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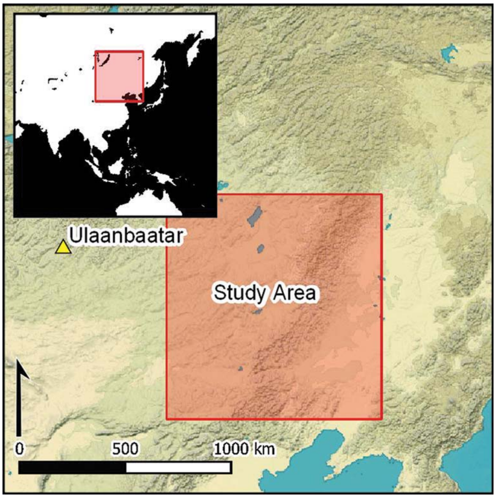
Research Article

Neolithic pathways in East Asia: early sedentism on the Mongolian Plateau

Chao Zhao[1], Lisa Janz[2,3,*], Dashzeveg Bukhchuluun[4,5] & Davaakhuu Odsuren[4]

[1] Department of Anthropology, University of Pittsburgh, USA
[2] Department of Anthropology and Frost Centre for Indigenous and Canadian Studies, Trent University, Canada
[3] School of Anthropology, University of Arizona, USA
[4] Institute of History and Archaeology, Mongolian Academy of Science, Mongolia
[5] Department of Anthropology, Yale University, USA
* Author for correspondence (✉ lisajanz@trentu.ca)



The shift to sedentary lifeways represents a significant change in human adaptation. Despite the broadly contemporaneous timing of this transition across East Asia during the Holocene Climatic Optimum, such changes varied regionally. This article synthesises new and existing data from Neolithic sites on the Mongolian Plateau to reveal a simultaneous shift towards investment in site architecture, with distinct variation in the organisation of settlement and subsistence across biogeographic zones. The development of sedentary communities here emphasises the importance of climatic amelioration for incipient sedentism, and demonstrates how differences in ecological and cultural contexts can encourage various responses to the same environmental stimuli.

Keywords: Mongolia, Neolithic, Holocene Climatic Optimum, sedentism, hunter-gatherers

Introduction

Human adaptation to northern climates is distinct from other world regions, particularly in terms of sedentism and domestication. Following the Last Glacial Maximum, northern latitudes are often characterised by the persistence of hunting and gathering, and a specific range of organisational changes, including an early and protracted reduction in residential mobility, an intensified exploitation of aquatic species and more active management of natural resources. Across the global north (broadly, North America and Eurasia north of 40°), these shifts occurred at different times following the Last Glacial Maximum, and were closely tied to climatic amelioration (Gamble 1986; Elston *et al.* 2014; Popov *et al.* 2014;

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Liu *et al.* 2015a; Janz 2016). Depending on the region, such changes preceded a range of further organisational shifts, including a return to greater mobility, the adoption of exotic domesticates and increasingly specialised hunting strategies (Basgall 1987; Beck & Jones 1997; Fisher 2002; Wolff 2008; Weber & Bettinger 2010; Bousman & Okasnen 2012; Chatters *et al.* 2012; Rosenthal & Fitzgerald 2012; Habu 2014; Popov *et al.* 2014). In the northern latitudes, subsistence was characterised by the continued management of local resources, with little emphasis on domestic crops or animals. Furthermore, the adoption of exotic domesticates occurred long after they were adopted in neighbouring regions (e.g. Ames 1998; Crawford 2011; Popov *et al.* 2019; Janz *et al.* 2020). Hence, in contrast to the situation in Western Eurasia, in North-east Asia, the 'Neolithic' was characterised by a series of shifts that did not always result in long-term sedentism or domestication.

The Mongolian Plateau is a critical but poorly understood region in East Asian prehistory. Scholars have been inclined to assume that, throughout prehistory, people on the plateau have persistently retained highly mobile lifeways, initially based on hunting and culminating in nomadic pastoralism; this interpretation stems from the historic narrative of 'steppe nomadism' and the absence of concentrated and productive r-selected resources (i.e. species with high reproductive potential, such as fish, shellfish and nuts) (Cao 2007). Such supposition, however, is now challenged by archaeological data from the eastern Plateau indicating more sedentary lifeways and intensified exploitation of local resources after 8.5 ka cal BP (Zhao 2020). This general reduction in residential mobility was supported by diverse subsistence strategies, including grain cultivation, broad-spectrum foraging and the intensive exploitation of large game. The juxtaposition of these various modes of subsistence is emphasised by their association with climatic amelioration, raising questions about the common drivers of change.

Geographically, the eastern Mongolian Plateau is bounded to the east by the Great Khingan Range, with ecozones today ranging from arid or semi-arid steppe to the semi-humid margins of north China and the north-east China Plain (Ren 1999). Notable variations in modes of subsistence across the region reveal the diversity of adaptations to sedentary life in monsoon-dominated East Asia during the Holocene Climatic Optimum (*c.* 8.3–5.5 cal BP (Herzschuh 2006: 167)). An examination of Neolithic subsistence and settlement patterns on the eastern Mongolian Plateau presents the opportunity to explore these variable trajectories in sedentism, including their limits in regions with low rainfall and extreme seasonal variation.

The sites of Baiyinchanghan, Hag and Tamsagbulag represent sedentary adaptations within three distinct micro-environmental zones of the eastern Mongolia Plateau: the transitional zone between steppe and deciduous forest, the resource-rich wetland zone and open steppe. Baiyinchanghan (Figure 1.1) is located on the upper West Liao River valley, in the southernmost part of the study area (Neimenggu 2004). The primary phase of occupation, dating to 8034–7325 cal BP (Table S1 in the online supplementary material (OSM)), is associated with the Xinglongwa Culture. Baiyinchanghan is one of the most westerly Xinglongwa sites to be extensively excavated and reported in the Chinese literature (Liu 2001). The site represents the westward expansion of early millet-based agricultural economies in north-east China. Hag (Figure 1.2) dates to 8580–8036 cal BP (Table S1) and is located on the Hulunbuir Steppe far in the north of the study area. The Hailar, a tributary of the

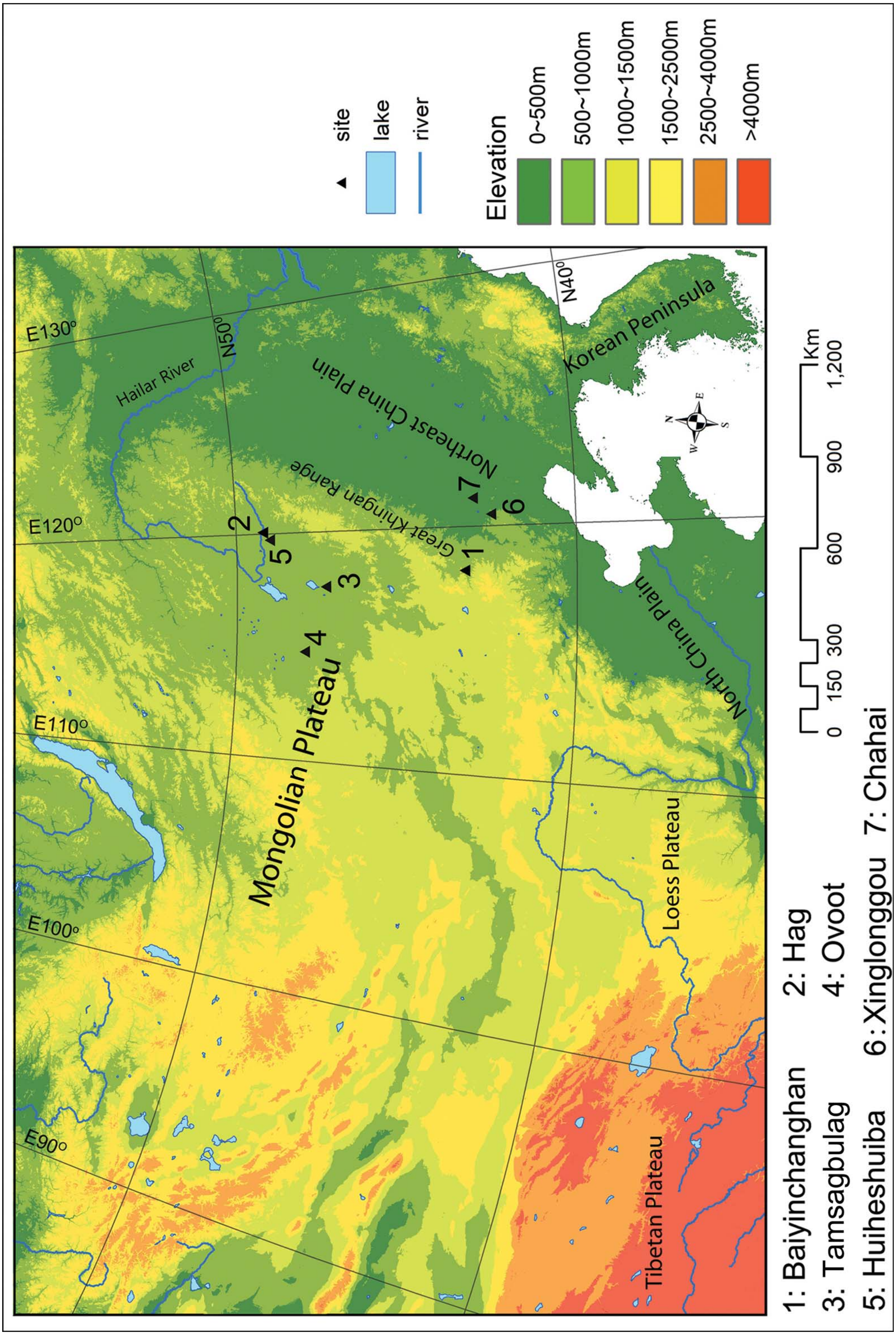

Figure 1. Geographic location of sites mentioned in text and online supplementary material (OSM) (GMTED 2010, image courtesy of the U.S. Geological Survey).

Amur (Heilongjiang) River, surrounds the site on three sides (Zhongguo *et al.* 2010). Dating to 8400–7339 cal BP (Table S1), Tamsagbulag (Figure 1.3) is located along tributaries of the Hulunbuir drainage system, a few hundred kilometres west of Hag. The upper West Liao River valley and the Hulunbuir Steppe are located on the margins of regions categorised by the Köppen-Geiger climate classification as cold semi-arid (BSk) and boreal winter dry with a cool to warm summer (Dwc to Dwb) (Beck *et al.* 2018). (The Köppen-Geiger climate classification system categorises all world climates according to seasonal temperature and precipitation patterns, and is one of the most widely used climate classification systems; B = arid, S = steppe/semi-arid, k = cold arid; D = boreal/snow, w = winter dry, c = cool summer, b = warm summer; http://koeppen-geiger.vu-wien.ac.at/.) Modern average annual precipitation at Tamsagbulag is 190mm, compared with 350mm at Baiyinchanghan. The Hulunbuir Steppe is colder than the West Liao River valley, with shorter growing seasons (Wu *et al.* 2015). Here, we examine similarities and differences in subsistence, site structure and material culture to identify variation in patterns of residential stability within some of the more marginal reaches of mainland East Asia.

Trajectories in sedentism

Site architecture

All three sites reveal significant investment in architecture that is consistent with full or intensive seasonal sedentism. Hulunbuir sites are characterised by large, 40–50m^2 dwellings, with carefully constructed roofs, floors, and indoor middens and/or storage pits (Figure 2) (Okladnikov & Derevianko 1970; Dorj 1971; Zhongguo *et al.* 2010). Evidence of surface dwellings at Tamsagbulag, within 1km of pit dwelling concentrations, suggest some form of year-round occupation (see the OSM). At the Hag site, a layer of shells more than 0.16m thick was found beneath the living floor, and may have served to keep the floors dry and provide insulation (Zhongguo *et al.* 2010).

Excavations at Baiyinchanghan have revealed contemporaneous, or slightly later (Table S1), evidence for intensively planned population nucleation, characterised by two settlement clusters on the hillslope—each with its own associated hilltop cemetery (Figure 3). Excavation has revealed 56 rectangular, semi-subterranean houses arranged in neat rows within the two clusters. Many of the houses had living floors that were typically surfaced with fired clay for durability (Neimenggu 2004). Extensive trench features at Baiyinchanghan and Tamsagbulag (see the OSM) and the elaborate floors at Hag and Baiyinchanghan illustrate investment in place that is uncharacteristic of earlier periods.

Differences in burial ritual between Baiyinchanghan and the two Hulunbuir sites similarly highlight contrasting levels of site investment. The Baiyinchanghan burials are represented by individual pit-tombs capped with layers of stone (Figure 4C). Some tombs have vertical stone slabs lining the walls (Neimenggu 2004). In contrast, the Hag and Tamsagbulag burials are scattered and unmarked (Figure 4A–B), including one subfloor interment at Tamsagbulag (Dorj 1971). Graves at Hag are often characterised by secondary inhumations (Zhongguo *et al.* 2010). The pattern of elaborate inhumation and structured community burial at Baiyinchanghan is characteristic of planned investment in recurrent and intensive

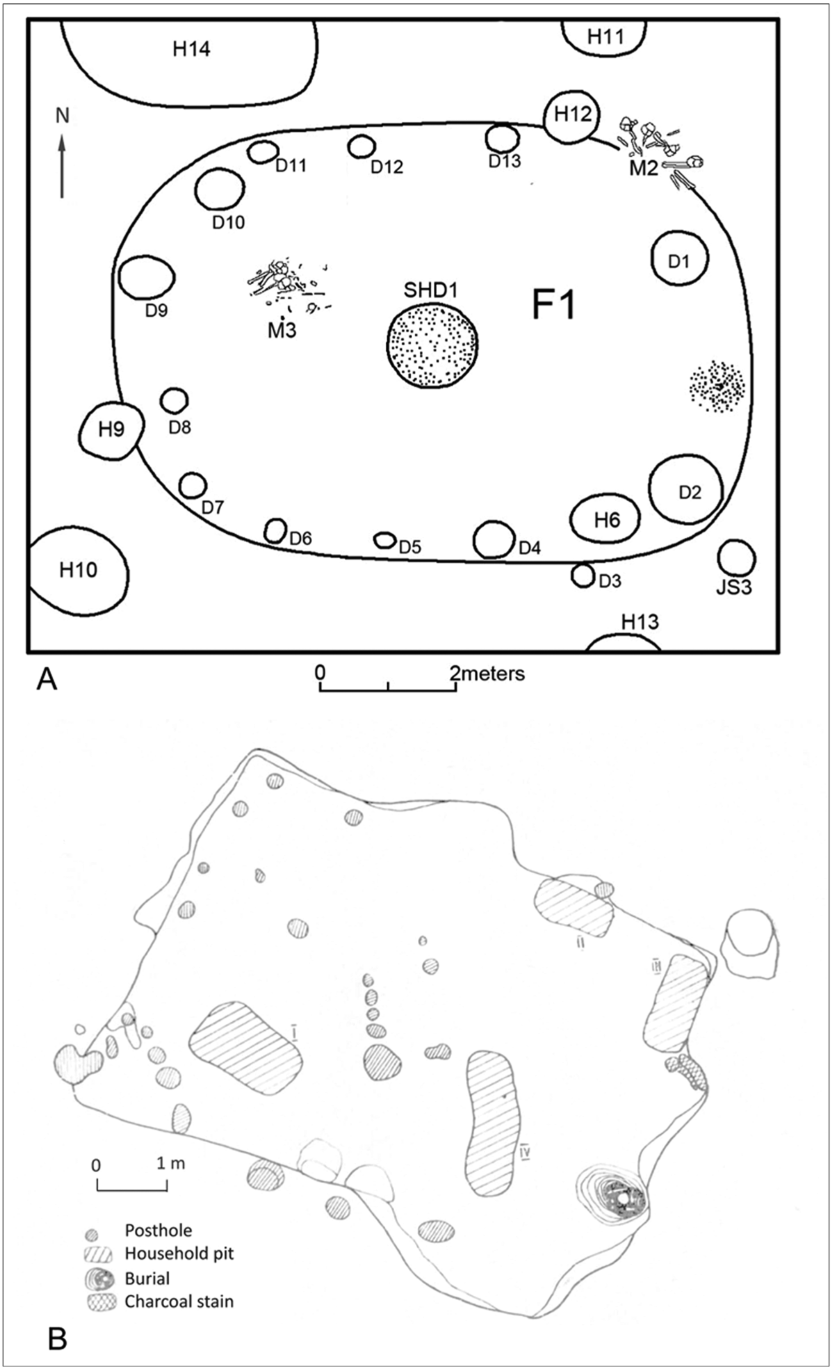

Figure 2. A) The excavation zone at the Hag site: F = house; H = midden or storage pit; D = posthole; M = burial; SHD = piles of sand; JS3 = piles of animal bones. All remains belong to cultural layer 7 (after Zhongguo et al. *2010: foldout page); B) house 1 from Tamsagbulag, showing postholes, pit features, and hearth. The circular feature on the northern wall is a human burial (redrawn from Okladnikov & Derevianko 1970: 5).*

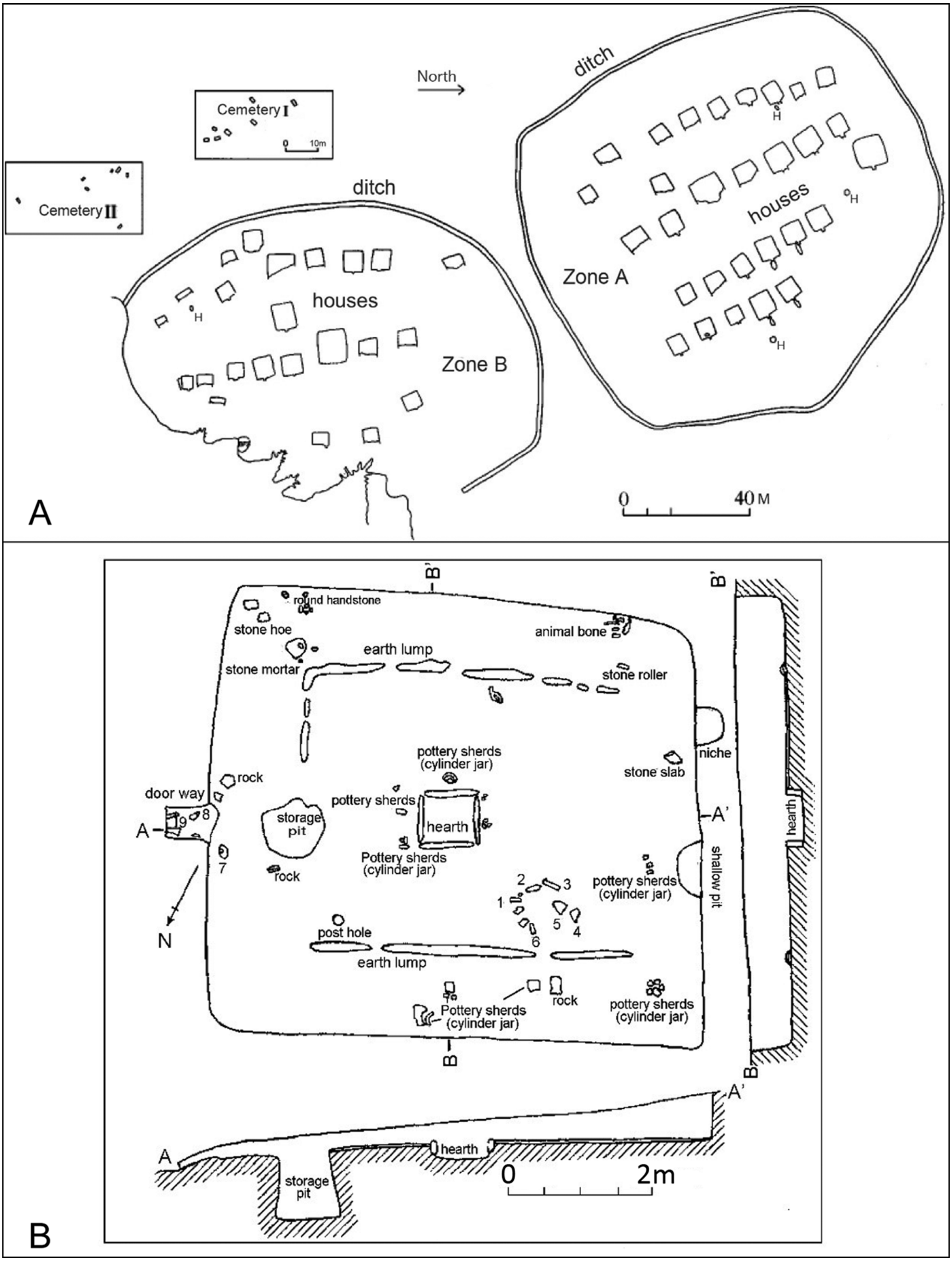

Figure 3. A) Layout of Xinglongwa-period houses at Baiyinchanghan (H = midden or storage pit) (redrawn from Neimenggu 2004: foldout page); B) the plane and section view of house AF32 of the Baiyinchanghan site (1, 3, 6, 8 = stone rollers; 2 = pestle; 4 = handstone; 5 = rock; 7 = perforated stone disk; 9 = cylinder jar) (after Neimenggu 2004: 145).

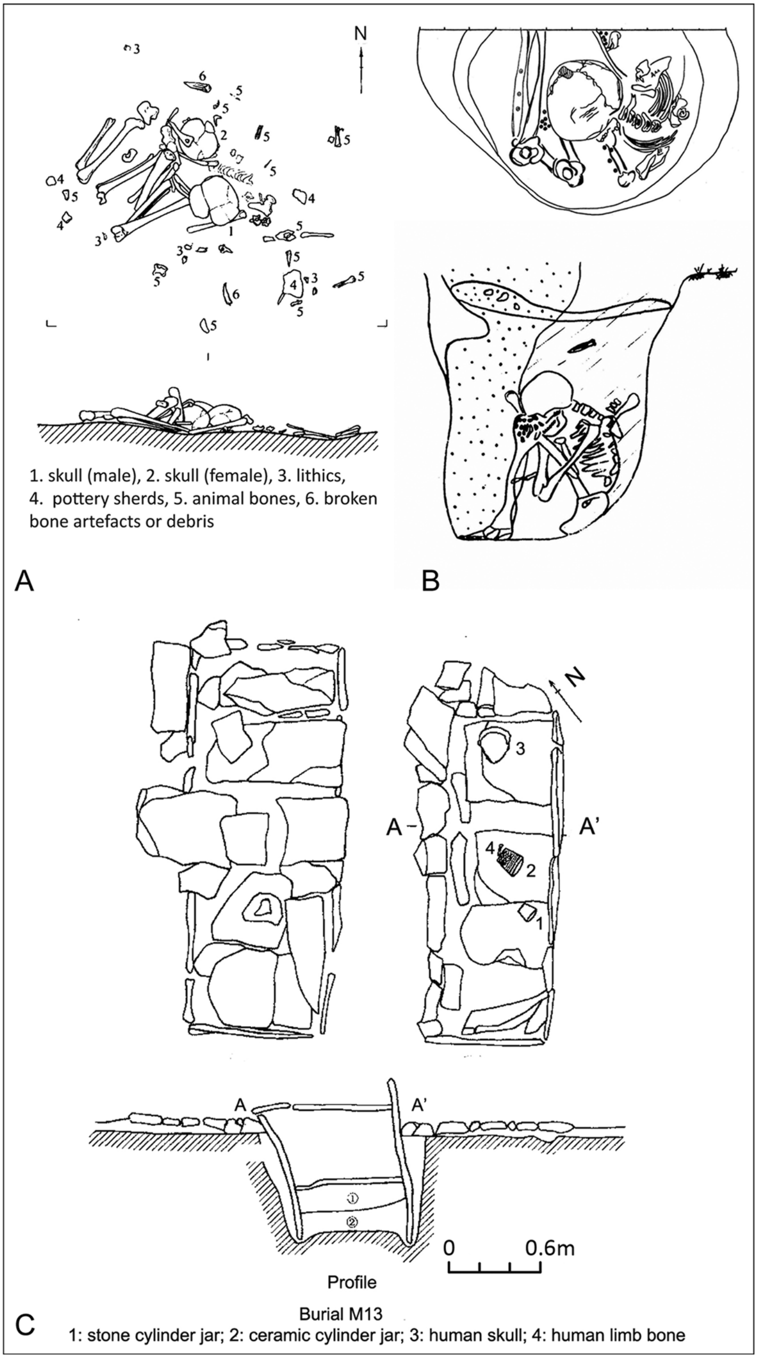

Figure 4. A) Hag burial 04 07T5-T6XM3 (after Zhongguo et al. *2010: 32); B) Tamsagbulag burial from house 1 (redrawn from Okladnikov & Derevianko 1970: 9); C) Baiyinchanghan burial M13 (after Neimenggu 2004: 29).*

site use. In contrast, across Hulunbuir, the diverse approaches to burial, the consistent lack of surface markings and evidence of secondary interment (e.g. at Hag) are more consistent with a less organised—or perhaps discontinuous—site usage.

The subsistence basis of 'sedentism'

Sedentism requires sufficient resources within the catchment zone and highly efficient methods of exploiting them. Without improved procurement strategies, people must relocate during the year in order to avoid local resource depletion (Kelly 1983). The use of storage pits at all three sites (see the OSM; Figures 2–3) highlights the fact that increased sedentism—particularly in northern climates—requires more abundant seasonal procurement for storage. Although sedentism was once assumed to be dependent upon farming, we now know that sedentism can be supported without agriculture through the intensive exploitation of wild species that occur in dense concentrations and are resilient to harvesting pressure, such as fish, shellfish, nuts and seeds (Henry 1985; Gamble 1986; Rosenswig 2006; Habu 2014; Popov *et al.* 2014). While the three sites in this study have yielded evidence for the exploitation of such species, it varies greatly across sites and does not necessarily correlate with the apparent degree of sedentism.

Pottery and milling stones are present at the three sites (Figures 5–7). Despite their ubiquity in agricultural communities, such tools have been widely used by hunter-gatherers for cooking, shelling, grinding and pulverising many types of wild or domesticated plants (Adams 2013; Dubreuil *et al.* 2015). As such, their presence indicates a more intensive approach to plant exploitation, although not necessarily agriculture. Residue analysis from Baiyinchanghan and other Xinglongwa-phase sites indicates the exploitation of a wide range of wild species, including nuts, roots, rhizome bulbs and grasses (Tao *et al.* 2011; Wu 2014; Liu *et al.* 2015b). The quantity and formality of milling stone assemblages may indicate the relative importance of plant foods, and there is a clear regional divergence in the importance of these tools. The small, fragmented assemblages of grinding slabs and ball-headed rollers from Tamsagbulag and Hag (Figure 6), for example, contrast sharply with Baiyinchanghan (Table S2). Their absence from earlier sites on the Mongolian Plateau (Janz *et al.* 2017), however, emphasises the relationship between reduced mobility and increased investment in plant processing (Table S2).

Aside from the exploitation of wild plant resources, millet-based farming also provided supplementary foods for the Baiyinchanghan communities. As no systematic flotation or bone chemistry studies have yet been published, we are unable to evaluate the dietary contribution of domesticated millets. Nonetheless, the presence and type of farming-related tools provide important clues to the scale and extent of the development of the farming. While Baiyinchanghan yielded no typical tools for harvesting (e.g. perforated knives) and ploughing (e.g. pointed spade-like tools), stone hoes comprise nearly 28 per cent of the entire lithic assemblage (Yang 2016). The lack of specialised harvesting and ploughing tools may suggest that cultivation was less intensive at Baiyinchanghan than at other contemporaneous sites in the heartland of north China, such as Cishan and Peiligang (Zhongguo 2010), although it could also indicate variation in agricultural practices. All Xinglongwa-period sites, including

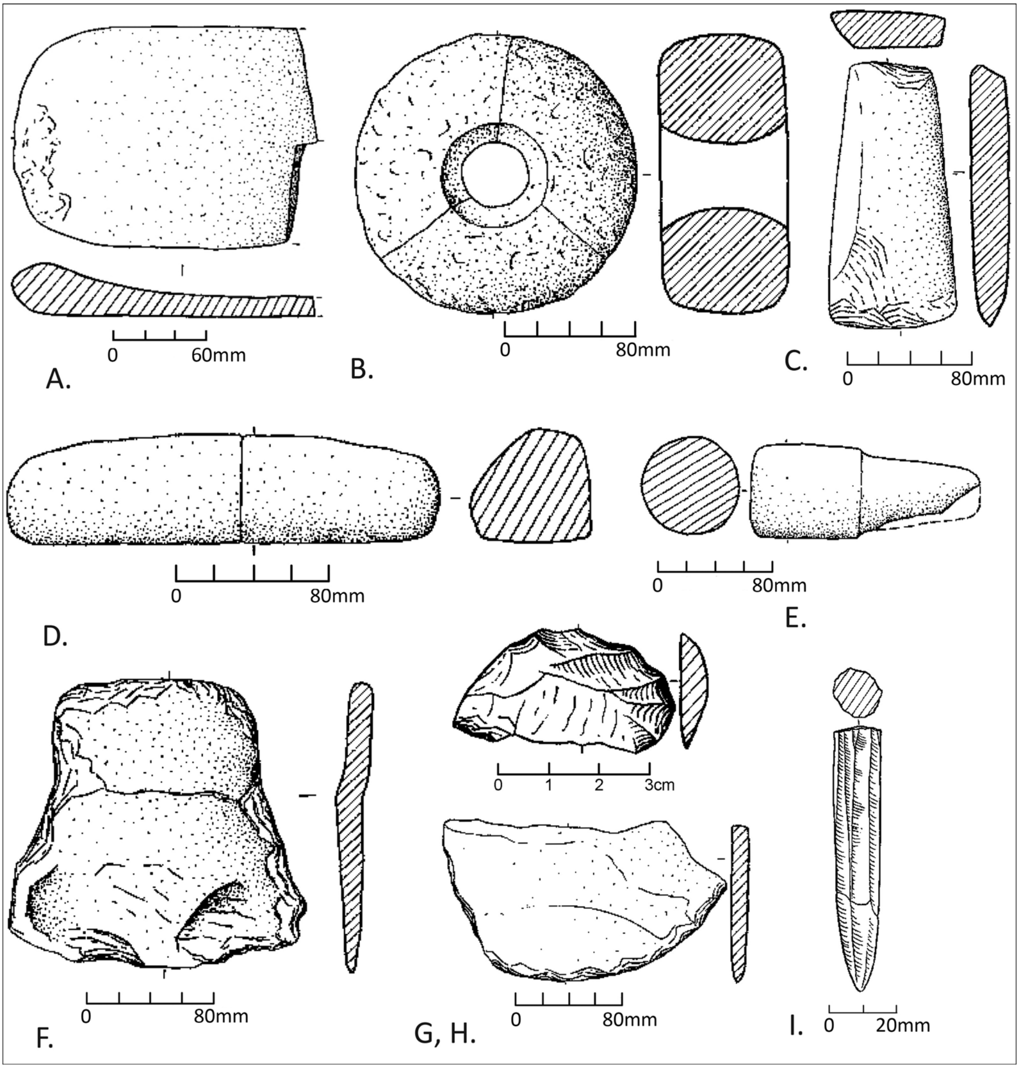

Figure 5. Selection of lithics from Baiyinchanghan (after Neimenggu 2004: 289, 292, 294, 300, 301 & 303): A) grinding slab; B) digging weight; C) polished axe; D) handstone; E) pestle; F) hoe; G–H) flake tools; I) microblade core.

Baiyinchanghan, contain large quantities of wild faunal remains, and those with evidence of plant use likewise demonstrate the continued importance of wild resources (Liu *et al.* 2015a).

Hoes and spades are rare or absent in Hulunbuir. The numerous digging weights found at Tamsagbulag were probably used to build the pit dwellings and trench features (Figure 6). The relative lack of plant-processing tools at Tamsagbulag and Hag suggests that heavily processed plant resources were less important than at Baiyinchanghan. Higher densities of faunal remains at the Hulunbuir sites, combined with an emphasis on microblade- and projectile-based hunting technology, further suggest the greater relative importance of game over plant foods.

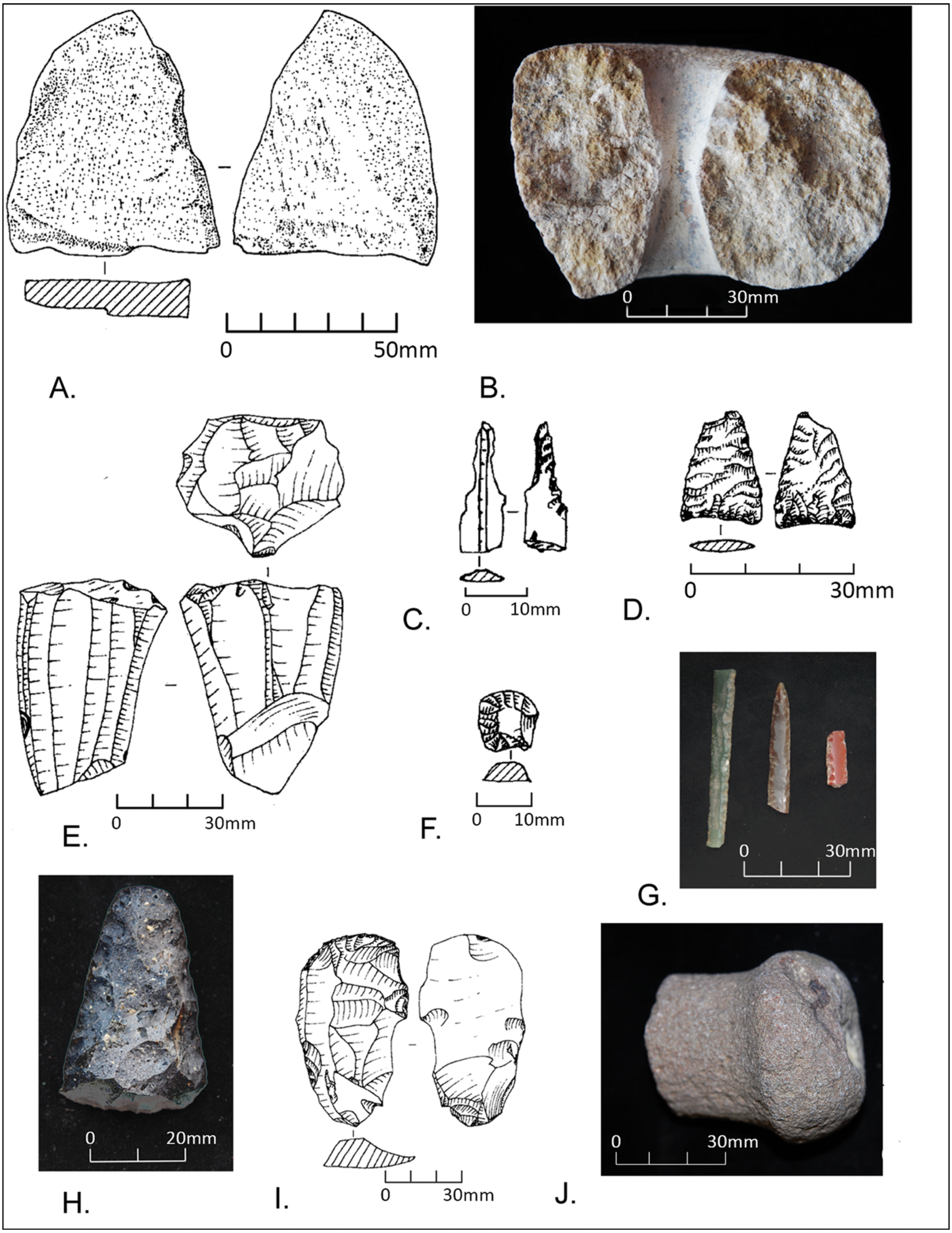

Figure 6. Selection of lithics from Hag (line drawings, all after Zhongguo et al. *2010: 35, 62, 64 & 71) and Tamsagbulag (photographs by L. Janz): A) grinding slab; B) digging weight; C) drill; D) projectile point (biface); E) microblade core; F) thumbnail scraper; G) retouched microblade tools; H) chipped adze; I) tongue-shaped scraper; J) fragment of ball-headed roller similar to those from Tamsagbulag.*

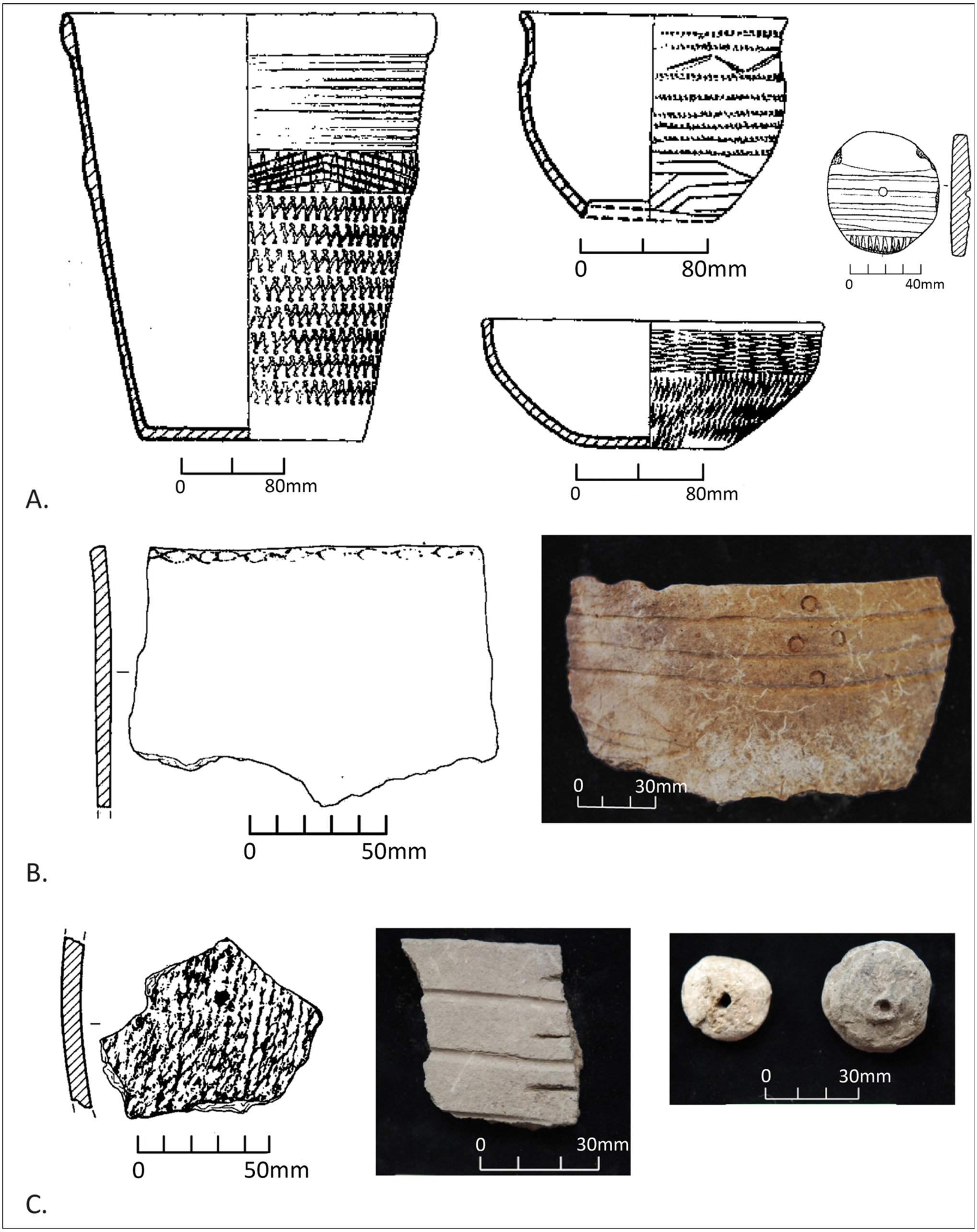

Figure 7. A (top row): selection of pottery from Baiyinchanghan (after Neimenggu 2004: 278, 283 & 286); B (bottom two rows): selection of pottery from Hag (line drawings, all after Zhongguo et al. *2010: 75 & 83), and Tamsagbulag (photographs by L. Janz).*

Direct evidence of diet is present in the sites' faunal assemblages, with the range of animals being highly divergent across sites. Published species lists are available for Baiyinchanghan and Hag (Table 1), while analysis of the Tamsagbulag fauna is ongoing. Cervids represent

Table 1. Comparison of faunal remains from Xinglongwa-period Baiyinchanghan and layer 7 of Hag (Neimenggu 2004; Zhongguo *et al.* 2010).

	Baiyinchanghan			Hag		
Species	NISP	NISP (%)	MNI	NISP	NISP (%)	MNI
Red deer (*Cervus elaphus*)	260	69.1	12	9	0.7	1
Sika deer (*Cervus nippon*)	44	11.7	5	0	0	0
Roe deer (*Capreolus pygargus*)	24	6.4	5	137	10.0	5
Aurochs or bison (Bovinae)	24	6.4	5	19	1.4	2
Boar (*Sus scrofa*)	15	4.0	4	27	2.0	4
Horse (*Equus* sp.)	0	0	0	13	1.0	1
Bear (*Ursus arctos*)	6	1.6	2	0	0	0
Hare (*Lepus* sp.)	0	0	0	56	4.1	5
Dog (*Canis* sp.)	0	0	0	8	0.6	1
Wolf (*Canis lupus*)	2	0.5	1	0	0	0
Fox (*Vulpes* sp.)	1	0.3	1	200	14.7	5
Raccoon dog (*Nyctereutes procyonoides*)	0	0	0	3	0.2	1
Badger (*Meles leucurus*)	0	0	0	24	1.8	5
Weasel (*Mustela* sp.)	0	0	0	2	0.1	1
Bird	0	0	0	219	16.1	
Fish	0	0	0	248	18.2	
Rodent	0	0	0	3	0.2	2
Unidentified	n.a			250	18.3	
Crushed bone	n.a			146	10.7	
Total	**376**	**100**	**35**	**1364**	**100.0**	**33**

the primary source of meat at Baiyinchanghan, while smaller prey was limited to a single fox (*Vulpes* sp.) element (percentage number of identified species (NISP) = 0.3). None of the animals were identified as domesticated. A broader range of species were exploited at Hag and Tamsagbulag. The latter site is characterised by an emphasis on aurochs (*Bos primigenius*), equids (*Equus hemionus hemionus* and *Equus ferus*) and antelope (cf. *Saiga tatarica mongolica*, *Gazella subgutturosa* and/or *Procapra gutturosa*), compared to the predominance of small prey (e.g. fox, birds, fish) and roe deer (*Capreolus pygargus*) at Hag.

Aurochs dominate the Tamsagbulag assemblage; four such skeletons were recovered from the upper layers of one dwelling (Dorj 1971). Moreover, what appear to be ritual burials were recovered from contemporaneous sites near the city of Choibalsan, about 400km west of Tamsagbulag, including an aurochs bull skull and a cache of horns (Dorj 1971). Scholars have previously interpreted these sites as belonging to agropastoralists (Derevianko & Dorj 1992). The exploitation of small-bodied prey at Hag differs from Tamsagbulag, and presents the broadest spectrum of dietary species of the three sites analysed here, with a focus on riverine resources and terrestrial species that thrive around shrubby, riparian wetlands. These differences correspond to the local environment: Tamsagbulag sits high above a river, on the edge of an open steppe, whereas Hag is surrounded on three sides by a river. These trends might also be temporal, as Hag pre-dates Tamsagbulag.

Both Baiyinchanghan and Tamsagbulag exhibit higher levels of dietary specialisation than the earlier Hag site, although the emphasis varies greatly. The intensive exploitation of deer at Baiyinchanghan supports the notion of high occupational permanency, as cervids are resilient to heavy predation and are well adapted to forage on plants associated with high human population densities—particularly agricultural crops (Butler & Campbell 2004). In contrast, important species at Tamsagbulag, such as antelope and khulan (*Equus hemionus hemionus*), decline relative to human population density (Kaczensky *et al.* 2011). The unique juxtaposition of seemingly high levels of sedentism and an emphasis on wary large game at Tamsagbulag suggests that inhabitants practised a distinct approach to settlement and resource use.

The evidence presented here demonstrates high variation in levels of sedentism across the Mongolian Plateau during the Middle Holocene. The two Hulunbuir sites clearly reveal increasing sedentism and the coalescence of small hunter-gatherer communities, whereas the organisation of Xinglongwa-period site architecture and infrastructure at Baiyinchanghan supports the idea of a permanent village settlement. The pattern of differentiated dwelling types at Tamsagbulag suggests that the pit dwellings were designed for cold-season sedentism, while the surface dwellings were used during the warmer months (see the OSM). Together, these regions exemplify a large-scale trend, although with different approaches, towards increasing sedentism across North-east Asia.

Discussion

Holocene climatic amelioration and the onset of sedentism

The close temporal association of increasing and widespread sedentism across monsoonal East Asia and the Holocene Climatic Optimum—when annual average temperatures peaked and the East Asian Summer Monsoon strengthened and reached its northernmost limits—is compelling (Figure 8) (Winkler & Wang 1993; Dykoski *et al.* 2005; Herzschuh 2006). Multiple lines of evidence from lacustrine sediments along the south-eastern edge of the Mongolian Plateau show peaks in effective moisture between *c.* 8.0 and 4.0 ka cal BP (Liu *et al.* 2015c: 200; Fan *et al.* 2017; Wen *et al.* 2017). Proxy data from Lake Hulun, immediately west of Hag (Figure 1), indicate high lake levels between 11.1 and 6.2 ka cal BP (Zhai *et al.* 2011), with a marked shift *c.* 8.0 ka cal BP from dry steppe to relatively wet meadow-steppe, and the expansion of birch (*Betula*) and hazel (*Corylus*). This pattern lasted until *c.* 6.4 ka cal BP (Wen *et al.* 2010), when large Hulunbuir sites had already been abandoned or were in decline. As seen from Russian excavations farther east, in the middle and lower sections of the nearby Amur River basin (Popov *et al.* 2014; Tabarev 2014) and in Japan (Pearson 2006; Habu 2014), initial trajectories towards sedentism corresponded with phases of climatic amelioration, and, on the Mongolian Plateau, with peaks in maximum humidity between 8.0 and 7.0 ka cal BP.

These dates suggest that the trend towards sedentism was probably facilitated by ecological changes associated with the Holocene Climatic Optimum. Environmental conditions were arguably the primary driver of major contemporaneous shifts in settlement and subsistence patterns on the Mongolian Plateau, and probably across North-east Asia (Popov *et al.* 2014; Janz 2016; Shelach-Lavi *et al.* 2019). These ecological changes differed from region to region. In the West Liao River valley, the expansion of deciduous forests would have enhanced access

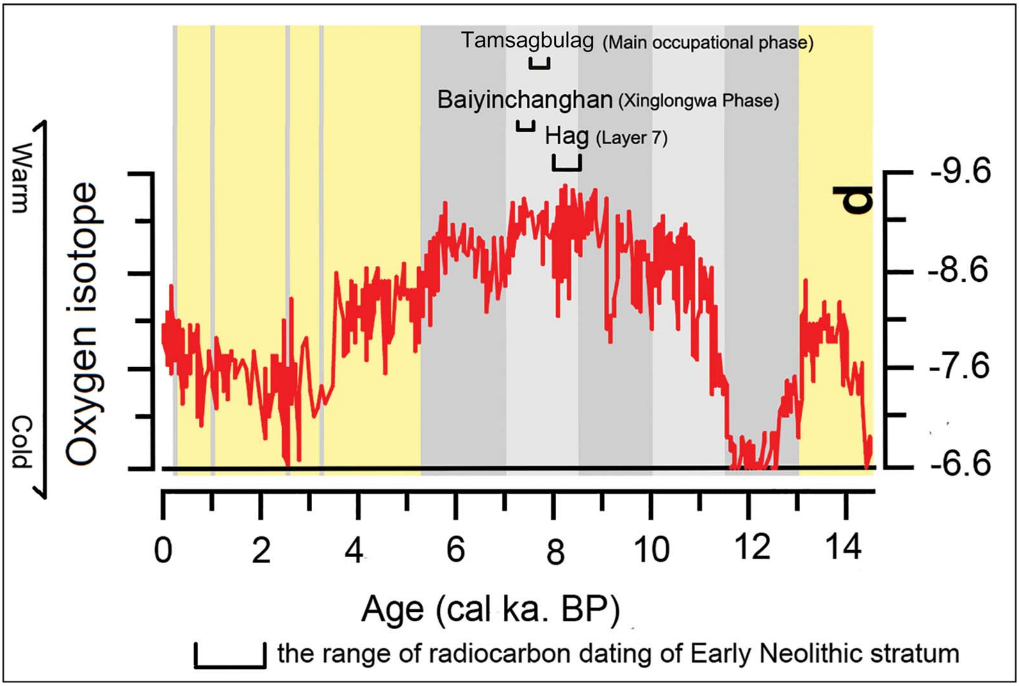

Figure 8. Timing of Holocene Climatic Optimum compared to sites in this study; climate curve based on stalagmite δ^{18}O records for Dongge Cave (after Dykoski et al. *2005).*

to nut-bearing trees, while longer growing seasons and higher annual precipitation would have expanded the limits for producing large-seeded grasses, such as millets. The expanding wetlands, forests and meadow-steppe in Hulunbuir would have created richer habitats for all prey types—a process also witnessed in even more arid reaches of the western Mongolian Plateau (Janz 2016; Janz *et al.* 2017).

The role of the environment in adaptation

The eastern Mongolian Plateau sites discussed here contrast with regions typically discussed in similar studies, which show that the changes expressed in Middle Holocene sites neither persisted nor developed into fully sedentary lifeways. It is hypothesised that increasing aridity stimulated a rise in residential mobility across Late Neolithic Mongolia (Cybiktarov 2002; Chen 2011). At Tamsagbulag, the main occupation was abandoned after *c.* 7300 cal BP, and recent unpublished survey and excavation data from eastern Mongolia suggest a decline in occupational intensity after 6500 cal BP. After the adoption of nomadic pastoralism by 3.5 ka cal BP (Tumen *et al.* 2014; Honeychurch 2015; Wright *et al.* 2019), herding economies dominated much of the region into historic times. This explains the relative lack of cultural material in the upper stratigraphy at Hag (2.0–0.9 ka cal BP). These layers contain little evidence for house structures and a much lower artefact density, suggesting shorter occupation durations and less extensive site use. Although house structures and farming tools were still present in the later Neolithic at Baiyinchanghan, the site was abandoned during the Bronze Age, and no sedentary settlements have been found in the surrounding area from that time through most of the historic period (2.8–0.1 ka cal BP).

This discontinuity in the development of sedentary lifeways contrasts with trends in more temperate, less arid regions of East Asia (see Shi 1989). The trajectory of intensified farming and more entrenched sedentism continued among communities to the south, such as in the Yellow River valley, where seasonality was less extreme and precipitation more reliable (Zhongguo 2010). In temperate Japan, sedentism developed even earlier than on the mainland, and although it was not uniform and unilinear, residential stability was largely retained, and became tied to intensive resource management and aquatic resource exploitation that continued even after the introduction of crop agriculture after 800 BC (Akazawa 1986; Crawford 2011; Habu 2014). To a certain extent, this confirms the assumption that people living in cold, arid climates are more sensitive to climatic fluctuations and, in response to such fluctuations, make major changes in subsistence strategies. The emphasis on ungulate prey—from specialised exploitation of aurochs at Tamsagbulag to the persistent and widespread reliance on domesticated herd animals—further highlights the critical importance of large-game exploitation for subsistence in northern, continental climates.

Simultaneously, despite the fact that variability in the degree of sedentism and population density between regions are closely tied to differences in resource availability, it is difficult to determine the relative importance of environment *vs* cultural influences, particularly when there are clear, large-scale consistencies in site structure and material culture across a range of environmental contexts. The subsistence practices employed at Baiyinchanghan show no fundamental differences to those practised by other Xinglongwa communities located within milder climate zones to the east, such as Chahai and Xinglonggou (Liaoning 2012; Wu 2014). The pattern is also consistent with contemporaneous sites to the south, where the intensive exploitation of diverse plant resources included, but was not limited to, millet (Sun 2015; Chen & Yu 2017). Despite stark differences in topography and vegetation, Hulunbuir sites bear some resemblance to hunter-gatherer sites around Lake Baikal and the Amur River Basin, including: broad-spectrum foraging and the exploitation of aquatic resources; the persistence of rectangular pit dwellings exemplified at Tamsagbulag and earlier Neolithic sites in the Amur River basin; emphasis on microblade technology; and the practice of secondary burials (Derevianko & Powers 1969; Lbova *et al.* 2008). The data presented here highlight the importance and potential of untangling the complexities of environmental and cultural influences on sedentism and associated subsistence practices.

Conclusion

Globally, researchers increasingly recognise that climatic amelioration corresponds with trends towards increased dietary breadth, sedentism and domestication (e.g. Gamble 1986; Pearson 2006; Liu & Chen 2012; Zeder 2012; Elston *et al.* 2014; Janz 2016; Piperno 2011; Shelach-Lavi *et al.* 2019). Janz (2016) argues that these changes occurred globally during the Holocene and were closely tied to the creation of highly concentrated and diverse biotic patches. These resulted from wetland expansion and unprecedented forestation, due to the combination of higher humidity, megafaunal extinctions and increased atmospheric CO_2. Other researchers have emphasised the importance of land-use management strategies as a feedback mechanism in increasing resource abundance in the context of emerging sedentism (e.g. Yen 1989; Smith 2001; Crawford 2011).

The variation in prehistoric subsistence strategies across the eastern Mongolian Plateau is striking, and includes broad-spectrum hunting, the intensive exploitation of large game and high investment in plant use, supplemented by resilient, medium-sized game species. Our data show that in relation to sedentism, exploited resources may vary widely, even within close geographic regions. Furthermore, large- and medium-bodied prey may be more critical to sedentary lifeways in some regions than previously acknowledged. The emphasis on aurochs and equids at Tamsagbulag is surprising, given that large game populations typically decline around settlements (Jerozolimski & Peres 2003; Badenhorst & Driver 2009; Broughton *et al.* 2010; Schollmeyer & Driver 2013). Additional research on species composition, the extent and nature of plant use, population density and occupation duration in regions such as Hulunbuir will be critical in further illuminating the relationship between sedentism and exploitation of large game, particularly in northern regions.

The establishment of sedentary communities and semi-permanent dwelling structures represents a remarkable change in human adaptive strategies. This study shows that despite being relatively simultaneous, such changes were highly variable in character, even within individual regions. Such changes in residential mobility and dietary breadth occurred across North-east Asia as lake levels increased, wetlands expanded and deciduous and mixed forests fragmented the Pleistocene steppe ecosystems. Similar types of responses to climate change across a range of environmental conditions support existing hypotheses that greater dietary breadth and reduced mobility are tied to ecological change, while the resulting variations in site organisation and material culture derives from local, culturally mediated solutions to environmental stimuli. Even in communities vulnerable to climate change, culture plays an important role in recognising, selecting and implementing solutions. Likewise, broad similarities in material culture, settlement planning and burial practice across the region emphasise points of cohesion in mediating adaptation. As such, there is still potential in the traditional analysis of material culture for tracing cultural interaction and affiliation. Environmental transition zones, such as the eastern Mongolian Plateau, offer a testing ground where we can trace long-term trends in human responses to ecological change and culturally mediated adaptation.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.15184/aqy.2020.236

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[Supplementary material]

Neolithic pathways in East Asia: early sedentism on the Mongolian Plateau

Chao Zhao[1], Lisa Janz[2,3,*], Dashzeveg Bukhchuluun[4,5] & Davaakhuu Odsuren[4]

[1] Department of Anthropology, University of Pittsburgh, USA

[2] Department of Anthropology and Frost Centre for Indigenous and Canadian Studies, Trent University, Canada

[3] School of Anthropology, University of Arizona, USA

[4] Institute of History and Archaeology, Mongolian Academy of Science, Mongolia

[5] Department of Anthropology, Yale University, USA

[*] Author for correspondence (✉: lisajanz@trentu.ca)

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Site descriptions

West Liao River Valley

Baiyinchanghan is located in Linxi county on the slopes of a southern extension of the Great Khingan range (Figure 1:1). An area of 7264.3m^2 has currently been excavated. Archaeological deposits belong to five different cultural phases, namely (from earliest to latest): Xiaohexi, Xinglongwa, Zhaobaogou, Hongshan and Xiaoheyan. All periods contain evidence of pit dwellings, except Xiaoheyan, for which only midden deposits were recovered. Xiaohexi cultural deposits represent the earliest phase of occupation. No radiocarbon dating samples were found from the Xiaohexi deposit of the Baiyinchanghan site. Chinese archaeologists estimate that Xiaohexi cultural period ranges between 8.5–8.2 ka cal BP based on the observation that it is earlier than Xionglongwa culture, which thrived in this region after 8.2 ka cal BP (Zhao *et al.* 2014), although recent excavations and direct dates for the Xiaohexi site Jiajiagou indicate that the site was occupied at 7.9–7.75 ka cal BP (Shelach-Lavi *et al.* 2019). Three houses and two middens from this period were excavated from west part of Zone B. From the Xiaohexi to Xinglongwa phases, there is expansion of the settlement and an increase in population. Only Xinglongwa-period dwellings are extensively distributed across the site area and they are distinct in their well-planned layout and dense distribution. The associated cultural remains are richer compared to later periods, indicating that the settlement was most intensively used during the

Xinglongwa phase. Only two radiocarbon samples from this phase have been dated (Table S1). Based on regional comparisons of dates across multiple sites, it is estimated that Baiyingchanghan was occupied between 8.2 and 5.0 ka cal BP (Neimenggu 2004).

Houses are distributed in two adjacent settlements which are surrounded by trenches, juxtaposed on the same slope with two separate cemeteries located on the hilltop (Neimenggu 2004). Rectangular semi-subterranean houses are laid out in neat rows within the settlement. Fifty-six houses were excavated, including all houses from Zone A and most of the houses in the west and southwest portions of Zone B (Figure 3A). Most of the houses had one hearth in the middle surrounded by stone slabs (Figure 3B). The living floors were typically lined in clay and fired to create a hard layer. Seven houses had empty indoor pits thought to have been used for storage. Nine midden structures are located outside the houses, four of which are illustrated in Figure 2. Lithic assemblages (Figure 5) reveal the persistence (though low-level use) of microblade core reduction strategies. The site is more notable for an emphasis on heavy duty equipment, much of which can be associated with plant exploitation, including hoes and grinding stones (hand stones, grinding slabs, and pestles) (Table S2). Pottery was sand-tempered, low-fired, and friable. Most were handmade using the coiling method. Vessels are simple but with a greater variety of forms and decorations than during the Xiaohexi phase (Figure 7). The increased emphasis on manufacture and sophisticated decoration highlight increasing investment and variety in pottery-making. The prevalence of hoes and grinding equipment suggests that farming could have been an important part of local subsistence practices at Baiyinchanghan. This is indirectly supported by potential evidence for millet starch on grinding stones from this (Tao *et al*. 2011) and other contemporary sites (Liu *et al.* 2015a) , as well as the presence of wild and/or early domesticated millet at other Xinglongwa-period sites in the Liao River valley (Liu *et al*. 2015b; Shelach-Lavi *et al.* 2019), and evidence for domesticated millet in the Yellow River valley at 8.0–7.6 ka cal BP (Zhao 2011).

Although charred plant remains were not recovered, starch grain analysis suggests that grinding stones were used to process both millet and acorns (Tao *et al.* 2011). The importance of such plant foods is attested by the rich assemblage of milling stones at Baiyinchanghan which make up 33.60 per cent of the lithic assemblage (Table 2). Likewise, stone hoes comprise 27.67 per cent of the lithic assemblage and have been found in 22 of the 41 houses where artefacts were left on the living floor (Neimenggu, 2004). All animal remains were from wild individuals, although the pig (*Sus scrofa*) had already undergone domestication in North China (Neimenggu 2004; Cucchi *et al*. 2011). Deer comprise 87.20 per cent NISP of the assemblage (*Cervus elaphus*, *Cervus nippon*, *Capreolus pygargus*), complimented by aurochs, boar, and wild carnivores (bear, wolf, fox) (Table 1). Evidence of millet and acorn in starch profiles of grinding stones suggests a fall or winter occupation (Tao *et al.* 2011), while red deer (*Cervus elaphus*) skull fragments with shed antlers suggests site use in late winter to early spring (Neimenggu 2004). This does not exclude the possibility of year-round occupation.

Several contemporaneous village-like settlements have been found with similar dwelling structures and linear arrangement of houses: some are larger in scale, but most are of a similar or smaller scale (Zhao 2006). Most Xinglongwa-period sites are found in the hilly land of the West Liao river drainage, within the ecological transition zone between the Mongolian Plateau and the Northeast China Plain. Baiyinchanghan represents the best excavated example this deep in the Mongolian Plateau. The dual-settlement layout and the public cemeteries are unique features, with indoor burials more typical of Xinglongwa sites (Chen 2013). This difference may be chronological, as the one set of dates comes from the end of the Xinglongwa phase (Zhao 2006).

Hulunbuir Steppe

Hag is located on a river terrace close to the west bank of Hailar River and is surrounded by water in three directions (Figure 1:2). A total of 296m^2 have been excavated to reveal cultural deposits from three different periods. Layer 7 is the lowest cultural layer with dates falling between 8.5 and 8.0 ka cal BP (Table 1). The site was only used intermittently in later periods with all overlaying layers post-dating ~1.8 ka cal BP (Zhongguo *et al*. 2010) (Table S1). These later components are few and simple with dispersed scatters of artefacts and fauna and only two pit structures (from layers 6 and 4) (Zhongguo *et al*. 2010). Layer 7 has a much more complex site structure and more abundant remains. The one pit house excavated was 56.08m^2 (Figure 2A) with thirteen postholes distributed around the interior perimeter. A layer of shells >0.16m thick, found beneath the living floor, may have served to keep the floors dry and provide insulation. Twelve smaller pit structures, possibly middens or storage pits were found: one within the house and seven surrounding it. All pit features contained lithics, pottery sherds, and animal bones, except for one (H2), which one large stone slab. H14, located at the northwest of the house, was especially large and contained rich amount of bone, particularly fish (Zhongguo *et al*. 2010).

Tamsagbulag is located in Dornod province, Mongolia, 30–40km from the border of Inner Mongolia along the high southern bank of a former tributary of Buir Lake (Figure 1.3), just west of the extant three-headed spring (*bulag*) for which the site was named. In 1968 another rectangular pit dwelling was excavated at Ovoot, about 9km west of Choibalsan on the north bank of the Kherlen River (Figure 1:4) (Dorj 1971). These sites are the only Neolithic ones known in Mongolia with clear evidence for substantial site architecture (Janz *et al.* 2017). The numerous radiocarbon dates for Tamsagbulag indicate that the site was used 8.4–6.0 ka cal BP, and most intensively at 7.8–7.5 ka cal BP (Table S1).

Four rectangular semi-subterranean dwellings, one surface-dwelling feature, two burials, and several other features have been excavated. House 1 (7.6 × 5.6m) was the best preserved and like Hag has deep post-holes around the perimeter walls, lacks a doorway, and has substantial interior pit structures (Dorj 1971). The house floor was surrounded by a foundation trench 0.50–80m deep within which one row of posts was set as a structural complement to a second cluster of posts in the centre of the living floor (Figure 2B); these would have served as support for a pyramidal roof. Four large rectangular household pits over a metre long and up to 0.40m deep were filled with darker soils, flaking debitage, and bone. The burial of a young woman was found seated in a sub-floor pit at the north end of House 1 (Figure 4B) (Dorj 1971; Derevianko & Dorj 1992).

Deposits up 1m deep of highly organic soils within and outside houses suggest intensive site use. Dates from deposit TB9, excavated in 2018, indicate accumulation within about a century (Table S1). A surface-dwelling feature (TB1) excavated in 2018, less than a kilometre from the pit-dwellings, may indicate year-round site use with different types of structures related to warm and cool season occupations. This interpretation is supported by variation in faunal assemblages: small ungulates dominating TB1 while aurochs dominated around pit-dwellings. A similar pattern of house structure variation occurs in Osipovka-type sites (13 000–10 000 BP) in the Lower Amur River region (Tabarev 2014). Year-round use is also possible for Hag based on the association of both migratory heron (April–October) and foxes (winter for fur) (Zhongguo *et al*. 2010).

Fish (18.20% NISP) and birds (16.10% NISP) comprise a significant proportion of the Hag assemblage (seeTable 3), but Tamsagbulag shows an overwhelming emphasis on aurochs (*Bos primigenius*), complimented by khulan (*Equus hemionus hemionus*), horse (*Equus ferus*), boar

(*Sus scrofa*), gazelle, and hare (*Lepus tolai*). Large freshwater mussel shells (Unionidae) were distributed in low densities, and were used for ornaments and pottery temper. All body parts, whether high or low utility, are represented for large game, indicating that the animals were either slaughtered near camp or that all body parts were transported to habitation sites. This has important implications for understanding resource use, but requires additional quantitative analysis, which is ongoing. Neither charcoal nor other botanical remains have been recovered from Hulunbuir sites, despite the fact that approximately 100L of soil was floated from Tamsgabulag deposits in 2018.

The lithic assemblages from Hag and Tamsagbulag (Figure 6) contain many more light duty tools than Baiyinchanghan, including an emphasis on microblades, highly curated arrowheads, scrapers, drills, and burins (Zhongguo *et al*. 2010). Microblades are a hallmark of hunter-gatherer technological assemblages in Northeast Asia. They are used as insets for projectile points and composite bone knifes and therefore correlated with hunting and butchering activities (Shelach 2006; Chen 2008). The high proportions of such tools imply that animal resource procurement and processing were important subsistence activities. Many digging weights were also found at Tamsagbulag, but probably tied to construction of dwellings, pits, and trenches. Low numbers of ball-headed rollers, grinding slab fragments, and heavy-duty scrapers made on coarse-grained materials were also recovered. The relative lack of milling equipment at Hag (Table S2) emphasises a very different emphasis on subsistence tasks than at Baiyinchanghan.

Sherds at both sites are sand-tempered and low-fired, and undecorated, incised, or cord-marked (Figure 7). They are more comparable to Xiaohexi- than Xinglongwa-period levels at Baiyinchanghan. Pottery at Tamsagbulag was sand- or shell-tempered and built using the slab method (Iizuka *et al*. 2018). As at other Early Neolithic Mongolian sites, some sherds are high-fired and durable. Most were too small to discern individual vessel forms, but diagnostic sherds from Hag Layer 7 indicate the use of both oval and flat-bottomed vessels. One rim sherd from Tamsagbulag indicates a very large vessel that was not likely to have been transported (Figure 7B).

Current data suggests a much lower level of community planning and occupation intensity than in the West Liao river valley. This is further reflected in burial traditions: Tamsagbulag burials are rare and unmarked, characterised by individuals (Dorj 1971; Cybiktarov 2002); at Hag they are characterised by the lack of burial pits or individuals in unmarked secondary inhumations

(Figure 4A) (Zhongguo *et al*. 2010). There are several other known Early Neolithic sites with pit-dwelling structures, including Ovoot (Dorj 1971) and Huiheshuiba (8.5–8.4 ka cal BP; about 44km south-west of Hag; Figure 1) (Liu *et al*. 2008), but most sites across the region are small microblade-dominated lithic assemblages distributed along rivers and around sand dunes (Dorj 1971; Zhao 2001; Guo & Liu 2007). The observed pattern of both significant population nucleation and dispersed land-use could be related to seasonal differentiation, variation in mobility strategies between groups, or simply change over time. The current lack of chronological control limits our understanding of these relationships.

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Table S1. Radiocarbon dates from Baiyinchanghan, Hag, and Tamsagbulag. All dates were calibrated using OxCal version 4.3 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer *et al.* 2013), dates from previously published sites were recalibrated from reported conventional dates.

Site	Lab #	Material	Radiocarbon yr BP	Cal yr BP (95.4%)	Reference
Hag, layer 7	BA081790	Charcoal	7710±40	8580–8416	Neimenggu (2004)
	BA081791	Charcoal	7355±35	8306–8036	Neimenggu (2004)
Hag, layers 1–6	BA071294	Collagen	1750±35	1775–1560	Neimenggu (2004)
	BA071295	Collagen	1785±35	1817–1616	Neimenggu (2004)
Huiheshuiba	n.a	Collagen	7750±40	8595–8431	Liu *et al.* (2008)

	n.a	Collagen (human)	8555±40	9560–9475	Liu *et al.* (2008)
Baiyinchanghan	WB90-1	Charcoal	n.a.	7612–7325	Zhongguo *et al.* (2010)
	WB90-1	Charcoal	n.a	8034–7669	Zhongguo *et al.* (2010)
Tamsagbulag Area 2	PLD-20347	Collagen	6698±26 6700±25	7613–7510 7614–7510	Odsuren *et al.* (2015)
Area 2	PLD-20348	Collagen	6646±29 6646±30	7578–7475 7579–7472	Odsuren *et al.* (2015)
Area 2	PLD-23211	Collagen	6758±27 6760±25	7663–7577 7661–7579	Odsuren *et al.* (2015)
Area 2	PLD-23212	Collagen	6702±27 6760±25	7616–7510 7661–7579	Odsuren *et al.* (2015)
Area 2, TB2	UOC-9624	Collagen	6928±29	7830–7685	Reported here
Area 2, TB7	UOC-10166	Collagen	6561±51	7571–7339	Reported here
Area 2, TB9, Level 1	UOC-9630	Collagen	6799±29	7679–7590	Reported here
Area 2, TB9, Level 1	UOC-9629	Collagen	6826±29	7699–7595	Reported here

Area 2, TB9, Level 2	UOC-9627	Collagen	6854±29	7751–7616	Reported here
Area 2, trench D	Gif. 10949	Charcoal?	5590±120	6673–6030	Séfériadès (2004)
Area 1, TB1 trench	UOC-9628	Collagen	6745±29	7662–7571	Reported here
Area 1, TB1 hearth	UOC-9625	Collagen	6962±29	7917–7700	Reported here
Area 1, TB1 hearth	UOC-10165	Collagen	6842±66	7825–7578	Reported here
Area 3, TB3	UOC-9623	Collagen	7178±29	8030–7945	Reported here
Area 3, TB5	UOC-9626	Collagen	7519±29	8400–8216	Reported here

Table S2. Comparison of tool assemblages between Baiyinchanghan and the Hag site.

Tool type		Baiyinchanghan			Hag		
		Count		P(%)	Count		P(%)
Microblade	microblade	18	23	9.09	392	420	74.73
	retouched microblade	5			28		
Light duty tools	end scraper	0	7	2.77	60	104	18.47
	scraper	6			8		
	point/drill	1			33		
	burin	0			3		
Heavy duty tools	hammer stone	3	27	10.67	0	4	0.71
	chopper	0			3		
	stone knife	24			1		
Woodworking	axe	19	27	10.67	0	1	0.18
	adze/chisel	8			1		

Milling stone	hand stone/stone slab	50	85	33.60	3	3	0.53
	pestle/mortar	18			0		
	round grinding tool	17			0		
Farming	stone hoe	70	70	27.67	0	0	0.00
Hunting	arrow head	0	0	0.00	16	16	2.84
Other	net sink	1	1	0.00	0	0	0.00
	stone ball	3	3	0.01	0	0	0.00
	perforated tool	2	2	0.01	1	1	0.18
	unknown	8	8	0.03	14	14	2.49