used (Table 2.1).

It is further apparent that the inhabitants of Site 7 had already mastered the technique of employing pressure flaking for the bifacial retouch of projectile points. This observation, in conjunction with emphasis on jasper at Site 7, suggests two possible explanations: there is no specific advantage in one material over another and differences in raw material use were related to the accessibility of specific quarries at specific times; or the inhabitants of this site found themselves in a unique position where they did not have access to the preferred material. The latter scenario could be related to a longer term occupation or a winter occupation, when new raw materials were becoming scarce and raw material stores could not be replenished. Similarly, the pattern observed at Site 1 might also have resulted from unique circumstances.

Either explanation requires that various groups of inhabitants of Shabarakh-usu had differential access to raw materials. This difference in availability may be related to variation in mobility and foraging rounds, or to long-term geological changes that made some materials more readily available than others. It is also possible that while the use of bifacial technology may not have been driven by an increased reliance upon chalcedony, it is possible that with the popularity of bifacial reduction sequences, chalcedony was more frequently chosen as a suitable raw material. Changes in raw material procurement strategies were probably necessary to have produced this pattern. An extensive survey of the region and the identification of raw material sources would be if great value in clarifying this relationship.

Considering the evidence currently available, it does seem probable that this variation in raw material use has some chronological implications. The later appearance of bifacially flaked projectile points in Mongolian assemblages (Derevianko and Dorj 1992) supports Nelson's conclusions about the relative age of assemblages containing bifaces. His observation on the stratigraphic context of the site is also an important consideration.

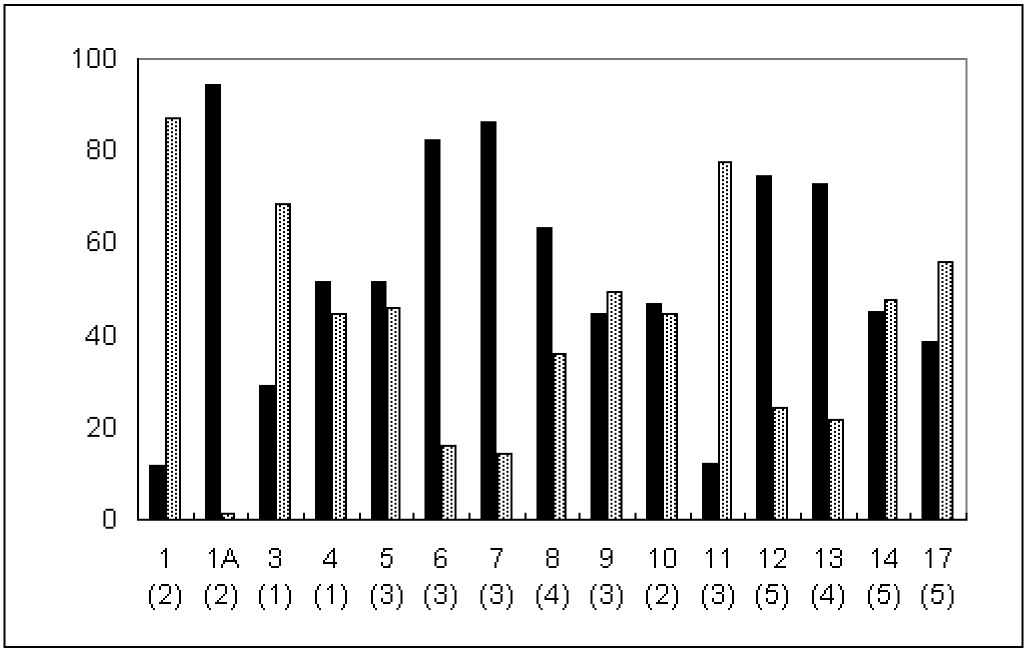

Figure 4.1: Jasper to chalcedony ratios for each Shabarakh-usu site. The solid bar represents jasper and the patterned bar represents chalcedony. The bracketed numbers represent spatially associated groups.

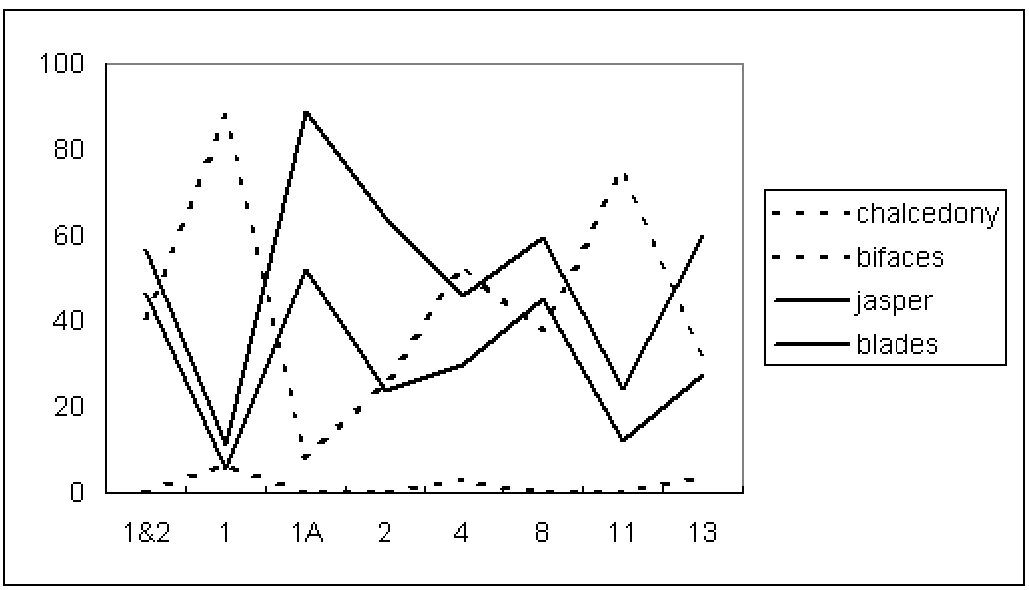

Figure 5.1: Frequencies of raw material use in the surface component of each site in relation to the frequency of blades and bifaces. Subsurface components were considered biased because they never contain bifaces.

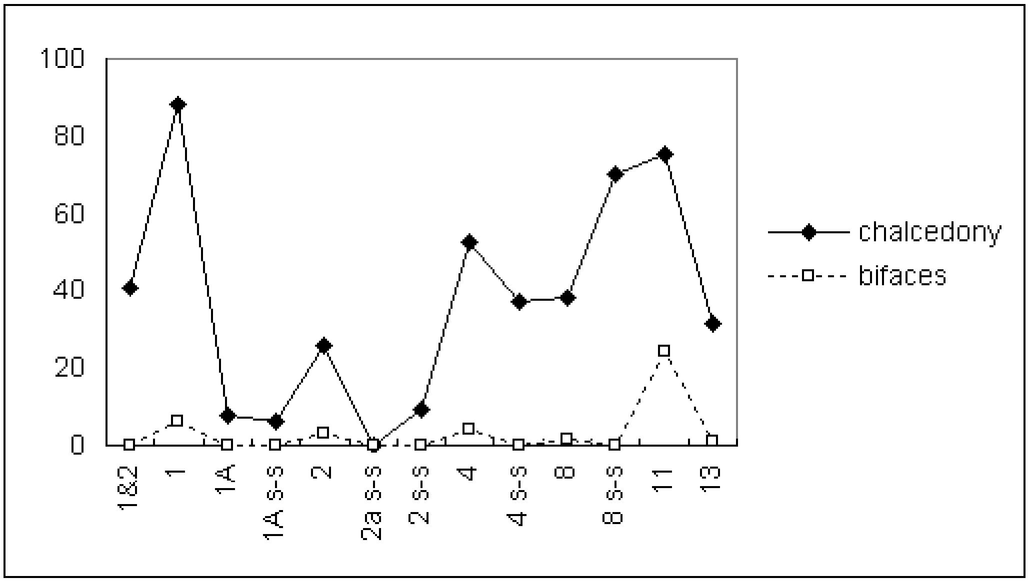

Figure 5.2: Frequencies of bifaces and total chalcedony artifacts in each site assemblage.

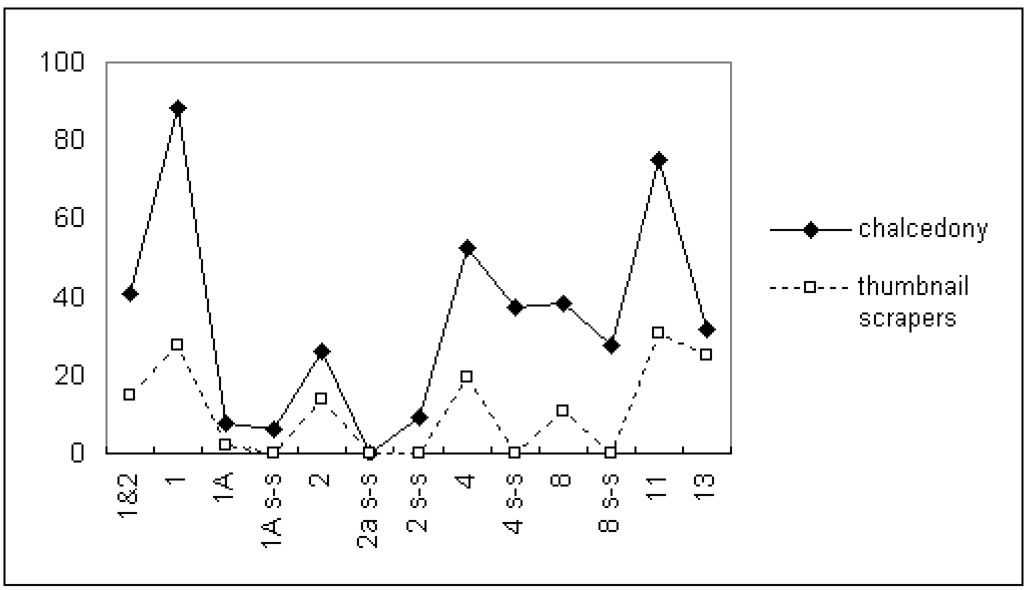

Figure 5.3: Frequencies of thumbnail scrapers in relation to frequency of chalcedony.

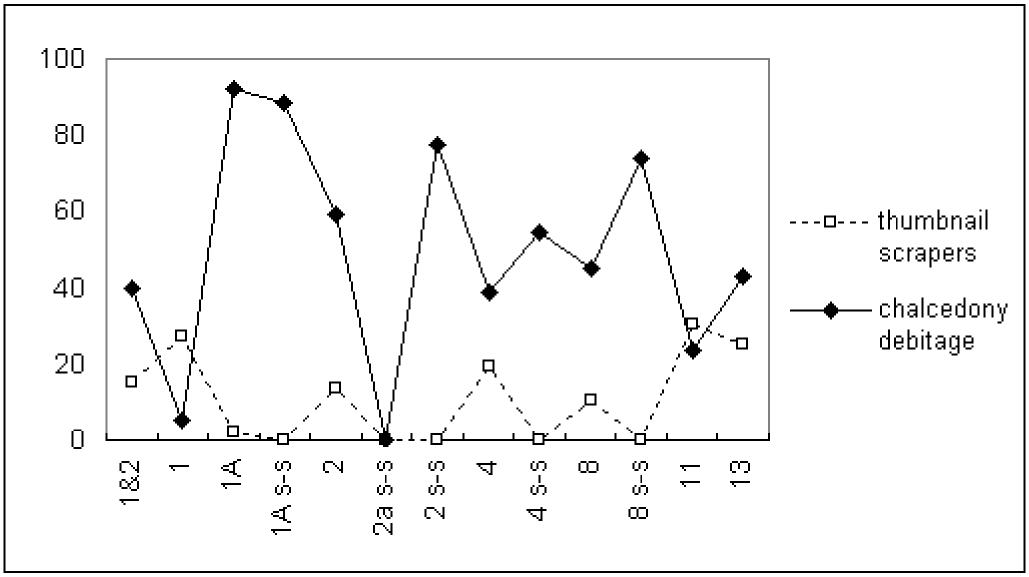

Figure 5.4: Graph illustrating statistically proven correlation between thumbnail scrapers and chalcedony debitage from site to site.

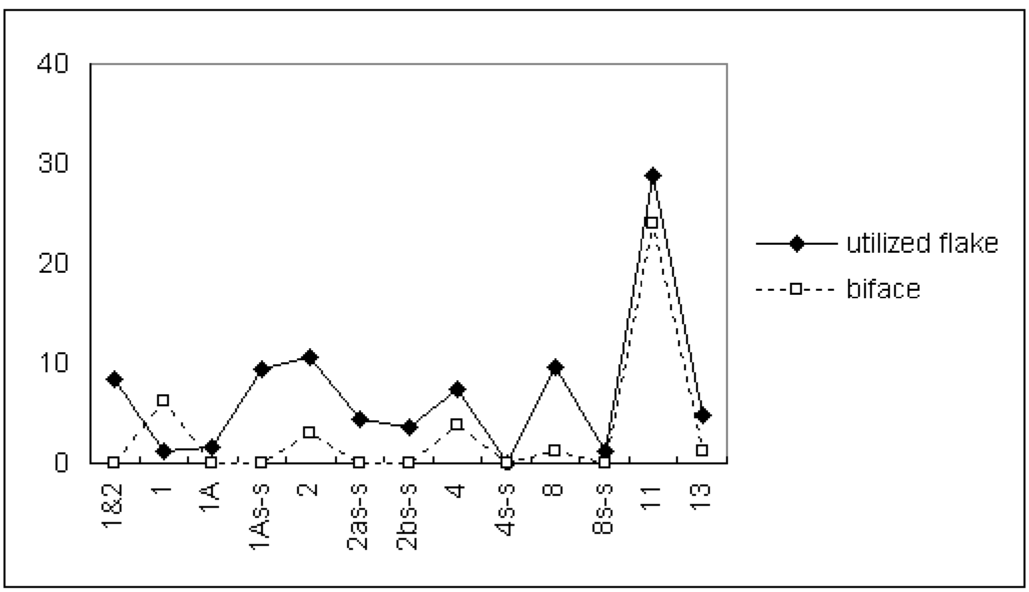

Figure 6.1: Frequencies of bifaces and utilized flakes in each assemblage.

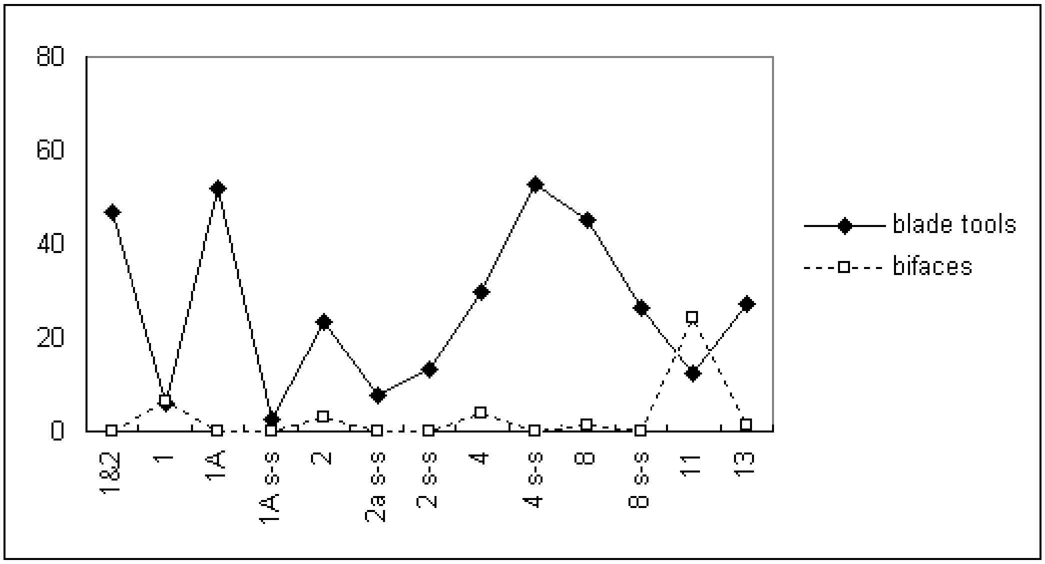

Figure 6.2: Graph illustrating the lack of association between the use of blades and bifaces.

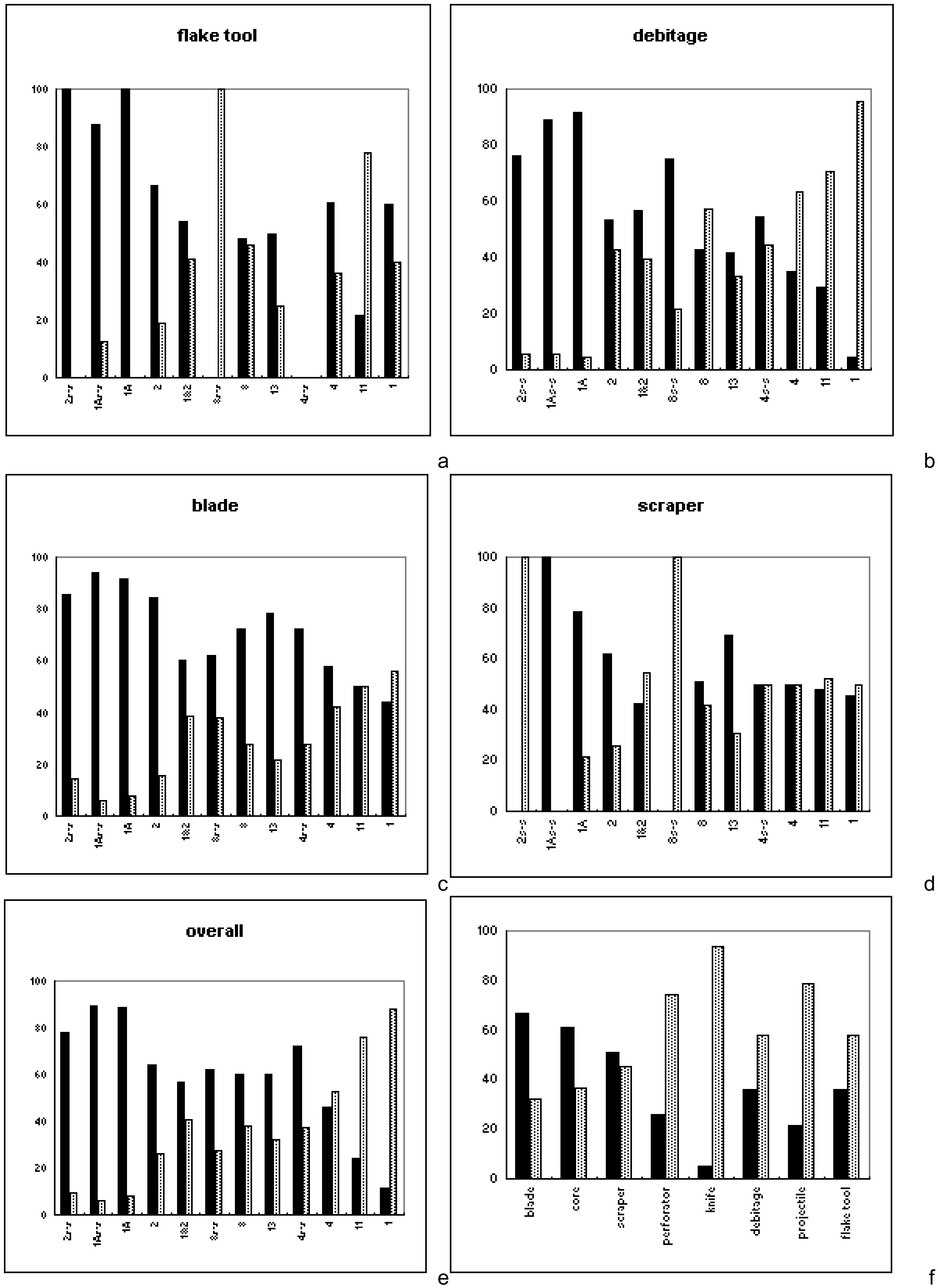

Figure 7.1: Frequencies of jasper (solid) to chalcedony (patterned) among various categories.

Blade Dimensions

Blade tools in the form of microblades (< 10 mm wide) and slightly larger blade forms created the foundation of many Northeast Asian lithic assemblages at the end of the LGM and well into the Holocene, and were probably used regularly at least as late as the Bronze Age (An 1992; Cybiktarov 2002). Again, the dearth of numeric dates in Northeast Asia leaves the question of exactly how long this technology was used unanswered. Metal age technologies should not have affected the reliance on stone tools until those materials were both widely available and inexpensive (Rosen 1996). Until that point, it is possible that both bifacial and microblade technologies were used by foragers at the end of the LGM and later by pastoralists.

Although bifacial and microblade technologies co-exist in Northeast Asian techno-complexes, including some of the first Neolithic, or pottery producing, sites in the Russian Far East (Kuzmin and Shewkomud 2003), the two reduction strategies are presumed to have been capable of fulfilling redundant needs as hunting technology. Both reduction sequences are part of a larger strategy of technological organization aimed at producing lightweight, multi-functional tool kits that are easily maintained and ideal for foragers with high residential mobility (Bamforth and Bleed 1992; Bleed 1986, 2002; Elston and Brantingham 2002; Kelly 1988; Kuhn 1994; Nelson 1991; Odell 1981; Parry and Kelly 1987). In addition, bifacial and microblade reduction sequences provide both tools that can used in hunting and various types of processing. Since the two technologies are often found together in this region, but with bifaces appearing only much later in the archaeological record, bifacial technology must have been employed for a specific purpose.

The lack of correlation between blades and bifaces illustrated in Figure 6.1 may imply that bifacially reduced tools did not replace blades in any significant way. This is further evidenced by the lack of statistical correlation between the frequency of bifaces and the mean width of blades at each site (0.481 [0.334] according to Pearson's Correlation). Instead, bifaces may have preformed a complimentary role rather than serving as a replacement for blade tools. One report on artifacts recovered from melting ice patches in the Canadian Arctic offers an example of weaponry, dated to 4360 $\pm$ 40 BP, which incorporates both bifaces and microblade segments (Figure 5 in Hare et al. 2004: 265). Bifacially flaked projectile points may also have encouraged a shift in the use of blades to other tasks. Since there does not appear to have been a change in blade dimensions, these elongated flakes were probably still hafted in similar ways, since hafts require that tools fall within a particular size range (Bergman and Newcomer 1983).

Additional evidence relating to the context of these finds could also be important for understanding how different individuals or groups were using these tools and for what purpose. The co-occurrence of bifacial and blade technology at some sites is an important aspect of intra-site patterning that could have resulted from differences in individual tasks, variance during seasonal occupations, or longer term temporal variation. This inter-site patterning is exemplified by a comparison of sites 1 and 1A, the latter of which may have been related to the manufacture and maintenance of weaponry (Appendix A). Only 5.8% of the Site 1 assemblage is blade tools (Table 2.1), which are quite evenly distributed between jasper and chalcedony (21 blades and 27 blades, respectively). There are 58 bifaces, including 34 projectile points, at this site, which is presumed to be the youngest of Nelson's Shabarakh-usu collection. Blades at this site fall within in the larger range of sizes, particularly those made from chalcedony (Table 2.3). Conversely, 37% of the site 1A assemblage is made up of blades, which are highly constrained in size (Tables 2.1, 2.2). There are few chalcedony blades in this sample and no bifaces. In both samples, there is little difference in blade measurements according to raw material.

The most immediate means to investigate possible differences in blades between assemblages is through measurements. This method is particularly relevant since measurements are primary characteristics that define blades (more than twice as long as wide) and microblades (generally blades less than 10 mm in width) from other types of flakes. For this study, dimensions were compared between jasper and chalcedony blades. In order to avoid arbitrary divisions within the blade category, all flakes with full lengths twice as long as their widths were included. Segments that had clearly once been part of a blade were also included in this group. The following table indicates that although the mean measurements of jasper blades tend to be smaller, the coefficient of variation is slightly larger than among chalcedony blades, with the exception of the length measurement, which is equal.

		Min.	Max.	Mean	St. Dev.	CV
Jasper	length	8	92	25.76	7.926	0.308
(1,079)	width	3	29	8.30	3.150	0.379
	thickness	1	16	2.52	1.599	0.634
Chalcedony	length	8	58	25.86	7.978	0.308
(521)	width	2	26	8.08	3.086	0.351
	thickness	1	13	2.84	1.661	0.585

Table 4.1: Comparison of jasper and chalcedony blades from all sites. Measurements are in mm. CV indicates coefficient of variation (standard deviation over mean), a measure quantifying the amount of variation in a sample. A lower CV indicates less variation within the sample.

By removing outlying numbers from the sample, in this case measurements occurring less than 5% of the time, it was possible to test the degree of variation within the regular size range of artifacts. The table below shows that jasper blades are still more variable in size than chalcedony blades, even though the width and thicknesses are smaller on average. The difference in variations between measurements is only slight, but remains standard even after the outlying measurements are removed.

		Min.	Max.	Mean	St. Dev.	CV
Jasper	length	12	41	25.16	6.380	0.254
(1,021)	width	4	14	7.82	2.326	0.297
	thickness	1	3	1.95	0.656	0.336
Chalcedony	length	12	41	25.06	6.199	0.247
(493)	width	4	14	8.39	2.307	0.275
	thickness	1	3	2.18	0.623	0.286

Table 4.2: Comparison of jasper and chalcedony blades from all sites with outliers removed from sample.

Explaining this pattern is then contingent upon deciding whether the difference in size and variability was conditioned by natural flaking qualities of the raw materials, or some other factor. The fact that the sample shows very different mean measurements and CVs from site to site (Table 2.2) suggests that even within the confines of blade reduction sequences, there is some freedom in the range of possible outcomes for blade sizes. During the flaking of blade cores to produce these elongated flakes, variously sized flakes are removed, some of which are little more than slivers while others may be wide and thick enough to be mistaken for regular flakes. Those that are suitable can be removed from the site for use elsewhere, employed at the site and then removed for further use or disposal, or re-deposited at the site when expended.

Since transverse breakage of the blades suggests their modification for inset hafting, measurements among these functionally specific components should have similar means and CVs independent of raw material use, unless sizes are controlled by flaking properties of the material. The CVs in Table 4.3 indicate that a comparable degree of variation among medial segments is present between this group and the entire group when outliers are removed. With the exception of length, the means of each material are also similar to those in Table 4.2. The pattern of relatively low means and high CVs remains the same with jasper medial segments, as when the outliers were removed (with the exception of width CV).

		Min.	Max.	Mean	St. Dev.	CV
Jasper	length	8	41	21.30	6.154	0.289
(240)	width	3	14	7.20	1.882	0.261
	thickness	1	5	1.95	0.758	0.389
Chalcedony	length	8	40	21.29	5.929	0.278
(136)	width	2	14	7.73	2.176	0.281
	thickness	1	5	2.22	0.776	0.349

Table 4.3: Comparison of jasper and chalcedony medial blade segments from all sites. Measurements are in mm.

Therefore, the consistency with which chalcedony blades tend toward slightly larger sizes, despite being well within the same range as jasper ones, may suggest a slight bias among chalcedony blades towards larger sizes. Nevertheless, variations in blade size between raw materials are not uniform from site to site. Table 2.3 further illustrates that despite the overall impression of the sample in Table 4.3, the CV of chalcedony is not always smaller than that of jasper in a given site assemblage, nor are the mean measurements always larger. Based on the consistency of dimensional relationships between jasper and chalcedony blades, there may be some underlying relationship to limitations or allowances of certain raw materials, but a lack of similar associations on a site to site basis suggests that blade dimensions are controlled individually on a more site specific basis.

Blade dimensions on a site specific level may be more related to the size requirements of the knapper (or the consistency of knappers). When both bifaces and blades are used within an assemblage, this may affect blade size if blades are required for different tasks when bifaces are available. Assemblages from sites 1, 2, 4, 8, and 11, all contain bifaces. By ranking site assemblages hierarchically according to the relative number of bifaces that they contain (0, <10, 11 – 50, 51 – 100, >100), the range of measurements in each of the five groups can be mapped to discover if they vary independently of the number of bifaces in an assemblage. Figure 8.1 indicates that although the range of blade lengths appear to be independent, widths and thicknesses tend to increase in tandem with the relative number of bifaces in an assemblage.

Variation in blade dimensions appear to be reversely affected if their association with other Neolithic technologies or ostrich eggshell is tested. Table 5.1 suggests that blades associated with eggshell, grinding stones, pottery or bifaces tend to have smaller means and lower CVs. One explanation for the occurrence of smaller, more uniform blades in connection with these diagnostic artifacts is the functioning of these sites as processing camps, where exhausted inset blades – those presumably falling in a more closely controlled size range – were deposited. This interpretation is contentious, since lower CVs could also suggest less variation due to a shorter term occupation. As previously noted, the pottery category may also be less reliable due to later, intrusive sherds (Figure 3.3).

		Min.	Max.	Mean	St. Dev.	CV
Eggshell (1,239)	length	8	60	25.87	7.795	0.301
	width	3	29	8.37	3.131	0.374
	thickness	1	12	2.61	1.546	0.592
No Eggshell (377)	length	11	92	25.57	8.476	0.331
	width	2	26	8.86	3.270	0.369
	thickness	1	16	2.70	1.880	0.696
Grinding Stones (1,334)	length	8	60	25.75	7.496	0.291
	width	3	29	8.30	2.983	0.359
	thickness	1	12	2.57	1.528	0.594
No Grinding Stones (282)	length	8	92	26.07	9.862	0.378
	width	2	26	9.34	3.827	0.410
	thickness	1	16	2.94	2.017	0.687
Pottery (1,506)	length	8	60	25.59	7.657	0.299
	width	3	29	8.34	3.050	0.366
	thickness	1	16	2.57	1.562	0.608
No Pottery (110)	length	13	92	28.75	10.918	0.380
	width	2	22	10.43	4.035	0.387
	thickness	1	11	3.50	2.208	0.631
Bifaces (549)	length	8	60	26.81	9.139	0.341
	width	3	29	9.05	3.809	0.421
	thickness	1	16	2.89	1.993	0.690
No Bifaces (1067)	length	8	92	25.28	7.224	0.286
	width	2	28	8.19	2.741	0.335
	thickness	1	11	2.49	1.385	0.556

Table 5.1: Relationship between size of blades associated with ostrich eggshell, “Neolithic”-style technologies, or bifaces, and those not associated with these temporally diagnostic artifacts.

Nevertheless, if functional blades were used and discarded more regularly at sites where grinding stones and pottery were being used, it is rational to assume that the blades at those sites would be more likely to be worked. Since pottery may be a less reliable measure considering the uncertainty of its association with the assemblages, site assemblages containing grinding stones were analyzed (since grinding stones are less mobile than sherds). As expected, Table 6.1 indicates that blades not associated with grinding stones show lower frequencies of working and breakage, but higher frequencies of wear. These figures may indicate that sites with processing technologies like grinding stones differ in function from those without, and likely indicate longer term occupations where retooling was done. Among all tool types combined, there is little difference between the degree of breakage and wear among when the presence or absence of grinding stones is considered (between 32-38%).

	Wear		Breakage	Working
	overall	medium to heavy		
Blades associated with grinding stones	56.7%	21.4%	75.1%	8.1%
Blades not associated with grinding stones	73.6%	19.1%	54.5%	2.7%

Table 6.1: Relationship between the presence or absence of grinding stones and the frequency of wear, breakage and working of blades.

In contrast to the trend towards smaller blades in association with pottery, grinding stones, and ostrich eggshell, sites containing bifaces appear to have slightly larger blades, which may support the idea that bifaces encouraged the differential use of blades. It has already been suggested that the use of these technologies did not lead to a decline in the popularity of blades (Table 2.1); therefore, the most plausible explanation for variation in dimensions is that bifaces, and perhaps the amorphous flakes produced in their manufacture, had replaced some functions formerly filled by small, standardized microblades. This relationship may have resulted from new hunting technologies, like the bow and arrow. It is important to reiterate that further west, throughout the desert-steppe ranges of the Gobi-Altai mountains, bifaces are not found. Grinding stones, polished stone, and frequently pottery, are similarly absent from the archaeological records of these regions (Derevianko *et al.* 1996, 1998, 2000; John Olsen, personal communication, September 2006). This difference in technological organization elucidates the existence of separate foraging groups, with varying subsistence and lithic organizational strategies.

It is important to note that statistical tests of Neolithic technologies and blade size do not support the interpretation of a correlative association. This does not mean that bifacial technologies or other diagnostic "Neolithic" artifacts are unrelated to changes in blade size, but it does indicate that more studies of this relationship are necessary, including the application of additional statistical tests. Another concern is that the smaller means and larger CVs always occur among the larger sample sizes. This might suggest that the sample size is influencing these results, or that the patterns identified above are actually the result of one or two sites with more artifacts biasing the final results.

Collection group 1&2, followed by Site 8, have the highest number of blades in the sample and contains all types of Neolithic technologies, with the exception of bifaces. Table 2.2 further indicates that, although the means and CVs at these sites are not exceptional, they are relatively small. Even so, sites and subsurface components containing no Neolithic technologies tend to have even smaller CVs and means (see 1A, 4s-s, 8s-s on Table 2.2). In contrast, sites 1, 2 and 11 have relatively high numbers of bifaces and rather high mean lengths, widths, thicknesses. Bifacial tools may not have led to a decrease in the popularity of blades, but it is possible that blade technologies were applied to different tasks when bifaces were used.

Wedge-shaped microcores also appear to be correlated with a reduction in mean blade size at the Shabarakh-usu site (Table 7.1). This is probably due to size constraints upon the final product when the cores are worked. Wedge-shaped, along with flat-backed and other common microcore types, produce much smaller blanks than larger cores, like the cylindrical ones from Site 4 (Figure 2.1a). Wedge-shaped cores tend to have the potential to be used for a long time and the size of a core worked in this manner can be smaller than 1 cm when finally exhausted (Figure 2.1c). Collection 1&2 and all components of sites 4, 8 and 13 have not only the highest frequencies of wedge-shaped cores, but also contain a range of Neolithic technologies. It may be that the use of wedge-shaped cores in sites with more shell, grinding stones, pottery and bifaces contribute to the results summarized in Table 5.1.

Table 7.1 also summarizes correlations between blade size and medial blade segments. The correlation between medial segments and mean length is almost certainly a product of the reduced size of these blade types. There is no correlation between the use of wedge-shaped cores and medial segments.

Pearson Correlation Sig. (2-tailed) (N=13)	Wedge-shaped	Medial Segment
Mean Length	-0.522 (0.050)	-0.745 (0.004)
Mean Width	-0.556 (0.049)	-0.248 (0.413)
Mean Thickness	-0.545 (0.054)	-0.248 (0.413)
Blank	0.649 (0.016)	0.584 (0.036)
Wedge-shaped	1 (.)	0.312 (0.229)

Table 7.1: Correlation between blade sizes and two artifact types. Variation is significant at the 0.050 or -0.050 level.

In summary, variation between jasper and chalcedony blade dimensions appears to be controlled more by the assemblage type than by raw material constraints. These analyses also suggest that the most important factors influencing blade size are related to the use of bifaces (Figure 8.1), wedge-shaped cores (Table 7), and possibly Neolithic technologies (Table 5.1). All of these technologies are considered to have been introduced to existing microlithic assemblages, with bifaces, grinding stones, and pottery coming into use as late as the mid-Holocene. In North China, even wedge-shaped microcores appear to be more common in later microlithic assemblages (Chen and Wang 1989; Elston and Brantingham 2002). In addition to possible chronological associations with changes in blade production, it is important to note that the use of these technologies are also related to a suit of activities with implications for site function.

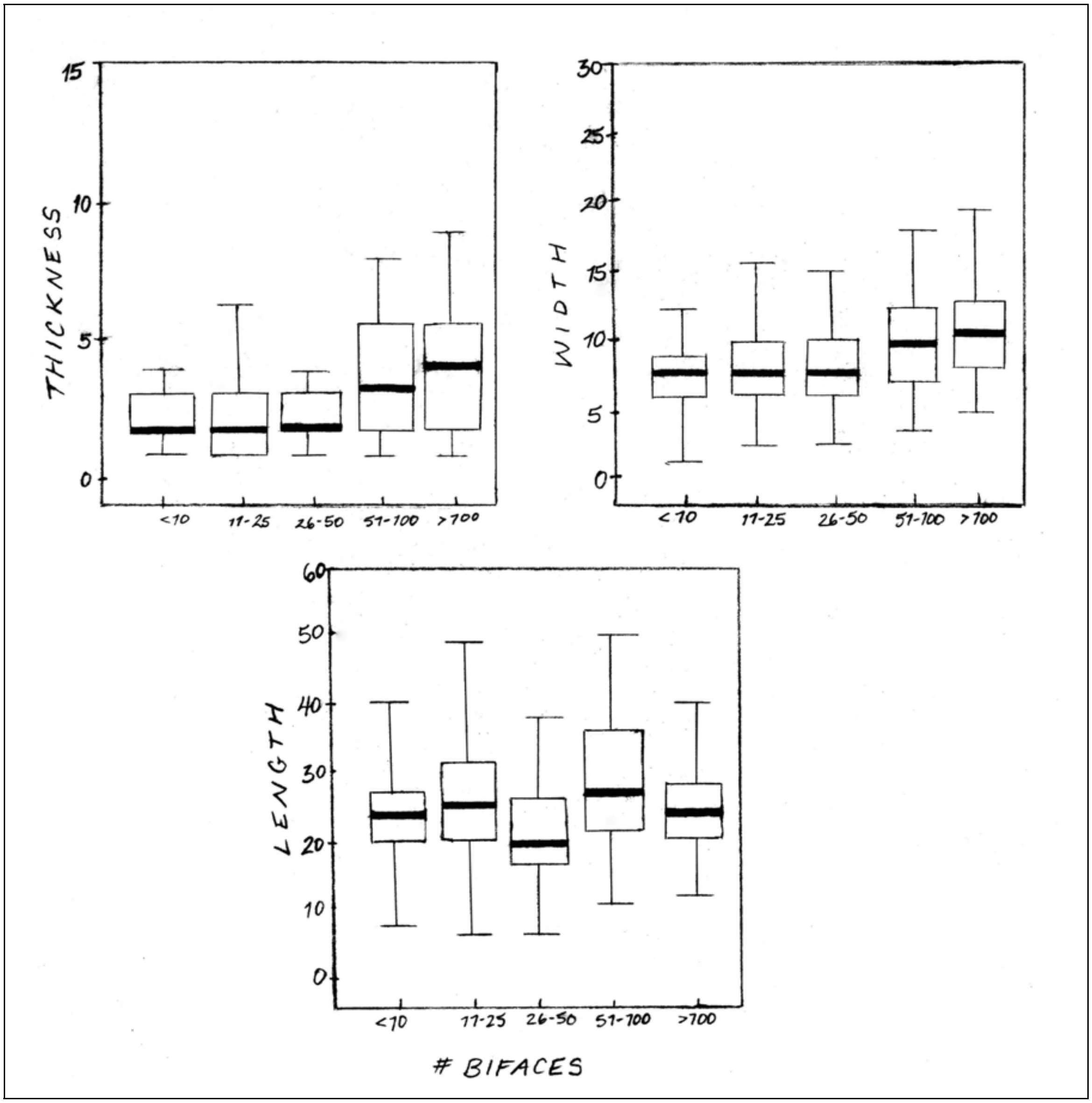

Figure 8.1: Boxplot illustrating the relationship between blade measurements and the number of bifaces in the collection each blade was associated with. Measurements are in mm.

DISCUSSION AND CONCLUSIONS

Studies of raw materials and blade dimensions focus on inter-assemblage variation as it relates directly to specific tool types within a larger site assemblage. The results of these tests indicate that there is a relationship between the types of raw materials chosen and the production of specific tool types. They also indicate that the types of artifacts used at a site are related to site function, which influence other aspects of tool production such as blade dimensions. Based on inter-assemblage variability in raw material use and blade dimensions, specific categories of sites can be defined and chronological implications assessed.

Raw material studies suggest that the use of chalcedony is positively correlated to the production of bifaces, and that the production of bifaces is related to the increased use of thumbnail scrapers and amorphous flakes. The influence of biface production on raw material procurement is also shown to be limited, as exemplified by site assemblages like Site 7. The implication of this discovery is that jasper and chalcedony may have been preferred for certain tasks, but the actual use of these materials depended on the availability of raw material resources. Despite the implications of biface production and chalcedony use for chronological reconstructions, changes in the availability of specific raw materials severely constrains the usefulness of such a technique.

An analysis of blade dimensions suggests a notable difference between the dimensions of blades produced from chalcedony cores and those produced from jasper cores, but further data indicates that this pattern is found only at the scale of the entire collection. While raw materials may have some influence on the blade dimensions, variation in these measurements from site to site indicates that the production of blades and their resulting dimensions is controlled differently at each site. The production of bifaces does appear to have an influence on blade widths and thicknesses, which may indicate that although the use of blades does not decline among assemblages with bifaces, that blade use changes as new technologies like projectile points and bifacially flaked knives replace them. A change in blade dimensions may then have chronological implications that might be applicable in additional contexts.

Finally, the form of blades that appear with site assemblages is also altered by the presence of Neolithic technologies like grinding stones. Blades from sites with grinding stones tend to have smaller lengths, widths and thicknesses, as well as showing less variation for each set of measurements (CV). These blades also enter the assemblage with less wear, but more retouch and breakage. Blunting retouch, or backing, is more common in blades associated with grinding stones. Several explanations for this are possible, including the use of these sites as longer term occupations were worked blades could be used and discarded in the same locale, or that specific tasks carried out at the site required the use of more heavily worked blades. The reduction in wear may be a product of the tool edges being reshaped by retouch, by their use in tasks less damaging to the edges, or by the increased availability of replacement blades.

Considering the results of this analysis in conjunction with site descriptions (Appendix A; Table 2.1) and the appearance of specific artifact types, four groups of assemblage types can be created. These include:

a. assemblages containing Neolithic technologies, ostrich eggshell, thumbnail scrapers, higher frequencies of utilized flakes and relatively equal or especially high frequencies of chalcedony in relation to jasper (1&2, 1, 2, 4, 8, surface finds from 13)

b. assemblages without bifaces or Neolithic technologies and minimal to no chalcedony (1A, 2as-s, 2bs-s)

c. assemblages containing bifaces but no other Neolithic technologies, chalcedony is most common (11)

d. assemblages found in ash pits (1As-s, 4s-s, 8s-s, most of 13)

The last of these assemblages were those found in what Nelson believed to be hearths. Their relationship with the associated surface components is unknown and they may or may not be contemporaneous. It is important to note that with the exception of two pieces of pottery found on the surface of the Site 8 ash pit, none of these assemblages contains Neolithic technologies or ostrich eggshell. Both 1As-s and 8s-s contain high frequencies of debitage and the artifacts in 1As-s were heavily used and many were burnt. A unique find of a polished and incised "shaft straightener" made of petrified wood was found beneath the ashes. Site 4s-s is exceptional because it contained high numbers of cores, as well as blanks (unutilized, unretouched and unbroken tools whose final form may not yet be determined) and other used and unused tools. The presence of these artifacts in ash pits suggests that they may be refuse, but it is also possible that some of the artifacts were being cached for later use.

Although the chronological relationship between site assemblages is difficult to assess based solely on the above characteristics, additional contextual information suggests the possibility that several temporal groupings can be identified. All the assemblages that do not Neolithic technologies were considered by Nelson to have been older. His assumption was based not only on the lack of Neolithic technologies, but also upon the stratigraphic context. Although Nelson's field notes do not express an opinion about the age of sites 2as-s and 2bs-s, it is probable that they are some of the oldest site assemblages in this collection. They were excavated from the base of sand dunes, lying almost directly on the valley floor. 2as-s appears to have resulted from one, short occupation episode. The 68 lithics were all made from a single type of chert and the majority of the artifacts were unutilized amorphous flakes, although a few tool types were also found. 2bs-s was collected from various small groups of artifacts found at the base of the dunes and the 54 lithics were mostly jasper debitage and few tools. Five pieces of ostrich eggshell were also found among the lithics.

The above explanation of Nelson's chronological sequence explains why he believed Site 1A to have been older than the majority of other site assemblages. His conclusions seem logical, and besides the emphasis on jasper raw materials, there are more blade cores (as opposed to microblade cores) here than at other sites and only 2.1% of the scrapers were of the thumbnail type. These points all suggest that this assemblage was different than the majority at Shabarakh-usu, those assemblages regarded as Neolithic. Stratigraphic observations on the part of Nelson further support the suggestion that this site was from an earlier period.

Site 11 is an important site because it contains technologies associated with a mid-Holocene date. This site is probably later those without bifaces, but it contains no evidence for other Neolithic technologies. Due to the abundance of projectile points, which are the most common artifact type after utilized flakes, a designation of hunting camp is appropriate. As a possible Neolithic site, Site 11 indicates that the playa margins were used for other purposes than the periodic extractive processing indicated by the presence of pottery, adze/axes and grinding stones at other Neolithic sites.

The majority of assemblages are considered to have been Neolithic. Nelson believed that Site 1 was the latest of these and that the others were transitional between the period of Site 1A and Site 1. Other than Site 1, which is much different in the frequency of various artifact types than the other in this group, these assemblages contain a range of artifact types and relative frequencies of jasper to chalcedony. They may be transitional, but they were mostly surface scatters and so may also represent a series of occupations from a range of time periods. Deflated and intermixed, they could easily mimic "transitional" periods. Interestingly, Nelson's notes suggest that sites 1 and 1A appeared less likely to have been contaminated with artifacts from other "temporal" sequences (Nelson 1925). Overall, three distinct time periods may be identifiable at Shabarakh-usu, as represented by Site 1, Site 1A, and by the subsurface components of Site 2. Surface assemblages from collection group 1&2 and sites 2, 4, and 8 may constitute a fourth temporally distinct group, but the scarcity of information about the formation of these scatters complicates the viability of this interpretation.

Despite Nelson's assertions about the nature of chronological change and raw material use, this designation of three, or possible four, time periods is based on possible stratigraphic associations, artifact types, and only partially the use of specific raw materials. While the use of chalcedony appear to have been related to the rise of bifacial technology, there is no proof that jasper and chalcedony ratios change progressively over time. The "earliest" sites make little use of chalcedony and the "latest" site is comprised almost entirely of chalcedony, but this simplistic association is contradicted by Site 7.

Site 7 suggests that despite an increase in the use of chalcedony when bifacial technologies appear, that forager mobility patterns, including seasonal constraints, may have played an important role in the frequency of raw material use among sites.

Whether or not the different flaking qualities of raw materials was instrumental in the vigorous representation of chalcedony at sites like 1 and 11, the importance of raw material procurement strategies can not be denied. Binford (1979) has suggested that procurement strategies may be arranged around other activities, rather than groups being organized for procurement specific tasks. In the case of the Nunamiut, raw material procurement occurred in conjunction with the round of seasonal subsistence activities, a model that seems reasonable, since the success of any group would depend on the efficient scheduling of activities related to subsistence. According to the Nunamiut model, changes in habitat range or the sequence in which different camps are occupied could explain changes in the types of raw materials being exploited at a specific locale.

In addition, changes in the availability of certain materials may be responsible for shifts in raw material use and procurement strategies. Alterations of the natural landscape, caused by seasonal conditions or more long-term geological contributors like deposition, deflation, or tectonics, are factors that could contribute to the accessibility of some quarries or the availability of workable cobbles. Thus, different materials may be differentially exploited depending on settlement patterns, the season, or short-term environmental changes. Since it is not known if these materials were merely picked up on the open steppes, or were obtained at quarries, it is difficult to speculate about how a preference for chalcedony might affect group organization, if at all. It is just as likely that groups using more chalcedony resources simply had better access to chalcedony than jasper, or that under most circumstances the two were similarly available.

Mobility is an interesting issue and a clearer understanding of raw material sources would be invaluable in the reconstruction of forager land use and how it changed over time. Two ecological explanations for the introduction of extractive processing technologies have been suggested: an increase in aridity that caused a decline in the availability of other resources, and an increase in humidity which made the exploitation of playa resources more profitable through enhanced biomass productivity. Ethnographic studies of modern desert foragers suggest that mobility in arid environments is seasonally constrained by the availability of water (Binford 1980; Kelly 1995: 117, 126-127). Foragers are seen as being tethered to regions where water is available and their movements become increasingly constricted as distances between water-rich locales expands. Increased aridity could then be expected to restrict the range of foragers, perhaps forcing them to spend more time in one spot or to exploit a wider range of resources.

Despite possible evidence for the exploitation of a broader range of resources, the Shabarakh-usu collection does not show evidence for increasingly long-term habitations. More frequent evidence of worked blades at sites with Neolithic technologies does support this possibility, but considering that the assemblages that they are compared against are from ash pits, one extremely short-term occupation, another collection of artifacts from several small scatters, and one assemblage with a comparable number of artifacts, this slight evidence is insufficient to support such a conclusion. The low frequencies of Neolithic technologies that appear in the archaeological record of the dune-playa regions do not suggest longer term occupations than sites without these technologies, they simply indicate that some new resources were likely being exploited.

The presence of ostrich eggshell among Neolithic sites is significant because it implies the contemporaneous existence of ostriches. Ostriches require a specific sort of environment, including open grasslands and a precise level of precipitation (Manlius 2001; Wendorf et al. 1977), but are also seen as capable of surviving droughts better than many other steppe animals (Sampson 1994). Slightly wetter conditions than today may have been needed in the south Gobi Desert to have promoted a resurgence in grasslands that would have been provided the sufficient ecological conditions for ostrich. Ostrich eggshell has been found throughout archaeological sites in North China (Jia and Huang 1985; Madsen et al. 2001) and Mongolia (Derevianko et al. 2003; Fairservis 1993) since the Upper Paleolithic, and appears to have been used regularly for bead-making and containers. In South Africa, eggs were used for bead-making since the Late Stone Age and were used as a source of protein by hunter-gatherers in recent centuries (Sampson 1994).

Suggestions have also been made that eggshells were from fossilized shell – and indeed, there were fragments of Cretaceous oviraptor eggshell at Shabarakh-usu – or that they were traded from somewhere else. The latter idea is partially contradicted by possible evidence for an eggshell bowl at Chikhen Agui, which may not have been as easily transported in trade as beads. If the eggshell used at these sites proved to be of a Holocene age, it is more likely that they indicate the use of fresh eggshell.

In further consideration of possible ecological motivators, dates from Pigeon Spring of approximately 11,500 BP (Elston et al. 1997) suggest that dune regions around springs and playas may have been initially occupied regularly following the Younger Dryas and before the early Holocene period of increased humidity. Similar dates from Zhalainuo'er (John Olsen, personal communication, September 2006) further support this conclusion. This would support that notion that desert conditions may have tied foragers to areas where water was more readily available. In the case of Neolithic type dune-playa adaptations in the south Gobi, these are likely to have taken place in the mid-Holocene, based on dates for Neolithic technologies in North China. If the introduction of these technologies are related to increased precipitation resulting from a northward shift in monsoon rains, new technologies may have been employed to utilize a range of new resources (see Richerson et al. 2001). These technologies may also have been introduced earlier to take advantage of a broader range of resources as desiccation negatively affected the obtainability traditional resources.

A florescence of playa adaptations in the mid-Holocene explains the widespread use of small numbers of Neolithic technologies throughout the south-western ranges of the Gobi. The distribution of Neolithic technologies in Inner Mongolia and southern Mongolia show that the majority of sites with high numbers of grinding stones have been found in the more eastern extents reaches. While grinding stones are found in small numbers among collections west of 105°E longitude, including those from Shabarakh-usu and elsewhere in the southern reaches of the Gobi Desert, including the Yellow Gobi (Derevianko et al. 1996; Derevianko et al. 1998; Derevianko et al. 2000; Appendix C) and the Alashan Plateau (Bettinger et al. 1994; Appendix B), some of the sites collected between 105°E and 113°E longitude during the 1928 Central Asiatic Expeditions, contain extremely high numbers of grinding stones (Fairservis 1993; Appendix B).

This divergence suggests a very specific adaptation to the dune-playa formations of the southern basin-ranges that differed greatly from the adaptations of millet-producing communities in North China. Neolithic technologies were likely to have been cached at sites where appropriate resources were available, used only for specific purposes and on a limited basis. Throughout the remainder of the year, it is probable that similar technologies were employed by these groups, as were used by foragers in the north. The main exception to this similarity in technologies would have been the use of bifaces. If this is true, the distribution of bifacial technology may then be distinctive enough to delineate group boundaries. Thus, the assemblages from Shabarakh-usu may be devoid of evidence for Neolithic cultivation or agriculture, they are probably the result of forager groups periodically exploiting wetland resources and eventually adopting a suite of "Neolithic" technologies well-suited to their subsistence needs. By the time that these adaptations disappear, there is already some evidence in eastern Mongolia (see Tamsagbulag, Figure 1.1) for the established use of domesticated cattle and ovicaprids in conjunction with a continued reliance on hunting (Cybiktarov 2002).

In order to better understand these adaptations, specific types of research must be carried out. As noted frequently herein, the lack of chronometric dates is problematic for a reconstruction of technological shifts and their relationship to ecological forces. The current lack of dates in Mongolia is due in part to the lack of organic preservation. Radiocarbon dating of ostrich eggshell and thermoluminescence on pottery may provide the most immediate results, since museum collections currently contain both types of material. The Shabarakh-usu collection would benefit from greatly from dates on ostrich eggshell from 2bs-s and several of the samples from the surface. This would provide dates on both subsurface and surface components. OSL (optically stimulated luminescence) dates from various stratigraphic levels at Shabarakh-usu might provide chronometric data related to both artifacts and paleoenvironmental shifts, if a geological chronology could be established.

Raw material sourcing studies could prove at least as important as chronometric dates. An understanding of where specific types of jasper and chalcedony were obtained might help to clarify mobility between time periods, as well as offer explanations for more short-term mobility patterns. Intra-assemblage variation among raw materials in relation to their degree of wear has been used to trace the movements of Paleolithic people in the both the United States (Hofman 1991) and Europe (Féblot-Augustins 1993). While knowledge of raw material sources would not provide a better understanding of chronology, it would allow clearer associations between artifact assemblages, foraging strategies and adaptations to the regional environment to be established.

A closer examination of late Pleistocene and early Holocene geological processes at Bayan-dzak might also be productive in reconstructing environmental changes in the basin. An important aspect of geological studies would be coring playa sediments and an analysis of changes in pollen ratios and microfauna following the LGM. Ideally, these studies could be carried out along with additional archaeological excavations that might give an better indication of stratigraphic associations between assemblage types. Finally, further analysis of existing collections from the south Gobi Desert and from the Alashan Plateau would aid in the identification of differences and similarities between types of sites and the distribution of Neolithic technologies.

In conclusion, it is unclear what drove foragers to adopt a new suite of technological adaptations. What can be said is that these adaptations were unique to a specific environment within the Gobi Desert and that they were added to a series of existing adaptations that foragers in the region had probably been using at least as early as the end of the Younger Dryas. The use of Neolithic technologies in this region is not characterized by the wholesale adoption of agricultural technologies, but by selective utilization of Neolithic technologies that were becoming widespread throughout Northeast Asia among both agriculturalists in China and other types of foraging groups in Siberia and Japan.

APPENDIX A

DESCRIPTION OF SITE ASSEMBLAGES

Collections made from the surface around Sites 1 and 2

As defined by the AMNH catalogue, this assemblage is composed of artifacts found around the periphery of Sites 1 and 2. These artifacts had eroded out of the dunes that lay between Sites 1 and 2. The main artifact types are distributed fairly evenly among processing tools, debitage, unused tools and insets; thus, a range of activities is suggested. Most of the wear on these artifacts is higher than at the majority of sites and there is some evidence of usewear in the form of striations on the perforators. The bulk of this site, barring too much interference from later time periods, is probably contemporaneous with Sites 1A, 8, and possibly Site 2. A multipurpose site is suggested by the wide range of artifacts present, including the 220 ostrich eggshell fragments and 16 pieces of fossilized oviraptor eggshell (Mark Norell, personal communication, November 2004) that the inhabitants were working into beads.

Site 1, surface and subsurface

Lying at a higher stratigraphic level than Sites 1A and 2, this locality was found in a small blow-out on the southern side of the ravine. Marked by a series of levels, the compacted dune profile exhibited “one extensive and several small independent [levels] marking water ponds – some with traces of vegetable matter enclosed” (Nelson 1925:35). The artifacts included in Site 1 were found scattered around and inside the dune from which they had been deflated. This assemblage was partially excavated and no fire-cracked rocks or hearths were found.

While a total of 934 artifacts was brought back to the AMNH, there were originally 128 pieces of pottery and 7,107 lithics. There were also bivalve shell beads present, one with two perforations as though intended for use as a button (these were not found among the Museum collections). The vast majority of the material that Nelson discarded was white chalcedony and this may influence the interpretation of jasper-to-chalcedony ratios for specific artifact types. Notably, most of the discarded material was debitage and there were no microcores present. Both ostrich eggshells and mammal bone are included in this assemblage. This site is probably the youngest of the sites and the high frequency of debitage as well as a lack of hearth features suggests an accumulation of debitage from tool manufacture.

Site 1A, surface and subsurface

Site 1A was found on the valley floor only 206 m from Site 1, 80° northwest. There were 2,267 artifacts spread out on the surface and scattered among sand dunes. The subsurface component was found underneath 13 cm of ash. Numerous fire-cracked rocks and a great deal of chipped material were found, including a double-grooved shaft straightener or smoother lying face down among various other artifacts, beneath the layer of ash, which was covered with 5 cm of clay.

The lack of formal tools and blades suggests that the subsurface group served as an ash dump for debitage, discarded tools and cores. Many of the flakes were burnt. The artifacts found in the 1A ash pit include the shaft straightener, along with a range of debitage, cores, and tools that had been discarded. In the surface component, insets are the most common tool type, while debitage dominates the subsurface assemblage.

Despite this difference, the frequency of jasper to chalcedony is nearly identical. The only Neolithic technologies found at Site 1A, with the exception of the pottery which Nelson took to be intrusive, included a piece of volcanic tuff ground into a leaf-shaped implement that could have been easily held and transported, possibly as a grinding stone. The subsurface component contained more standardized core forms than the surface group. This site probably functioned in the manufacture of hunting equipment, further exemplified by the high frequency of blunting retouch in this group. Relying on evidence for a dependence upon jasper, a focus on insets and blade tools rather than bifaces and flake tools, and the lack of typical Neolithic technologies, this site was probably older than Site 1.

Site 2, surface

Site 2 was found just a few meters north of Sites 1 and 1A, and Nelson reports that the locale was very rich in artifacts, with thousands of flakes running up the slope to the base of a low escarpment where they appeared to be in place. After digging into the dunes, Nelson found some pieces at a depth of about 8 cm below the surface, while only a quarter of the site remained in place within the dune matrix (Nelson 1925). The base of the artifact layer was 1.35 m below the aforementioned “mud” layer. The white chalcedony flakes, which lay around the periphery of this group, indicated that an earlier stratigraphic level had already been deflated from the nearby dunes. It is probable that these flakes were included in the Site 1&2 assemblage, but Nelson is not clear on this point.

The highly polished adzes and axes in this group may have originated from later occupations since such tools are commonly found only within levels of occupation associated with the late Neolithic (Derevianko and Dorj 1992), and are the only ones found among the sites analyzed. Other Neolithic technologies were found here, but in low numbers. As in the subsurface component of 1A, Nelson found fragments of a shaft straightener or smoother made on petrified wood. In addition, a flaked lanceolate biface made on mottled, coarse-grained, orange and black stone was found and is unique in the Shabarakh-usu collections. There is a range of artifact types, but the highest distribution is between debitage and cores. The cores in this group are mostly generalized cores used in producing amorphous flakes. There are also few tools related to hunting in this sample, but scrapers are common and this site has a higher frequency of flake wear than other Shabarakh-usu sites. Secondary retouch is also more common than at the majority of sites.

There are 55 ostrich eggshell fragments that had been worked for preparation as beads, but no bone was found. This assemblage appears to be consistent with a multi-purpose site, but this impression arises from the wide range of artifacts at the site, which may have resulted from the intermixing of several occupations. The relatively small sample size in relation to Nelson's report of thousands of flakes may also indicate a bias in sampling. Nelson probably discarded most of the debitage and kept more of the worked artifacts.

Site 2a, subsurface from one discreet cluster

This assemblages is composed entirely of green or black and yellow cryptocrystallines referred to in the museum catalogues as chert. This group seems unrelated to the surface level accumulations just discussed. There are no Neolithic technologies present nor are there any faunal remains in this group. This assemblage is small and very consistent in the use of raw materials. There is also no evidence for retouch and the blades are rather large – only one of these can be considered a true microblade (9 mm). This assemblage may be earlier than the other collections discussed here, based on blade size and the lack of diagnostic artifacts. Furthermore, the consistency of raw material use indicates that the assemblage should be seen as resulting from a single occupation episode. Site 2a is probably older than Site 2, as evidenced by the lower stratigraphic level. This site may also be older than 2 s-s, as it was collected from the very base of the dunes.

Site 2, subsurface from various locations

The second subsurface component of Site 2 was collected from various locations where artifacts were found eroding from the dunes. CV calculations suggest that the blades in this group were heavily dispersed, but figure 9 indicates that the range of widths were centered in both the 5-10mm and 11-15 mm categories, indicating focus on wider blades. Notably, 13% of the assemblage was made of "chert," suggesting a relationship with 2as-s. The microcores in this groups are conical or cylindrical and rough, but no wedge-shaped cores were found.

Additionally, faunal remains were excavated from the nearby dunes and although their relationship to the artifacts is unclear, they include a fully articulated lagomorph skeleton and equine teeth (identified by the AMNH Paleontology Department as belonging to a wild ass or other equid) from 5 and 6 m below the surface, respectively. An unidentified, and now missing, metapodial belonging to some large – though it is not clear how large – animal, along with calcined bone fragments, were found at the base of the dune. Five fragments of ostrich eggshell were associated with one set of the artifacts collected for this assemblage, but were not unequivocally worked. These artifacts came from a lower stratigraphic level than the "surface" component and should be considered to be older.

Site 4, surface

Sites 3 and 4 were found near the northern end of the stabilized dune formation, about 2-3 km north of the previous group of sites on the western edge of the saxual-dune to gobi-steppe transitional zone. The two sites are about 0.8 km apart, the former lying further east on a slope among the dunes. Here there are a series of east-west finger-like escarpments with the high ends facing west and U-shaped hollows scoured out between them. The whole valley was strewn with material and Site 3 was found in the two lowest and southernmost of the ridges with distinct hearth lines full of ashes, charcoal, bone, broken rock and chipped stone. Site 4 was collected by gathering artifacts from several distinct groups over several hundred meters. Rather than being the remains of one occupation, this assemblage combines artifacts from several discrete clusters. The subsurface component was actually an ash pit from one of the artifact clusters (4E) that makes up Site 4.

All types of Neolithic technologies were present in relatively high numbers at Site 4, except for polishing. Although there is a higher frequency of chalcedony in comparison to jasper, the two are almost equal. The dispersed collection area may be responsible for this, if two distinct time periods were originally represented. The artifacts in this site assemblage are distributed mostly between debitage and processing related tools, including a large number of scrapers. Both jasper and chalcedony were used in the production of bifaces, but white chalcedony is the most common material used.

There are a number of core types at this site, the most interesting being several large barrel-shaped cores made of chalcedony or fine-grained quartzite, which were not found at other Shabarakh-usu sites. Other microblade cores were wedge-shaped or simply roughly worked and several flake cores were also included in this group. A range of artifacts were found here, but since there is a lack of contextual consistency, no interpretation made about the function of this site. It is probable that these artifacts come from a range of time periods, but the majority of the assemblage is related to later periods as evidenced by the raw materials used and the presence of many diagnostic Neolithic technologies. Additionally, 296 unmodified ostrich eggshell fragments and three fragments of bone were found.

Site 4E, subsurface

This accumulation of bone and lithics was found in and under a deposit of ashes. About 270 m to the southwest, one sherd, some lithics and ostrich eggshell fragments were found. Southeast of 4E, about 460 m away, an accumulation of reddish colored ceramics was also found. Site 4E itself was the surface component of one coherent group of artifacts that was subsumed within with Site 4 assemblage. Nelson noted that the surface component of 4E contained, among other things, a flaked adze, a pestle (that is not included in the museum catalogues, but added to the table 4), cores, potsherds, thumbnail scrapers, side scrapers, two projectile points, small curved knives made on narrow blades, and a large knife or point. In the subsurface component, one fragment of ground slate-like stone was also found and considered to be a scraper by Nelson.

The subsurface component is interesting because it contains a similar ratio of jasper to chalcedony as Sites 2, 8 and 13. Like other subsurface components, 4s-s contains a high frequency of debitage and little wear or retouch and 38.2% of the assemblage was unused, but finished tools. Although Nelson's journal mentions a group of fragmentary bone among the lithics, none were listed in the museum catalogue, nor are there any ostrich eggshell fragments. Based solely on raw material use and blade measurements, this group of artifacts site is most like the surface component of sites 8, 2, 13.

Site 8, surface and subsurface components

Several sites were found in the southwestern region of the dune formation, focusing on the small playa and extending east along the ravine that follows the southern edge of the dune fields. This is where the remainder of the sites collected by Nelson was found. Nelson saw Sites 5-9 as having a close chronological relationship (Nelson 1925). These sites, with the exception of Site 9, contain more jasper than chalcedony and Site 5, 8, and 9 assemblages have fairly balanced distributions.

Site 5 was found about 350-450 m southeast of Site 7, which was located between Site 6 and the playa, about 360 m northwest of the former. Site 7 lay across a mostly flat and level surface stretching west towards the playa and interspersed with oblong hollows of compacted sand, eroded by wind and water. Extremely rich in artifacts, this site produced 15,600 specimens, of which 677 were kept. The assemblage was comprised primarily of small chips made on pebbles and there was a lack of standardized microcores. Nelson believed that it represented the transitional stage between early jasper and later chalcedony sites. The bifaces in this group were made on jasper and other than these, no other Neolithic technologies were found here. Site 9 was located on a large, nearly flat surface of about 60 x 150 m, which lay north of the playa and a bit below at least two "high water marks"[7].

Located at a higher elevation than other neighboring sites, Site 8 lay about 1.2 km southeast of Site 7. It consisted of several scattered spots which were within a few

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[7] It is not clear if by this Nelson means the beach strand lines on the western edge of the playa or another "mud" layer. If the latter is inferred, than this may indicate that Site 9 is *older* than Sites 5-8 and possibly as old as Sites 1A and 2. The relationship between these "mud" layers or high water marks and the chronology of these sites is suspect. It is probable that several episodes of shifting water tables may have resulted in these marks and Nelson's descriptions give us very little information by which to judge the nature of their establishment.

meters of each other, on rolling ground between the high dunes in the north and a streambed to the south. There also appeared to be pottery lying embedded in the ashes of another ash pit. Although no adze/axes were found, there was one grinding stone and several bifaces. This site assemblage, including both the surface and subsurface components, provides ample evidence for processing, but there are few hunting-related artifacts.

Compositionally, Site 8 is more like Collection 1&2, showing high numbers of both hunting related and processing related tools, as well as the presence of more Neolithic technologies. Furthermore, a similarly high degree of wear is attested. This group also contains a wide range of core types, with higher frequencies of the wedge-shaped type. There are a few dressed ostrich eggshell fragments but no bone. As a whole, Site 8 suggests a multi-purpose site and may be older than Site 1, but younger than Site 1A.

Site 11, surface

As do all the easternmost sites, Site 11 lies in the transition zone where vegetation thins out and dunes recede onto the bare valley floor separating the dunes from the gobi-steppe. The entire area slopes gently to the west, towards the playa. This particular site lay about 3 m lower than the other sites in the vicinity, which may be one reason why Nelson believed that it was older than the others. The entire assemblage was fixed in or on top of an alluvial fan and there were no fire-cracked rocks or hearth features. Projectiles were most common in this group but Nelson also reported microblades and a large number of cores. The microblades that were collected lay in an area of approximately 30 m in diameter.

Although the two types of artifacts were found together, Nelson believed that these projectiles were much earlier than ones from other Shabarakh-usu sites (1925). It is plausible that Nelson's observation was correct, at least as far as the inconsistency between the various styles of projectile points found at Shabarakh-usu. Nevertheless, the exact chronological relationship can not be judged accurately for such a small sample size. Like many of the others at this site, it was reduced significantly from 1,139 to 505. Nelson originally reported the existence of over 170 cores, 694 debitage flakes, 24 blanks, 16 end scrapers, 190 projectile points, 20 worked flakes and 25 blades. While the number of blanks seems to have more than doubled to 60, the number of cores and flakes were greatly decreased.

The lithic assemblage is composed almost exclusively of the speckled black chalcedony-like material that Nelson refers to as "yellow-moss jasper." Other than these projectile points, there are no other indicators of a Neolithic age. Only nine of the bifaces in this group were made on jasper; half the blades were jasper and the other half chalcedony. Variously fractured projectiles (153 out of 159), possibly resulting from impact during use, filled this sample and the remarkably high degree of wear but lack of retouch suggests that this site may have been an area of tool reworking and disposal, or perhaps a kill/butcher site, where hunters were butchering animals with blade and flake tools but not taking the time to formally retouch them. Blade sizes appear to be consistent with those of Sites 1, 4 and 13 and the CV shows a degree of variation in measurements. The cores in this group were primarily generalized flake cores but wedge-shaped microcores and elongated flake cores were also present. Assigning this site to a specific time period is difficult because the relationship between blade and projectile point components is unclear. Due to the high number of bifaces present, this site may be roughly contemporaneous with Site 1.

Site 13, surface and subsurface

Although the museum catalogue refers to this as a surface site, Nelson reports having dug out four hearths, all 0.9-1.5 m in diameter and 1.3-5.2 cm deep, which were full of ashes and rock but no potsherds. He later found several sherds in the vicinity, including four pieces 180 m north of the main site. Site 13 is about 360-460 m east of Site 8 and just north of the ravine, which contained flowing water at the time of Nelson's investigations (mid to late May). This assemblage was composed of artifacts from several ash pits within a radius of 46 m. Nelson's notes do not explicitly state whether the whole site assemblage came from the ash pits or if surface scatters were also included. His journal further indicates that the features were not thoroughly excavated and about 35% of the total assemblage was discarded.

Most of the tools in this assemblage were related to processing and there was also a relatively high number of insets and debitage. Only two bifacially flaked knives were present and both were made of white chalcedony, which was also used in the manufacture of two drill points. These were the only Neolithic technologies found at Site 13, which is not surprising since these types of tools tend not to be associated in large numbers with the ash pit features. There is a relatively high number of worn and retouched tools.

APPENDIX B

POST PLEISTOCENE MICROLITHIC SITES IN THE SOUTHERN GOBI[8]

Region	Site	Pottery	Grdstone	Adze/Axe	Projectile	Biface	Perforator	Blade	Uniface	Core	Total #
Bayan-	1&2	105	1	1	34	18	7	772	208	98	2002
dzak	1	73	1				11	48	22	11	934
	1A							233	47	22	452
1925	1As-s							16	1	4	93
	2	2	2	6	3	3	1	46	48	29	254
	2as-s							5		2	68
	2bs-s							7	2	5	151
	4	168		1	6	11	4	131	52	25	905
	4s-s							18	2	3	35
	8	47	2		6	1	1	240	88	59	582
	8s-s	2						21	1	1	82
	11				69	88		64	23	80	523
	13	9				1	2	23	24	5	93
Pigeon	surface	6	5	17		21		9	17	19	242
Mountain	in situ		1		1			215	14	21	891
Inner	1	9	1	14	3	3		11	44	25	
Mongolia	3							53	3	2	
(as well	4				2	2	2	45	24	11	
as Suiyuan	5			1	1	1	1	28	10	14	
& Chahar)	6	47	1		9		12	710	121	22	
	6D							31	11	21	
1928	7	5			1		1	117	36	11	
	9F				1		1		13	88	
	10				1		2	12	14	5	
	11					3		64	2	76	
	12							10	11	22	
	13						1	5	6	6	
	13A							34	8	9	
	14				1		2	62	2	9	
	15				1			35	3	17	
	16	72	1		6		3	59	54	62	
	17		1				3	26	3	8	
	18	54	25	1	26		35	1912	549	140	
	19	180	116	22	28		44	2491	1226	236	
	20	2	5		1		2	15	20	9	
	20A	1	2		1	1		3	1	2	
	20B	1					1	22	1	13	

[8] Data from Bettinger et al 1994; Fairservis 1993; Elston et al. 1997

Region	Site	Pottery	Grdstone	Adze/Axe	Projectile	Biface	Perforator	Blade	Uniface	Core	Total #
Inner	21		1	1	3		1		18	21	
Mongolia	22		6	2			2	97	12	19	
(as well as	23A	19	2		4			18	2	51	
Suiyuan	24A		3		3			86	15	8	
& Chahar)	26		2	1	2	44	2	308	6	128	
	28A		5	4	4	22		33	3	39	
1928	29		3	2		23	3	119	1	22	
	30A		1			12		12		22	
	31	2	9		15	31	2	350	3	81	
	32	3	2		7	28	3	28		33	
	33		10	2	1	24	1	143	3	72	
	34									24	
	35	124	25	13	9	247	4	168	38	104	
	36					1		1		5	
Inner	48	77	1			4		249	45	28	405
Mongolia	176	121		1				146	5	15	288
(Alashan)	177			1			4	929	5	8	947
	178	1						7			8
1927-1935	179	13						2			15
	180	11		1			5	196	8	12	237
	181	19		1	1		4	29	7	1	62
	182							1	1		2
	183	1		1			1	60		2	65
	184	4						24	2	2	32
	185							2	3	1	6
	186							48	11	4	63
	187									1	1
	188							13	1		14
	189			1			1	78	9	4	93
	206							20	11	7	38
	207	11		5			3	73	5	15	112
	208	1		2				1		10	14
	209	37		3		9	2	313	4	91	461
	210	7		8		7		122	22	104	287
	211							7	1	3	11
	212	51	1	3		3	14	254	37	89	455
	213			1	13			9	2	4	16
	214							1			1
	215							5	1	1	7
	216				2			74	6	3	85
	217							22	1	5	29
	218	2				1	4	221	14	44	286

Region	Site	Pottery	Grdstone	Adze/Axe	Projectile	Biface	Perforator	Blades	Uniface	Core	Total #
Inner	219								1		1
Mongolia	220					1			2	1	5
(Alashan)	221							20	5	5	30
	222	1				1	1	33	6	1	43
1927-1935	223	6		1	1	1	2	78	84	23	196
	224	5			1			9	2		17
	225			1		2	1	42	9	23	82
	226					1		59	3	6	69
	227	2						6	3	2	14
	228					3		2		1	8
	229							4		1	5
	230	67									75
	231			3		1	2	279	20	88	404
	232			2	1				6	8	20
	233							201	35	65	306
	234	1		1		8	1	52	3	40	108
	235	1	1	2	1			137	17	54	221
	236	2	2	8		21	1	787	66	263	1163
	237					1			5	9	16
	238					1	1	26	1	22	51
	239	1		4					8	11	24
	240		3	6		2	2	890	80	99	1092
	241			13		1	1	1147	32	271	462
	243								3	3	7
	244							5			5
	245									3	3
	246						2	186		7	195
	247					1	6	145	1	6	160
	248	38		38			1	57		1	97
	249					1					1
	250							1			1
	251										1

APPENDIX C

SUMMARY OF GOBI LITHIC SITES[9]

Year	Site/Locus	Type	N =	Period	Location	Description	Nature
1925	Shabarakh-usu	surface		4,5	Ömnögov'province		
	1&2		1661			valley b/wn dunes	4
	1		824			--------"--------	3,4
	1A		1291			--------"--------	3,4
	2		319			--------"--------	3,4
	4		473			--------"--------	4
	8		615			east of playa	4
	11		523			transition to plain	4
	13		84			--------"--------	4
1985	Baidarik Gol	surface			Valley of the Lakes	along Baidarik	
/86	1		18	3	(north of Gobi-Altai	and Tsagaan river	1
	2		4	3	range, south of	valleys, on terrace	1
	3		9	3	Khangai range)	ledge or slope	1
	4		111	2,3			2
	5		6	3			1
	6		12	3			1
	7		29	2,3			1
	8		92	3			1
	9		68	2,3			1
	10		172	2,3			2
	11		49	3			1
	12		17	3			1
1960	Baidarik	surface					
	1		70	2,3			1,2
1977	Baidarik	surface	721	2,3	Valley of the Lakes	Nariin river valley	3
1985	Nariin Gol	surface					
/86	1		18	2,3			1
	2		27	3			1
	3		45	2,3			2
	4		21	3			1
	5		61	3			1
	6		48	2,3			2
	6A		25	2,3			2
	7		30	3			1
	7A		23	2,3			1
	8		13	3			1
	9		8	3			1
	10		18	2,3			1

[9] Period is assigned based on the description of authors or by their own assignation. All categorizations for period and nature follow those suggested by Derevianko (2000). Period: 1 = Pre-"Mousterian", 2 = "Mousterian", 3 = Late Paleolithic, 4 = Mesolithic, 5 = Neolithic. Nature: 1 = Locality, 2 = Workshop, 3 = Occupation site and Workshop, 4 = Long term / Seasonal Occupation. Two numbers indicates uncertainty over classification or the presence of artifacts from more than one time period. From Derevianko 2000 and Derevianko et al. 1996, 1998, 2000. Note: "Neolithic" refers to complexes with Neolithic technologies.

Year	Site/Locus	Type	N =	Period	Location	Description	Nature
1985	Nariin Gol	surface			Valley of the Lakes	Nariin river valley	
/86	11		10	3			1
	12		10	2,3			1
	13		15	2			1
	14		10	2			1
	15		12	2			1
	16		10	3			1
	17A		686	2,3		mountain basin	2
	17B		212	2,3		along old river	2
	17C		65	2,3		channel	2
	17D		33	2			2
	17E		220	2,3			2
	17F		37	2,3			1
	17G		38	2,3			1?
	18		83	2,3			2
	19		30	3			1
	21		10	3			1
	22A		50	3			1
	22B		20	3			1
	23		16	3			1
	24A		14	3			1
	24B		45	3			1
	25		28	3			1
	26A		27	3			1
	26B		31	3			1
	26D		31	3			1
	27		34	3			2
	29		211	3			1
	30		20	3			1
	31		11	3			1
	32		47	3			1
	33		7	3			1
	34		15	3			1
	35		57	3			1
	36		24	3			1
	37		39	3			1
	Tuin Gol	surface			Valley of the Lakes	Tuin river valley,	
	left bank		6	3		left bank – near	1
	2		35	3		Bayankhongor	1
	3		25	3		center	1
	4		15	3			1
	5		19	3			1
	6		37	3,4			1
	7		18	3			1
	8		33	3			1
	10		98	3			2
	11		40	3			1
	12		18	3			1
	13		42	3			1

Year	Site/Locus	Type	N =	Period	Location	Description	Nature
1985 /86	Tuin Gol left bank	surface			Valley of the Lakes	Tuin river valley, west bank – near Bayankhongor city	
	14		52	3			1
	15		218	3			2
	16		64	3			1
	17		64	3			1
	18		53	3			1
	19		69	3			1
	20		102	3,4			2
	21		85	3			1
	22		89	3			1
	23		48	3			1
	24		187	3			2
	27		23	3			1
	28		57	3			1
	29		13	3			1
	30		10	3			1
	31		21	3			2
	32		21	3			1
	33		46	3			1
	34		37	3			1
	35		21	3			1
	Tuin Gol right bank	surface			Valley of the Lakes	right bank	
	2		125	3			2
	4		17	3			1
	5		26	3			1
	5	in situ	682	3			1
	6	surface	63	3			2
	7		11	3			1
	8		26	3			1
	9		23	3			1
	14		46	3			1
	15		49	3			2
	16		101	3			1
	17		4	3			2
	18		16	3			1
	19		9	3			1
	Bogd	surface			Valley of the Lakes	mouth of Tuin river,	1
	1		15	3		near mouth of Nariin	1
	2		18	3,4		river, by Orok Nuur	1
	3		5	3		lake	1
	5		56	3			1
	6		13	3			1
	7		29	4		north of Orok Nuur,	1
	9		32	4		southern Tuin river	1
	Argalant	surface			Valley of the Lakes		
	1		949	2,3,4			3
	2		186	2,3			3

Year	Site/Locus	Type	N =	Period	Location	Description	Nature
1985	Argalant	surface			Valley of the Lakes	north of Orok Nuur,	
/86	3		228	3		southern Tuin river	3
	4		93	3			1
	5		194	3			2
	Orok Nuur	surface			Valley of the Lakes	NE of Orok Nuur,	
	1		273	2		southern reaches of	4
	2		736	2		Valley of the Lakes	4
	3		13	3			1
	4		19	3			1
	Tatsin Gol	surface			Valley of the Lakes	Tatsin river valley	
	1		12	2			1
	2		4	2			1
	3		7	2			1
	4		6	2			1
	Zodokh Guvshikh	surface			Valley of the Lakes	mouth of Tatsin	
	1		282	3,4		river	4
	2		22	3,4			1
	Guchin Us	surface			Valley of the Lakes	between Tatsin and	
	1		31	3		Ongiin rivers,	1
	2		11	3		500 m from well	1
	3		9	3			1
	4		140	2			4
	5		9	3			1
	6		85	3,4			1
	7		16	3,4			1
	Jinst	surface			Valley of the Lakes	left bank of Tuin	
	1		16	3		river	1
1995	Locus 1	surface	17	2,3,4	Övörkhangai	near old volcano	1
	2		4	2	province	30 km east	1
	3		9	5	(south Gobi-Altai)	proluvial fan	1
	4		26	3		2 km east	1
	6		130	2,5?		slope of drainage	3
	7		154	2,3		gobi pavement	2
	8		95	2,3,4		3 km north	2,3
	9		17	2		4 km north	1
	10		61	2		4 km north-west	3
	11		25	2,4	Bayankhongor	between streams	3
	12		52	2,5	province	near drainage basin	3,4
	13		8	3	Valley of the Lakes	bedrock, alluvium	3
	14		20	2,5	Bayankhongor	slope near drainage	3
	15		15	2,3	province	piedmont	3
	16		14	2	(south Gobi-Altai)	terrace of drainage	1
	Zuukh Sands	surface	100s	4			?
	Zoog Blowout	surface	few	5			?
	18	surface	209	2,3		spring, near cave	3
	19		45	2		raised area on plain	?

Year	Site/Locus	Type	N =	Period	Location	Description	Nature
1996	“Flint Valley” Bosgo	surface	1000s	2,3,4?	Övörkhangai	mesas, flint outcrops	2
	Locus 1	surface	1000s	2,3,4?	Bayankhongor	raised area in basin	3?
1997	2	surface	1	3	Yellow Gobi		1
	3		1	2	Bayankhongor	mountain slope	1
	4		5	2	(central Gobi-	oasis with well, slope	1
	5		24	2	Altai)	slope of drainage	1
	6		5	2		slope of drainage	1
	7		3	2		plain with ravines	1
	8		10	2		slope of drainage	1
	9		2	2		slope of drainage	1
	10		1	2		2.2 km from well	1
	11		2	2		8.4 km from well	1
	12		25	2			1
	13		2	2			1
	14		16	2			1
	15		121	2,3			3
	16		403	2,3			4?
	17		64	2			3
	18		6	2			1
	20		21	2			1
	21		10	2			1
	22		35	2		bog, hilly ridges	3?
	23		20	2		spring, hill range	1
	24		48	2		hill range, jasper	2
	25		54	2,3			1
	Ekhiin Gol		47	2			1
	Jasper Complex	surface	18	2	Yellow Gobi	flat, high terrace	1
	Locus 1	surface	25	2		jasper, no water	1
1998	2	surface	3	2			1
	3		410	3,4,5?		terrace above pond	2,3,4?
	4		65	2			3?
	5		197	2		ancient alluvium	2
	Khadat		96	2	Gov’ Altai	100 km from L. 4	2
	Bulghiin Davaa		275	4	province	near spring, by dunes	3
	8		12	4	(central region	mountain pass	1
	9		31	4	Aj Bogd Uul)	1.2 km from pass	3
	10		260	3		ridge, near spring	3
	11		14	2			1
	12		11	2			1
	Urtyn Bulag		10	2	Bayankhongor		1
	Suuzh 1		225	4	province	spring, marsh, dunes	2,3
	2	surface	76	2	Bayankhongor	piedmont with flint	3
	3		119	2	province	and fresh water	2,3
	4		153	2,3?			2,3
	5		86	2			3
	6		35	2			3
	7		11	2			1
	Collection area 1		83	2			3
		surface	486	2,3			2,3

Year	Site/Locus	Type	N =	Period	Location	Description	Nature
1998	Collection area 2	surface	1,165	2	Bayankhongor		2
1995	Chikhen Agui	in situ			Bayankhongor	cave, at spring where ridge	
/98	Horizon 1		722	5?	province	bisects narrow canyon	3
	2		280	4			3
	3		142	4			3
	4		105	3		cave, overlooks	3
	Tsagaan Agui	in situ			Bayankhongor	canyon, local flints	3
	Stratum 2		30	4	province		3
	3		20	3			3
	4		108	2			3
	5		7	2			3
	6		31	2			3
	11,12		10	2			3
	13		6	2			3

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