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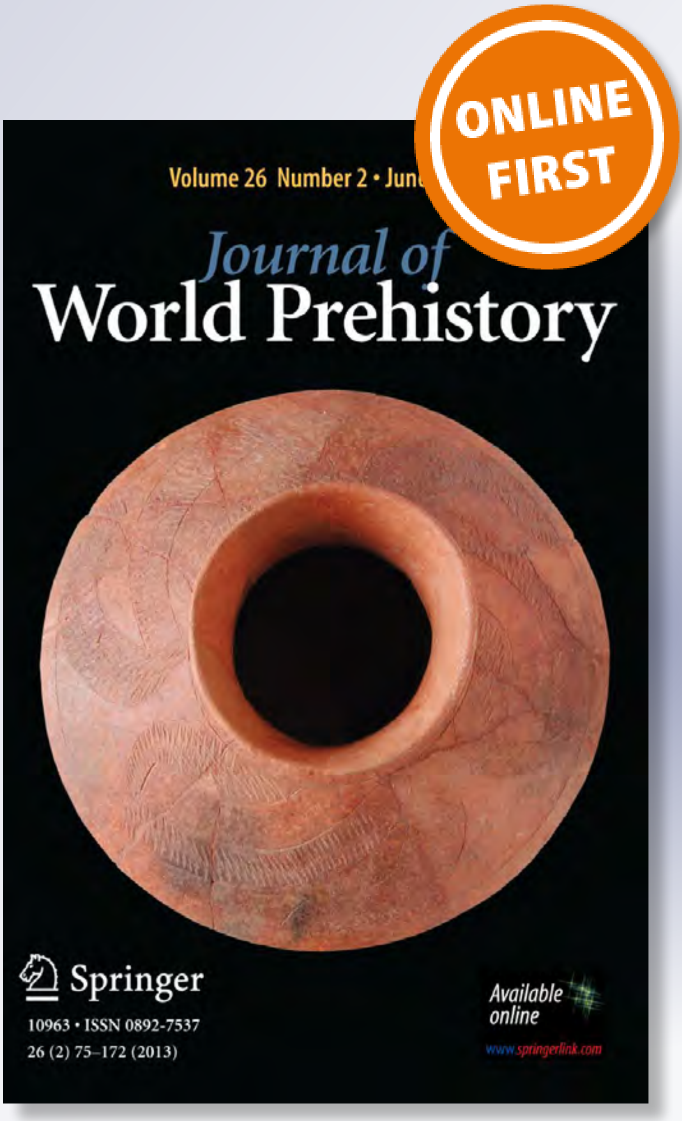

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Transitions in Palaeoecology and Technology: Hunter-Gatherers and Early Herders in the Gobi Desert

Lisa Janz[1,2] · **D. Odsuren**[3] · **D. Bukhchuluun**[3,4]

Abstract The desert and arid steppes of Mongolia and northern China were geographically central to the spread of pastoralism and the rise of pastoralist states, but research on the organizational strategies of pre-pastoralist hunter-gatherers and the spread of herding has been extremely limited. Until recently, catalogues of sites collected by Westerners in the 1920s and 1930s comprised the body of English-language publications on Gobi Desert prehistory. This article introduces a wealth of new site-specific and interpretive data, drawing on English-language sources as well as Russian- and Mongolian-language publications to create a synthesis for the prehistory of the Gobi Desert from the end of the Last Glacial Maximum to the adoption of herding. Special emphasis is placed on the relationship between a major shift in desert ecosystems, comparable to the 'greening of the Sahara', the establishment of an oasis-based broad-spectrum foraging strategy, and progressive desertification and deforestation after 2000 BC. We conclude that an oasis-based adaptation was contemporaneous with the expansion of forests and wetlands and persisted throughout the early stages of herding. A major decline in these economies occurs after 1000 BC, in conjunction with continuing trends towards heightened aridity and major societal changes across Northeast Asia. The persistent co-existence of Bronze Age burials and microblade-based habitation sites around oases, as well as similarities in material culture, suggest that these groups overlapped geographically or were the same entity.

Keywords Hunter-gatherers · Herders · Mongolia · China · Neolithic · Bronze Age · Deforestation

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Товчлол Монгол болон Умард Хятадын говь, говь хээрийн бүс нутаг нь газарзүйн хувьд мал аж ахуй болон түүнд суурилсан нүүдэлчдийн төрт улсууд бүрэлдэн бий болоход нөлөөлсөн чухал бүс нутаг юм. Гэвч эдгээрийн суурь болсон эртний анчин, түүвэрлэгч нарын нийгмийн бүтэц, мал аж ахуйн тархалтын талаарх судалгаа туйлын бага хийгджээ. Саяхныг хүртэл 1920-1930-аад оны үед барууны судлаачдын говьд хийсэн түүхийн өмнөх үеийн судалгааны бүтээлүүд хожмын англи хэлээр бичигдсэн цөөн хэдэн эрдэм шинжилгээний ажлуудын гол хэрэглэгдэхүүн болсоор иржээ. Харин энэхүү өгүүлэл нь сүүлийн жилүүдэд тухайн бүс нутагт хийгдсэн монгол, англи, орос хэл дээрх археологийн судалгааны эх хэрэглэгдэхүүнд тулгуурлан мөстлөгийн сүүл үеэс мал аж ахуйн үүсэл хүртэлх үеийн говь нутгийн түүхийн өмнөх үеийн асуудлуудыг нэгтгэн дүгнэсэн юм. Мөн зохиогчид өнөөгийн “Сахаарын цөлийн ногоорол” хэмээх үзэгдэлтэй жишиж болохуйц эртний экосистемийн томоохон өөрчлөлт, хүмүүсийн “Баянбүрд” түшиглэсэн амьдралын хэв маяг болон НТӨ 2000 оноос хурдацтайгаар явагдаж эхэлсэн цөлжилт гэх зэрэгт онцгой анхаарал хандуулан тэдгээрийн хоорондын уялдаа холбоог судалсан байна. Эртний хүмүүсийн баянбүрд түшиглэсэн амьдралын хэв маяг нь ойн болон чийглэг хөрст бүс тэлэн өргөжсөнтэй нэг цаг хугацаанд явагдаж мал аж ахуйн хөгжлийн эхний үе шат хүртэл үргэлжилсэн хэмээн зохиогчид үзжээ. Харин энэхүү амьдралын хэв маяг нь Зүүн хойд Азийг хамарсан хэт хуурайшилт болон тухайн үеийн нийгмийн бүтцэд томоохон өөрчлөлт гарч эхэлсэн зэрэг шалтгааны улмаас НТӨ 1000 оноос хойш аажмаар хумигдаж эхэлсэн байна. Зохиогчид говь хээрийн бүсэд өргөн тархсан баянбүрдүүдийн ойр орчимд хүрлийн үеийн булш оршуулга болон ижил хэлбэрийн бичил ялтас бүхий бууц суурингууд олноор тохиолдож байгаа нь эдгээр дурсгалуудыг үлдээсэн бүлгүүд нэг дор эсвэл хоорондоо холгүй амьдарч байсныг харуулахаас гадна нэг угсааны хүмүүс байх магадлалтайг цохон тэмдэглэжээ.

Introduction

The transition from hunter-gatherer to either sedentary agriculturist or nomadic pastoralist represents a pivotal phase in human society. As in other parts of the world, these two modes of food production developed in East Asia in close proximity; the bearers of each shared very similar technological traditions since the Pleistocene. However, with the rise of more intensive forms of food extraction in the Holocene, divergent ecosystems fostered very different adaptive mechanisms, and as population densities rose and conflicts in land-use emerged following the Bronze Age, intense political opposition eventually came to polarize economic ideologies (see Li 1989; Janz 2007). Although modes of subsistence were much more fluid in prehistoric societies than we often acknowledge (see Kislenko and Tatarintseva 1999; Honeychurch and Amartuvshin 2006; Svyatko et al. 2013; Spengler 2015; Honeychurch 2017), it is because of this ideological dichotomy that the Gobi Desert has long been seen as a frontier zone, a geographical barrier between significant and divergent cultural trajectories (sensu Lightfoot and Martinez 1995; Janz 2007). Despite this dualistic focus on long-term trajectories towards steppe pastoralism and agriculture, what lay between is seldom studied, but often central to the course of East Asian prehistory: the spread of microblade technology, the establishment of oasis-based economic networks, and the rise of nomadic pastoralist economies and identities along the arid northern borders of Chinese civilization. It is in such developments that we can see the desert plains of East Asia as an important zone of migration, innovation, and interaction (see Shelach 2002, pp.16–25). At the same time, knowledge of prehistoric hunter-gatherers and early herders living at the juncture of ‘the steppe and the sown’ (Peake and Fleure 1928) is severely limited in East Asia and almost non-existent in the West. The purpose of this review article is to draw attention to the role of Gobi Desert groups in the greater technological, cultural, and economic milieu of East Asia, and to begin to understand the interplay of natural environmental change, adaptation, social organization, societal change, and the effects of these processes on local environments.

The purpose of this review is to synthesize the growing body of data on Gobi Desert archaeology in order to establish it as a distinct archaeological region and to draw attention to its importance in the post-glacial prehistory of Northeast and Inner Asia. Although we know that hominins were present in the region during the Middle, and probably the Lower, Palaeolithic, this review focuses on technological and palaeoecological transformations among modern *Homo sapiens* throughout four geological periods that extend from the Late Upper Palaeolithic to the Late Bronze Age: the Last Glacial Maximum (LGM) to deglaciation; the terminal Pleistocene and early Holocene; the middle Holocene; and the late middle Holocene. Based on current data, much of it related to the components and distribution of lithic and ceramic assemblages, our primary foci are changes in subsistence, technology, settlement systems, and palaeoenvironment—the latter with an emphasis on climatic amelioration at the end of the Upper Palaeolithic to deforestation and desertification during the Late Bronze Age. The paper is divided into six main sections—the geographic and historic context of Gobi Desert archaeology; current evidence for LGM and early post-LGM populations; hunter-gatherers during the Pleistocene–Holocene transition; middle Holocene oasis-based broad-spectrum foragers; current evidence of production-based economies, including the spread of Bronze Age herding cultures; deforestation/desertification and the decline of oasis-based land-use—followed by recommendations for future research. We offer a cohesive discussion of human palaeoecology within the context of palaeoenvironmental change, as well as detailed data on numerous important archaeological sites, many of which are unknown outside Mongolia and others of which were previously unknown to Mongolian researchers. In this way, we hope to create a more integrated and holistic knowledge of regional prehistory.

Geographic and Historic Context of Research

Spanning the southernmost regions of the nation of Mongolia, the Gobi Desert also covers a vast area of northern China, including much of Nei Mongol Zizhiqu (Inner Mongolia Autonomous Region), northern Gansu, and the northeastern Xinjiang Uyghur Zizhiqu (Xinjiang Uyghur Autonomous Region) (Fig. 1). The continental desert environment separates two distinct ecological and cultural zones of East Asia—the fertile loess plains of agricultural China and the vast northern steppes of pastoralist Central and Northeast Asia—and is bounded on all sides by less arid desert-steppe and steppe environments. In the east, the desert-steppe transitions southward into the fertile loess plains that lie along the lower reaches of the Yellow River (Huang He) and eastward into the temperate woodland-steppe of the North China Plain, including the Chifeng region (CICARP 2003), both of which have been heavily disturbed and deforested through intensive agriculture. Farther

Fig. 1 Map of geographic locations and features mentioned in the text. Small lakes mentioned in text: **1** Ulaan Nuur; **2** Bayan Tökhömiin Nuur; **3** Gashun Nuur; **4** Sogo Nuur; **5** Juyanze; **6** Ulaan Nuur; **7** Diaojiao; **8** Daihai; **9** Dali

west, the Gobi Desert is part of a large swath of arid and hyper-arid lands that includes the Ordos Desert in the middle reaches of the Yellow River, and the Alashan, Badain Jaran and Tengger deserts to the south, and is separated by the Ruoshui–Hei He drainage system (Ejina River/Etsin Gol) from the Taklamakan Desert farther west. Territory south of the Badain Jaran and Tengger Deserts, situated along the upper reaches of the Yellow River, is less arid and best known archaeologically for its association with the late Neolithic agriculturalist Majiayao and Banshan–Machang phases, and with the Qijia, early Bronze Age agropastoralists who are thought to have been of major significance in the flow of Bronze Age culture from Central Asia into China through the Hexi Corridor (Chang 1987; An 1992a, 1992b; Debaine-Francfort 1995). Intensive millet agriculture and sedentary communities emerged during the Neolithic Dadiwan or Banpo phase around 5000 BC (Chang 1987; An 1992a; Bettinger et al. 2010b). The northern fringe of the Gobi Desert transitions to desert-steppe and steppe, eventually merging into the boreal forests of Siberia. Figure 1 illustrates the southeasternmost extension of the Altai Mountains into the western Gobi Desert, as well as the Khangai Mountains, which constrain the Gobi Desert to the northwest. Since evidence of herding and Bronze Age burial monuments in East Asia emerges first in the Altai Mountains (Frachetti 2008, 2012; but with regard to dates see Svyatko et al. 2009, pp. 254–262; Polyakov and Svyatko 2009; Kovalev and Erdenebaatar 2009), we would expect the Gobi–Altai to present a first frontier of interaction between Gobi Desert hunter-gatherers and early herders in East Asia.

Topography is broadly characterized by extensive mountain ranges, plateaux, erosional basins, large and small dry lake basins, gravel plains, and by alluvial and aeolian dune-fields. Precipitation varies greatly across the region, with an overall average of less than 200 mm/year, most of which falls in the summer. Annual extreme temperatures easily reach +40 °C in the summer and −40 °C in the winter. Climate is largely controlled through interplay of the Indian and East Asian Summer Monsoon systems, the Siberian–Mongolian High-Pressure System, and the Westerlies. Differences in average levels of precipitation across the Gobi Desert, as well as variation in local topography, mean that desert environments vary markedly from region to region. In order to account for potential effects of this variation on the archaeological record, Janz (2012) has roughly divided the region into three sub-regions: the East Gobi, the Gobi–Altai, and the Alashan.

The East Gobi

The East Gobi is a desert-steppe environment of basins, small lakes (*nuur/nur/nor*), plains, and mesas, which are dissected by numerous drainage channels, riverbeds, and dry gullies. This sub-region includes the southeastern areas of Inner Mongolia and the eastern part of Ömnögovi, and most of the Dornogovi *aimags* (provinces) in Mongolia. Chinese scholars divide the eastern and western deserts according to their relationship to the Helan Mountains (see Fig. 1) (Li et al. 2014). Janz's (2012) definition considers the eastern desert to begin east of the northernmost bend of the Yellow River and to extend eastwards to the Hunshandake (Otindag) Sandy Land in Inner Mongolia. Several locations of significant archaeological remains include: an area of plains and mountains northeast of the Yellow River's northernmost bend; dunes, lakes, and wetlands around the badlands, valleys, and mesas of the Shara Murun (Hsi-la-mu-lun) river system; and a large, mostly dry lake basin in Hunshandake Sandy Land (Great Lake Basin), characterized by badlands, plains, valleys, many mesas, numerous small lakes, and dune-fields (Army Map Services, Corps of Engineers, U.S. Army, Washington, D.C. 1949; Hill n.d., pp. 21–22). The southern edge of the East Gobi falls under the influence of the East Asian Summer Monsoon System and is located along what is today a temperate desert to temperate desert-steppe transitional zone. It is bounded on the south by the Yin or Daqing Mountains. A northward migration of the monsoon system during the early to middle Holocene would have heavily influenced the East Gobi and possibly some parts of the Alashan Gobi and Gobi–Altai.

The Gobi Altai

The Gobi–Altai (Fig. 2.1, 2.2) is a desert to desert-steppe environment surrounding the easternmost foothills of the Altai Mountains and extending over Ömnögovi *aimag* and the southern portions of Övörkhangai, Bayankhongor, and Govi-Altai *aimags*. The region is characterized mostly by sparsely vegetated gravel pavements or *govi* (the Mongolian root word for the Gobi), but is interspersed with dune-field accumulations. Long-lived, internally-drained lake basins, shallow brackish former or seasonal lakes, and wetlands are scattered throughout lowland habitats. Large alluvial fans and scattered west-to-east trending ranges divide the Gobi–Altai and Alashan Gobi regions. Many of the sites in this region are located in the basins around and northeast of Arts Bogd, where many dune-field accumulations flank dry or seasonally filled shallow lakes and riverbeds, some with *Haloxylon ammodendron* 'forests' (*zag*/*dzag*/saxaul). Notable areas within this subregion include the Arts Bogd–Ulan Nuur Plain, an area particularly rich in both archaeological sites and high quality lithic raw materials such as jaspers and chalcedonies, and the Valley of the Gobi Lakes, a large valley scattered with dune-field accumulations and east–west trending sub-valleys situated along the southern slopes of the Khangai (Khangay) Mountains. There are four major semi-saline lakes (Böön Tsagaan Nuur, Adagin Tsagaan Nuur, Orok Nuur, and Tsagaan Nuur) in the valley, which are fed by rivers draining from the Khangai Mountains. Due to its northerly position, the valley is today largely outside the influence of the summer monsoon system. Rain is thought to be controlled by the Westerlies (Chen et al. 2008), and the region is fed extensively by drainage from the Gobi–Altai Mountains.

The Alashan Gobi

The Alashan Gobi is located within the western reaches of Inner Mongolia and can be described as a semi-desert region characterized by dune-fields, dissected badlands, and gravel plains (*govi*). Dune-fields are more extensive here than in the East Gobi or Gobi–Altai regions. Archaeological collections are derived from several key areas including: the eastern Alashan, just west of the Yellow River and foothills of the Langshan Mountains; the Galbyn *govi*, an extensive basin of dunes, badlands, and dry lake basins which stretches along the border between Mongolia and Inner Mongolia; the Goitso Valley on the southern margin of the Galbyn *govi* depression, where near-surface-level groundwater hosts many small oases and supports rich pasture land; the Ukh Tokhoi/Khara Dzag plateaux, an upland zone separating the Goitso Valley and Badain Jaran Desert, rich with high quality tool stone and characterized by drift sand and relict higher elevation marshlands; the Juyan region, located in the far west, which represents lakes (e.g. Gashun Nuur, Sogo Nuur) and oases of a terminal palaeolake system fed by major river drainages from the Qilian Mountains; and, finally, the Gurnai Depression, a major erosional basin situated between the Ruoshui–Hei He drainage system and the Badain Jaran Desert. Local palaeoecology is distinct but most similar to the Gobi–Altai region. We expect that the Alashan would have been influenced by the northward migration of the summer monsoon. Drainage from the Qilian Mountains through the Ruoshui–Hei He drainage system historically supplied much

Fig. 2 Different environmental contexts of archaeological sites in the Gobi Desert: **1** Chikhen Agui rockshelter, Gobi–Altai (courtesy of John W. Olsen); **2** Bayanzak dune-field/wetland site, Gobi–Altai; **3** Dariganga dune-field/wetland site, Gobi–Steppe; **4** Delgerkhaan Uul river valley wetland site, Gobi–Steppe

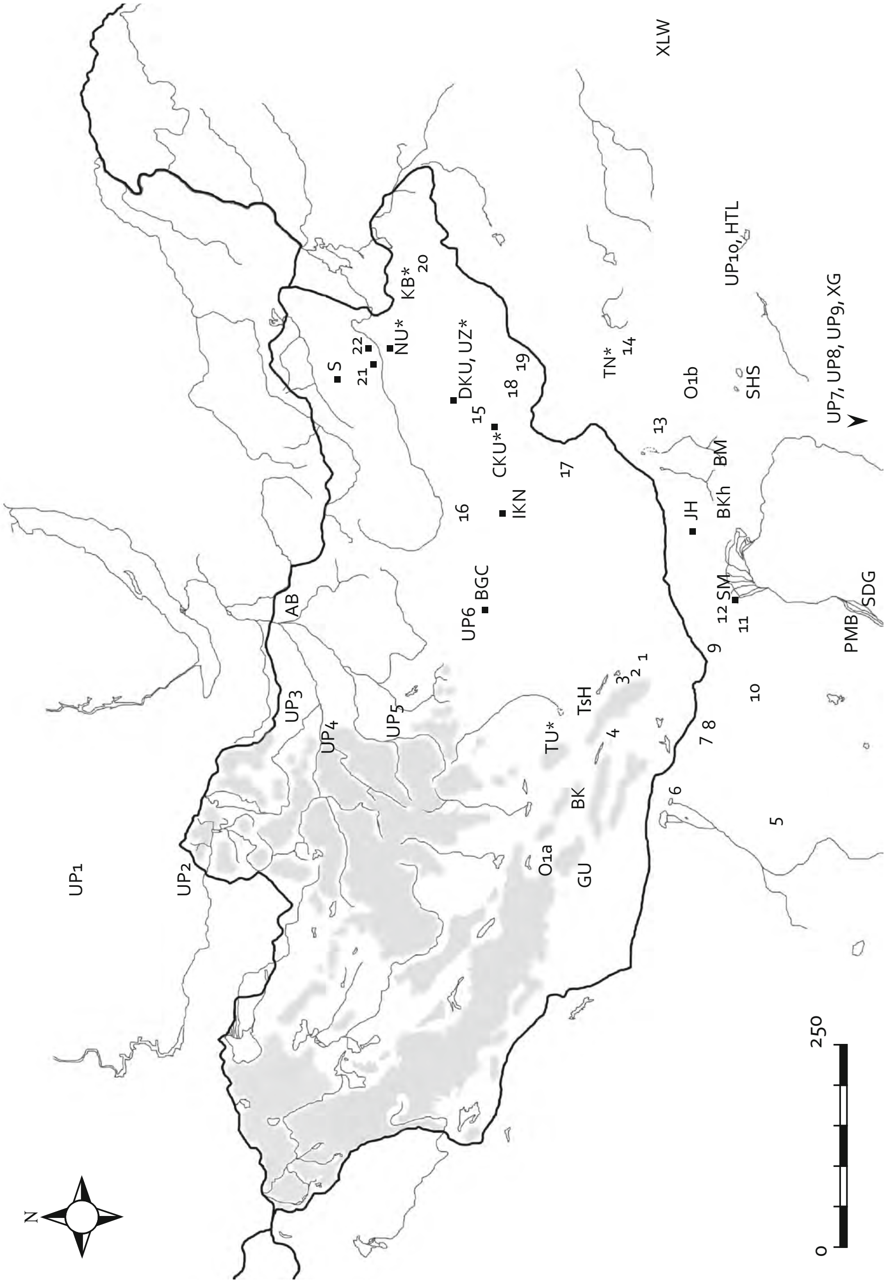
of the water table (Lu et al. 1997), but there is some evidence that lake levels have at times been bolstered by excessive drainage from the Gobi–Altai Mountains (Hartmann 2003; Janz 2012, pp. 323).

The Gobi—Steppe

We can also add the more peripheral Gobi–Steppe (Fig. 2.3, 2.4), which is less well studied and represents the northern transitional zone between desert and arid steppe, extending from central to eastern Mongolia across the provinces of Dundgovi, Govisümber, Sükhbaatar, and northern Dornogovi. The region is much less arid than the Gobi Desert proper and exhibits better soil formation and less extensive erosion. This subregion is notable for its relative lack of geographic relief, broken occasionally by long stretches of rocky outcrops like the eroded canyons and granite massifs Ikh Nartyn Chuluu (Ikh Nart), Baga Gazryn Chuluu, and Delgerkhaan Uul (Fig. 3.IKN, BGC, DKU). Dry shallow lake basins and dune-field formations are also scattered across the region but are a much less prominent feature of the landscape. Two large tracts of this area have been or are being surveyed by a large scale Mongolian–American collaborative project—Baga Gazryn Chuluu, Dundgovi *aimag* and Delgerkhaan Uul, Sükhbaatar *aimag*, respectively (Wright et al. 2007; Amartuvshin and Honeychurch 2010). Ikh Nart is a third region of extensive survey and exploratory excavation (Schneider et al. 2015, 2016).

History of Research

The initial study Gobi Desert archaeology can be attributed largely to an increasing interest in the geological, palaeontological, and biological aspects of the region, in conjunction with the discovery of stone tools and *Homo erectus* and early modern *Homo sapiens* fossils, as well as Neolithic pottery and burials, in North China during the early 1900s (Andersson 1943; Wu and Olsen [Eds.] 1985; Chang 1987; Fiskesjö and Chen 2004). Such discoveries led to the inclusion of archaeologists in two important scientific expeditions in Mongolia and China during periods of tumultuous local political upheaval in the 1920s and 1930s. The Central Asiatic Expeditions were led by Roy Chapman Andrews under the auspices of the American Museum of Natural History (AMNH) in New York City. Sven Hedin led the Sino–Swedish Expeditions, which were funded by the Swedish state, the Chinese government, Deutsche Lufthansa and several private donors (Hedin 1943). Altogether, artifacts from almost five hundred Stone Age sites were shipped to the United States and Sweden for analysis, along with the materials recovered by other expedition scientists. Archaeological materials from these expeditions spanned all occupation periods, from the Palaeolithic to modern times, but the vast majority of finds were Stone Age and considered to represent the Mesolithic and Neolithic periods (Berkey and Nelson 1926; Nelson 1925, 1926a, 1926b; Bergman 1945; Maringer 1950, 1963). Most were derived from surface assemblages and a few from excavated contexts. Heightened political tensions and civil war, followed by the rise of isolationism among the communist governments, effectively terminated work by Western scientists. Collections made by Central Asiatic Expedition archaeologists Nels C. Nelson (1925) and Alonzo Pond (1928, n.d.) are currently housed at the AMNH (Fairservis 1993; Janz 2006, 2012), and those made by Folke Bergman during the Sino–Swedish Expeditions at the Museum of Far Eastern Antiquities (MFEA) in Stockholm (Maringer 1950). Half of the materials collected during the Sino–Swedish Expeditions were left in China and eventually studied by Chen Xingcan in the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UP2
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UP4
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IKN
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TN*
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UP10, HTL
UP7, UP8, UP9, XG
O1b
SHS
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JH
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◀ **Fig. 3** Map of archaeological sites mentioned in the text: *UP1* Tarachika; *UP2* Ui; *UP3* Dörölj; *UP4* Tölbör; *UP5* Moiltin Am/Orkhon; *UP6* Yorool Govi; *UP7* Xiachuan; *UP8* Xiaonanhai; *UP9* Shizitan; *UP10* Youfang; *O1a* Chikhen Agui; *O1b* Shara Kata; *AB* Altan Bulag; *SDG* Shuidonggou; *PMB* Pigeon Mountain Basin; *HTL* Hutouliang; *XG* Xueguan; *TsH* Tsakhiurtin höndi; *1* Bayanzak/Shabarakh Usu; *2* Ergiin Khooloi; *3* Khoyor Khairkhan (Baruun Zuun Khairkhan); *4* Zuukh; *5* Mantissar; *6* Sogo-nuur; *7* Bayan Khuduk; *8* Dottore Namak; *9* Yingen Khuduk; *10* Ukh Tokhoi and Altat; *11* Jabochin Khure; *12* Gashun and Hoyar Amatu*; *13* Baron Shabaka; *14* Chilian Hotoga; *15* Zaraa Uul*; *16* Shavartain Bulag; *17* Dulaany Govi; *18* Ongon; *19* Dariganga; *20* Tamsagbulag*; *21* Kherlen 9; *22* Ovoot*; *NU** Norovlin Uul; *XLW* Xinglongwa; *SHS* Shihushan; *BGC* Baga Gazryn Chuluu*; *IKN* Ikh nart*; *DKU* Delgerkhaan Uul*; *UZ** Ulaanzuukh; *CKU** Chandmani Khar Uul; *KhB* Khuiten-bulag; *TN** Tairum Nor; *TU** Tevsh Uul; *BM* Beli Miao*; *SM* Shande Miao*; *BKh* Bulung Khuduk*; *JH* Jisu Hongeur*; *BK* Bayanleg Khad; *GU* Getseliin Us. Abbreviated site designations with an *asterisk* are primarily associated with burial structures. An *asterisk* follows the full name for other types of sites with known burial components

1980s (see Fiskesjö and Chen 2004), and those housed at the MFEA were studied by Lisa Janz in 2008 (Janz 2012).

Beginning in the late 1920s, Mongolian amateur archaeologists began collecting lithic artifacts in the Gobi Desert, and in 1949 Russian archaeologists began working with local researchers (Gunchinsuren and Bazargur 2009). Since then, Mongolian, Russian, and Chinese archaeologists have been responsible for most of the archaeological work undertaken in the Gobi Desert. Numerous site reports have been published in those languages, and several summaries of their findings have appeared in English, most rather brief regional synopses (Wang and Olsen 1985; Cybiktarov 2002; Derevianko and Dorj 1992; An 1992a, 1992b; Gunchinsuren and Bazargur 2009). This research remained fundamentally culture-historical due to a lack of date-based temporal controls, stratified sites, and applicable theoretical models. Such an approach is needed in regions where a great deal of basic research has yet to be done. At the same time, the resurgence of better-funded and more theoretically diverse foreign collaborations, which began in the early 1990s, has led to progressively richer data production. Recent studies in chronometric dating have also now facilitated the production of a date-based chronology for the Gobi Desert (Derevianko et al. 2003; Janz et al. 2009, 2015). These advances have made it increasingly possible to begin weaving a tapestry of interpretative research upon the basis of firm contextual data. This study will present little-known data from a wealth of early and recent scholarship in order to synthesize a foundation for Gobi Desert prehistory.

Last Glacial Maximum to Deglaciation: Late Upper Palaeolithic Foragers

The Stone Age archaeology of the Gobi Desert is largely known through surface scatters of stone tools, and the lack of hominin remains limits our understanding of early population genetics. One partial skullcap was discovered at Salkhit in northeastern Mongolia (Fig. 3. S); this has been classified as archaic *Homo sapiens*, but definitive genetic analysis or chronometric dates have yet to be published and there is some speculation that the individual could represent modern *H. sapiens* or even *H. erectus* (Coppens et al. 2008; Lee 2015; Tseveendorj et al. 2016). Lee (2015) refers to radiocarbon dates in the range of 27 ka ago from a widely cited but currently inaccessible 2010 National Geographic interview. These dates are currently unsubstantiated. Due to the difficulty of dating such assemblages, relative ages are frequently assigned based on comparison with typological characteristics from neighboring regions. Based on the fossil record, we know that anatomically modern humans were present in East Asia by 45.0 ka ago (Fu et al. 2014). Blade core reduction strategies also developed in eastern Central Asia around 45.0 ka ago and became widespread after 40.0 ka ago. This makes it tempting to assume that blade technology coincided with the arrival of modern humans (Brantingham et al. 2001; Derevianko et al. 2004; Kuzmin 2004; Gladyshev et al. 2012; Morgan et al. 2014); however, the relationship between lithic reduction strategies and genetics is indistinct (Brantingham 1999; Kuhn and Zwyns 2014; Li et al. 2014; Groucutt et al. 2015).

The earliest millennia of modern human occupation occurred during a period of relatively warm/wet conditions typified by palaeosol formation, the infilling of massive palaeolake basins, and the expansion of steppe and forest-steppe on the Loess Plateau (Feng et al. 2007; Grunert and Lehmkuhl 2004; Herzschuh and Liu 2007), with desert vegetation dominating the Gobi lowlands (Herzschuh et al. 2004). Although this period was much warmer and wetter than preceding periods, there is some disagreement about whether the climate reached Holocene levels (Herzschuh and Liu 2007). Pollen profiles spanning the last 40.0 ka of the Pleistocene indicate that coniferous forests were dominant and deciduous species poorly represented (Feng et al. 2007).

These conditions lasted until about 25.0 ka cal BP, when mean moisture values decreased during the LGM. Desert vegetation shifted south while taiga extended into the Gobi region from the north (Feng et al. 2007). Permafrost developed along desert floors and frequent flash-flooding contributed to the formation of alluvial fans (Owen et al. 1997, 1998; Lehmkuhl and Lang 2001; Hülle et al. 2009). Due to the greater influence of the Siberian–Mongolian High Pressure System, the western desert is expected to have experienced more extreme environmental conditions during the LGM, but there is evidence that groundwater tables remained relatively high and evapo-transpiration low under conditions of severe winter cold and cooler average temperatures (Owen et al. 1998; Komatsu et al. 2001). Hyperaridity is thought to have dominated across northern latitudes between 20.3 and 19.0 ka cal BP (Feng et al. 2007; Herzschuh 2006; Lehmkuhl and Haselein 2000; Wünnemann et al. 1998), but more localized limnological data suggests that lower temperatures could have allowed for stable or increased lake levels in some parts of the Gobi Desert (Komatsu et al. 2001; Liu et al. 2002b; Herzschuh 2006).

Currently, there is very little data about the nature of human settlement in the Gobi Desert and it is unknown whether the region was inhabited during the LGM; therefore, recognizing archaeological sites from this period requires a knowledge of technological processes in neighboring regions. According to the chronology proposed by Gladyshev et al. (2012), the LGM coincides with the Middle Upper Palaeolithic, which represents the complete replacement of large blade-based industries by a flake and microblade industry (but see Zwyns et al. 2014a). Early elements of microblade reduction strategies are evident in the Early Upper Palaeolithic and include the production of bladelets (>12 mm width) from small prismatic, carinated and flat-faced cores. This phase is expressed in upper levels of Orkhon-7 (Fig. 3.UP3); Dörölj 1 (Fig. 3.UP3); Tölbör 4 and 15 (Fig. 3:UP4); Moiltyn Am (Fig. 3.UP5); Level 4 (Horizon 4) of Chikhen Agui (Fig. 3.O1a; Derevianko et al. [Eds.] 2000; Gladyshev et al. 2010, 2012; Zwyns et al. 2014a, b; Tsogtbaatar and Bolorbat 2016; Jaubert et al. 2004); and in surface assemblages from the Yorool Govi (Dno Gobi) locality (Fig. 3.UP6; Okladnikov 1986). Chronology is variable. Charcoal from a hearth in Level 4 of Chikhen Agui dates to 32,572 ± 760 cal BP (27,432 ± 872 BP). Cores from Levels 2 and 3 of Moiltyn Am (Fig. 3.UP5) exhibit such trends, while the Level 1 assemblage contains a few true microblades and microblade cores and more extensive retouch of flakes, alongside the continued use of heavy-duty pebble tools (see Okladnikov 1981); however, Tsogtbaatar and Batbold (2016, p. 180) report a date of 20,240 ± 130 BP (24,185 ± 299 cal yr BP) on wood charcoal from Level 4.

Tool-kits based on true microblade core reduction strategies are hypothesized to have been used in Siberia prior to 25.0 ka ago, spreading slowly between 25.0 and 20.0 ka ago (Keates 2007; Kuzmin 2007; Gladyshev et al. 2010, 2012). Some of the earliest well-documented evidence for the southward expansion of a microblade-based industry comes from Youfang (Fig. 3.UP10) in the lower reaches of the Yellow River. The cultural layer where 13 of the 72 cores were categorized as microblade cores was bracketed by OSL dates of 26.6 ± 2.1 ka and 29.2 ± 2.0 ka (Nian et al. 2014). Four flat-faced cores are depicted by Nian et al. (2014, fig. 2b). These dates demonstrate that microblade core technologies had expanded beyond Siberia and across the Gobi Desert by the onset of the LGM. Sites 1 and 3 from Yorool Govi (Dundgovi *aimag*) are intriguing with regard to early spread of microblade core technology, as the assemblages contain true microblade cores (including boat-shaped cores: Okladnikov 1986, pp. 168, 200–201), bladelet cores, flake cores, bifacial core preforms and/or tools, and large elongated flakes reminiscent of Early Upper Palaeolithic large blades. Such assemblages are also recovered from surface contexts in the Arts Bogd region of the Gobi–Altai. The technological characteristics of these assemblages position them as potential representatives for the southward spread of microblade industries. Additional research on raw material use and flaking techniques should be conducted to determine whether these sites are chronologically-coherent or palimpsest accumulations.

Despite early dates on several pre-LGM microblade-based assemblages in China, the technology was limited in frequency and distribution this far south and the extent of pre-LGM microblade use in Mongolia is currently unknown. The later spread of microblades/cores is thought to have been connected to post-LGM population expansion (Goebel 2002; see also Barton et al. 2007). Since true microblade reduction strategies appear first and most ubiquitously in Siberia, it is likely that the technology diffused from these regions into the Gobi Desert and subsequently into other parts of northern China (Kuzmin 2007; Nian et al. 2014). Microblade-using groups in the Gobi Desert would presumably have receded northwards into the steppes of northern Mongolia and Siberia (see Kuzmin 2007) and southwards into the Yellow River region during the LGM as they sought refuge in less extreme environments (Goebel 2002; Barton et al. 2007). If the Gobi Desert was abandoned during the LGM, these populations should have re-expanded into the desert region with the onset of post-LGM amelioration.

Whatever the case, microblade core reduction strategies spread across Northeast Asia after the end of the LGM to become the dominant core reduction technique by 15.4–11.5 ka cal BP (13.0–10.0 k yr BP)(Lu 1998; Kuzmin et al. [Eds.] 2007; Yi et al. 2014). These later microblade assemblages typically contained a wider diversity of microblade types and retouched microblades (Vasil'ev and Semenov 1993; Aikens and Akazawa 1996; Elston et al. 1997; Lu 1998; Xia et al. 2001; Cohen 2003; Ackerman 2007; Barton et al. 2007; Chen 2007; Norton et al. 2007; Seong 1998, 2008; Gladyshev et al. 2010). One well-studied example of this diversity is Xiachuan (Fig. 3.UP7). Although this site is often cited as belonging to the LGM, there is a wide range of dates [from 23,220 ± 1000 BP (29.1–26.5 ka cal BP) to 13,900 ± 300 (16.5–17.5 ka cal BP)] and their association with the microblade assemblages is questionable (Nian et al. 2014; Yi et al. 2014). The wide range of microblade core types, including conical, semi-conical, and boat-shaped, along with points and scrapers on microcores and microblades, chipped adzes, and grinding slabs (Chen and Wang 1989; Lu 1998; Nian et al. 2014; Tang 2000) is more characteristic of the early post-LGM when assemblages contain a wider diversity of microblade core types and retouched microblades. Based on the Chinese microblade industries, LGM and early post-

LGM assemblages in the Gobi Desert are expected to contain boat-shaped, wedge-shaped and sub-conical forms (see Janz 2012).

If humans were present in the region during this period, they almost certainly maintained high residential mobility. Data from a number of Late Pleistocene and Holocene sites across the western Gobi Desert (Derevianko et al. [Eds.] 1996, 1998a, Derevianko et al. [Eds.] 2000) and the Valley of the Gobi Lakes (Derevianko [Ed.] 2000) show that long-term occupations were rarer prior to the early Holocene (Derevianko [Ed.] 2000, pp. 241–243; Janz 2006). Bettinger and colleagues (2007) have posited that post-LGM adaptations in northwest China included high mobility and varied land-use strategies across a variety of habitats, while Janz's (2012, 2016, fig. 3) analysis of Stone Age assemblages from across the Gobi Desert supports the conclusion that Palaeolithic sites were relatively evenly distributed across upland and lowland settings.

Large-bodied herbivores were distributed across Northeast Asia until the terminal Pleistocene and early Holocene (Kuzmin and Orlova 2004; Janz et al. 2009, 2015; Kurochkin et al. 2009; Kuzmin 2010), and the proliferation of large game in contemporaneous sites in Northeast Asia suggests that they were an important resource. About 200 km north of the Mongolian–Siberian border, LGM faunal assemblages from Ui (Uy) I (Fig. 3.UP2) and Tarachikha (Fig. 3.UP1) include species such as *Mammuthus primigenius* (woolly mammoth), *Bos primigenius* (aurochs), *Bison priscus* (steppe bison), *Equus hemionus* (Asiatic wild ass/onager), *Cervus elaphus* (red deer), *Rangifer tarandus* (reindeer), *Ovis ammon* (Argali sheep), *Capra sibirica* (Siberian wild goat), and a range of small-bodied prey such as *Alopex* sp. (arctic fox, cf. *Vulpes lagopus*), *Lagopus* sp. (ptarmigan), and *Marmota* sp. (marmot) (Derevianko et al. [Eds.] 1998b, pp. 117, 120, 122). Faunal remains from Youfang included ostrich (*Struthio*) eggshell, *Myospalax* sp. (zokor), and antelope (Antelopinae) (Nian et al. 2014). Early post-LGM period sites in the region show a continued reliance on large game such as *Alces alces* (moose), *Bos primigenius* (aurochs), and *Equus ferus* (horse), alongside grinding stones and remains of *Lepus* sp. (hare), fox, birds, fish, and eggs (Vasil'ev and Semenov 1993). In North China, faunal remains from Xiaonanhai (Fig. 3.UP8) [15.7–12.8 ka cal BP (13,075 ± 500 and 11,000 ± 500 BP)] evidence the use of large-bodied species such as *Rhinoceros tichorhinus* (extinct rhinoceros), *Equus hemionus* (khulan/wild ass), *Cervus canadensis* (elk or wapiti), and *Bubalus wansjocki* (extinct water buffalo) (Tang and Gai 1986). Considering the composition of later faunal assemblages, *Struthio anderssoni* Lowe (ostrich and/or their eggs) and *Equus hemionus* were likely species of major economic importance. Use of grass seeds was also evidenced at some LGM sites in North China. Combined usewear and starch grain analysis of grinding stones from Shizitan Locality 14 (Fig. 3.UP9) (c. 23.0–19.5 ka cal BP) indicates that the tools were probably used for grinding grass seeds, tubers/roots, and beans (Liu et al. 2013), while the identification of several grains of wild millet (*Echinochloa* sp., *Setaria* sp.) and Chenopodiaceae from a collection of 28 charred seeds supports the idea that seeds were being exploited by hunter-gatherers (Bestel et al. 2014). At the same time, considering the relative paucity of plant remains and grinding equipment, and the probability of widespread landscape instability until after 16.5 ka cal BP (see below), it seems likely that the exploitation of plant foods was incidental and non-intensive during the LGM, and particularly the early part of it.

In summation, microblade technology developed several thousand years prior to the LGM and saw an extensive geographic expansion following deglaciation. Grinding stones and pottery were known across Northeast Asia even though their use is not evidenced in the Gobi Desert until much later. Based largely on evidence from better known regions, we posit that prior to the Holocene, Gobi Desert subsistence would have been characterized by an emphasis on large game with the complementary use of smaller prey and the non-intensive exploitation of easily available plant foods. Wild grasses, edible leaves (i.e. greens) and underground storage organs would have been most productive in this arid region. We see subsistence as being organized around exploitation of the resources most productive and readily available to an omnivore species with highly effective hunting strategies. Despite the lack of clear data for this period, we know that post-LGM tool-kits were rooted in local technological developments across Siberia, Mongolia and China (e.g. Larichev 1962; Chard 1974).

Terminal Pleistocene to Early Holocene: Broad-Spectrum Foragers?

Diet breadth expansion, or the emergence of broad-spectrum foraging, is a topic of primary importance for researchers studying post-LGM organizational strategies. The more regular inclusion of small, fast prey into hunter-gatherer diets and increasingly intensive exploitation of species with low caloric return rates is considered to be a necessary and distinctive precursor to food production and domestication (Stiner 2001). Known as the Broad Spectrum Revolution (Flannery 1969), this shift in subsistence is recognized in different world regions at vastly different times, but became much more widespread during the Pleistocene–Holocene transition (Janz 2016). Despite a traditional focus on a potential relationship between resource depression and diet breadth expansion (Binford 1968; Flannery 1969; Christensen 1980; Stiner et al. 2000; Stiner 2001), Janz (2016) attributes the global rise in broad-spectrum foraging to ecological changes that made the exploitation of *r*-selected species (those with high reproductive potential—often, but not always, small and fast) more productive and reliable. The expansion of wetlands and mast forests, and the juxtaposition of these environments created contexts where a high diversity of *r*-selected prey was concentrated, which would have allowed hunter-gatherers to take a more specialized approach to land-use.

Based on these environmental changes and a clear divergence in land-use and technology that characterizes archaeological assemblages from the terminal Pleistocene and early Holocene, Janz (2012) has proposed a new nomenclature for the late Stone Age of the Gobi Desert. The terminology highlights what Janz sees as a distinct economic relationship between hunter-gatherers and oases that is largely uncharacteristic of earlier or later periods. This new date-based chronology supports many of the hypotheses presented in earlier twentieth century syntheses, but adopts a more regionally-specific scheme that refines the original Mesolithic/Neolithic categorization adapted from the European record (Berkey and Nelson 1926; Nelson 1926a, 1926b; Maringer 1950, 1963). (It should be noted that the term 'Neolithic' has been used in this region in the literal sense intended by John Lubbock in 1865 to denote a change in technological development, specifically for Lubbock the use of polished stone tools: Trigger 1989, pp. 94–95. Russian archaeologists use the term to identify assemblages containing pottery: Chard 1974; Kuzmin 2003). Based on analysis of nearly one hundred sites spanning much of the Gobi Desert, Janz's chronology is adopted herein and can be outlined as follows: Oasis 1/Mesolithic (13.5–8.0 ka cal BP) represents a period of incipient use of oasis environments alongside the regular use of a range of other ecozones, particularly those associated with rivers or lakes; Oasis 2/Neolithic (8.0–5.0 ka cal BP) represents the onset of intensive oasis exploitation typified by camp sites centered around dune-fields and wetlands, the regular use of grinding stones, pottery, chipped and/or polished macrotools such as adzes and axes, and a wider range of microlithic tool types; and Oasis 3/Bronze Age or Eneolithic (5.0–3.0 ka cal BP) represents a time during which oasis-based habitation continues alongside a few technological shifts such as a greater variety of pottery types and the use of bifacial flaking for projectile points, knives, and other small tools (Janz 2012). Tables 1 and 2 provide a more detailed summary of the technologies and pottery types, respectively, associated with each phase.

Palaeoecology

According to Janz's hypothesis, we would expect diet breadth expansion in the Gobi Desert to correlate with climatic amelioration and the expansion of wetlands after 16.5 ka cal BP. The most directly representative palaeoenvironmental data comes from lakes in the western desert. C/N ratios of cored sediments from Ulaan Nuur in the Gobi–Altai region indicate that terrestrial plant cover in the region surpassed modern conditions by 16.5–15.5 ka and again between 11.3 and 3.1 ka (OSL) (Lee et al. 2013). Combined geochemical, granulometric, palynological and ostracod analysis of a core from Bayan Tökhömiin Nuur, farther south in the Gobi–Altai, offers a comprehensive record of changes since 15.0 ka cal BP (Felauer et al. 2012).

At 15.0–12.0 ^{14}C ka cal BP the core suggests an environment characterized by a relatively wet and cold Artemisia steppe with *Ephedra* shrubs growing on a rocky or gravelly surface surrounding what was then a shallow freshwater lake with submersed plants and reed beds (Felauer et al. 2012; but see Lee et al. 2013). The presence of grazing herbivores is recognized by the pollen of grazing weeds and the spores of dung-living

Table 1 Summary of chronological phases and associated technologies (Janz 2012; Janz et al. 2015)

Chronological phases	Dates	Tool types	Pottery types
Oasis 1 (Mesolithic)	13.5–8.0 k cal yr BP	Microblade technology; expedient core and flake; small, informal milling stones ('rubbing stones'); sidescrapers; thumbnail scrapers; mostly local homogeneous cryptocrystallines	By 9.6 k cal yr BP Plain; impressed? High organic content; low-fired
Oasis 2 (Early Neolithic)	8.0–5.0 k cal yr BP	Microblade technology; expedient core and flake; large formal milling stones (e.g., slabs, mortars, pestles, rollers); chipped macrotools; chipped and partially polished adzes and axes; thumbnail scrapers; small unifacially pressure-flaked points and some bifacially-flaked forms; highest quality cryptocrystallines	Plain; honeycomb/'net'-impressed; corded; string-paddled, rows of moulding and punctates Organic content; sand/gravel-tempered; shell?; mica? Low-fired
Oasis 3 (Eneolithic, Bronze Age)	5.0–3.0 k cal yr BP	Microblade technology; expedient core and flake; retouched massive flakes; chipped macrotools; chipped and partially or fully polished adzes and axes; thumbnail scrapers; bifacially–flaked arrowheads, blades, knives; small and large(?) grinding stones; whetstones?; copper slag; local high quality material, increased use of chalcedony esp. for bifaces	Plain; string–paddled; moulded rim; painted; fine redware; burnished; geometric incised Organic content, sand/gravel, mica, shell, fibers (incl. hair) High–fired and low–fired

Table 2 Diagnostic pottery types and associated date range (Janz et al. 2015). Number of direct-dated samples used to make designation in brackets

Pottery types	Date Range [cal yr BP (95.4%) and ka]
Earliest pottery	9683–9499 (1 sample)
Net-impressed pottery	7670–4875 (5 samples)
Corded	8010–2990 (3 samples)
String-paddled pottery	4973–1450 (3 samples)
Coarse redware	2830–1450 (3 samples)
Fine redware	4590–3350 (1 sample)
Geometric incised	4150–2910 (1 sample)
Burnished	4660–3260 (1 sample)

organisms (Felauer et al. 2012, pp. 130). Lake cores from Dali Nor, situated east of the Hunshandake Sandy Land and slightly southeast of the East Gobi study area, also indicate a reduction in aeolian activity after 16.5 ka cal BP (13.5 k yr BP) (Wang et al. 2001), while temperature and effective moisture surpassed modern conditions by12.4 ka cal BP (10 k yr BP) (Wang et al. 2001, 2010; Liu et al. 2002a; Shi and Song 2003).

This trend in amelioration was broken during the Younger Dryas by a brief reversion to highly arid conditions. The timing of the Younger Dryas seems to have varied greatly across arid Northeast Asia (see Wright and Janz 2012), and is typically recognized by suppressed lake levels and declines in vegetative biomass (Madsen et al. 1998; Shi and Song 2003; Herzschuh 2006). Limnological data from Bayan Tökhömiin Nuur indicates desert conditions in the Gobi–Altai, with shrinking lakes, increased aeolian deposition and low vegetation cover between 12 and 11 ka cal BP (Felauer et al. 2012). Researchers working at the southeastern margins of the Gobi Desert have identified a later climatic shift, from woodland-steppe mosaic towards desert-steppe vegetation, between 10.4 and 8.8 ka cal BP (9.2–7.9 k yr BP) (Wang et al. 2001; Shi and Song 2003; Feng et al. 2007; Wang et al. 2010).

Following the Younger Dryas, conditions in the Gobi–Altai appear to have been moister but unstable, and there are indicators of high surface run-off until the height of climatic amelioration beginning at 7.5 ka cal BP (Felauer et al. 2012; Lee et al. 2013). Records from numerous lakes in the Alashan Desert indicate a broadly similar timeline with the climatic optimum beginning after 7.5 ka cal BP (Long et al. 2007; Zhao et al. 2008; Li et al. 2009; but see Herzschuh et al. 2004; Hartmann and Wünnemann 2009) when precipitation was twice as high as in modern times, with an average of about 200 mm/year (Yang and Williams 2003). In the east, post-Younger Dryas dune stabilization and palaeosol formation in the Hunshandake Sandy Land attests to improved climatic conditions between 10.0 and 3.0 ka (Li et al. 2002; Gong et al. 2013; Yang et al. 2013), with lake sediments suggesting optimal conditions between 10.0 and 8.5 ka cal BP (Tang et al. 2015). Farther to the east and south, along the southern desert-steppe transitional zone, warm/wet conditions peaked at different times after 8.9 ka cal BP (Wang et al. 2001, 2010; Shi and Song 2003; Peng et al. 2005; Jiang et al. 2006; but see Wang et al. 2012). Additional data from dune fields and lake cores more central to the East Gobi would greatly improve our understanding of climatic amelioration in that region, but existing data suggests that the Holocene Climatic Optimum in the western Gobi Desert may have been several hundred to more than a thousand years later.

Archaeological Sites

Despite the probability that vegetation and hydrology were well developed in the Gobi Desert as early as 16.5 ka cal BP, few sites have been definitively attributed to the terminal Pleistocene. Janz (2012) attributes seven of the sites that she analyzed to Oasis 1, spanning the terminal Pleistocene and early Holocene. Chikhen Agui (Figs. 3.1, 3.O1a) is one of two sites that have been excavated and firmly dated to Oasis 1. With an accepted date range of 13.4–8.7 ka cal BP (Derevianko et al. 2003; there are several later dates, but see Derevianko et al. 2008), this is the only Oasis 1 site so far dated to the terminal Pleistocene, and the oldest post-LGM dates were used to determine a tentative start date for that period. The rockshelter is near a spring and situated at an elevation of about 1970 m.a.s.l. Lithics were discovered by Derevianko and Petrin in 1988 and excavated by the Joint Mongolian–Russian–American Archaeological Expedition (JMRAAE) in 1996–1998 and 2000 (Derevianko et al. [Eds.] 1998a, 2000, Derevianko et al. 2003, 2008). Organic remains were extremely well preserved. Grass bedding features and a large hearth near the entrance suggest a cool-season occupation. The wide range of dates and relatively low density of artifacts (1144 tools were recovered from three horizons over an area of 52 m^2) suggest a short-term camp that was periodically reoccupied over several millennia (Derevianko et al. 2008). Microblade insets for composite tools were the most common artifact type (Figs. 4, 5). A pointed wooden tool (13.8 cm × 1.8 cm) with a rounded tang and incised vertical groove is interpreted as a projectile point into which microblades could have been set (Derevianko et al. 2008). Bone artifacts included an awl and a pointed tool. Non-utilitarian artifacts included ostrich eggshell beads, and a serpentine–antigorite pendant (Derevianko et al. 2008).

Faunal remains from an open-air trench at Chikhen Agui were primarily small fragments of unidentified ungulate bone; the remainder were identified as *Lepus capensis* (hare, but cf. *Lepus tolai*), *Ochotona* cf. *O. Alpine* (pika), *Marmota* sp. indet. (marmot), *Spermophilus* sp. indet. (ground squirrel), Dipodidae gen. et sp. indet. (jerboa), *Equus hemionus* (wild ass/khulan), *Procapra gutturosa* (Mongolian gazelle), and *Capra sibirica* (Siberian ibex) (Derevianko et al., 2008). Since marmot hibernate from October to March, the human exploitation of this species along with *Spermophilus* and Dipodidae suggests occupation during the late summer or possibly early spring (see Batsaikhan et al. 2010). However, the assemblage spans several millennia and could have been formed during different seasons. Species inhabiting both the plains and the mountains were targeted, suggesting to the researchers that animals may have been ambushed as they came to the spring to drink (Derevianko et al. 2008). Grass seeds were recovered but represent an intrusion of more recent, domesticated cereals that probably originated from a rodent burrow (personal observation from photograph of seeds, confirmed by Robert Spengler 29 May 2016; personal communication, Sergei Gladyshev and Andrei Tabarev, 24 May 2016). The combination of large and small prey from Chikhen Agui might suggest some level of diet diversification, but does not differ significantly from the faunal remains reported from other LGM and early post-LGM sites in Northeast Asia.

Technology

Technologically, a number of traits developed that distinguish terminal Pleistocene and Holocene tool kits from earlier assemblages. Lithics in the lower horizon of Chikhen Agui were made primarily on dark silicified sandstone, while jasper-like rocks and chalcedony

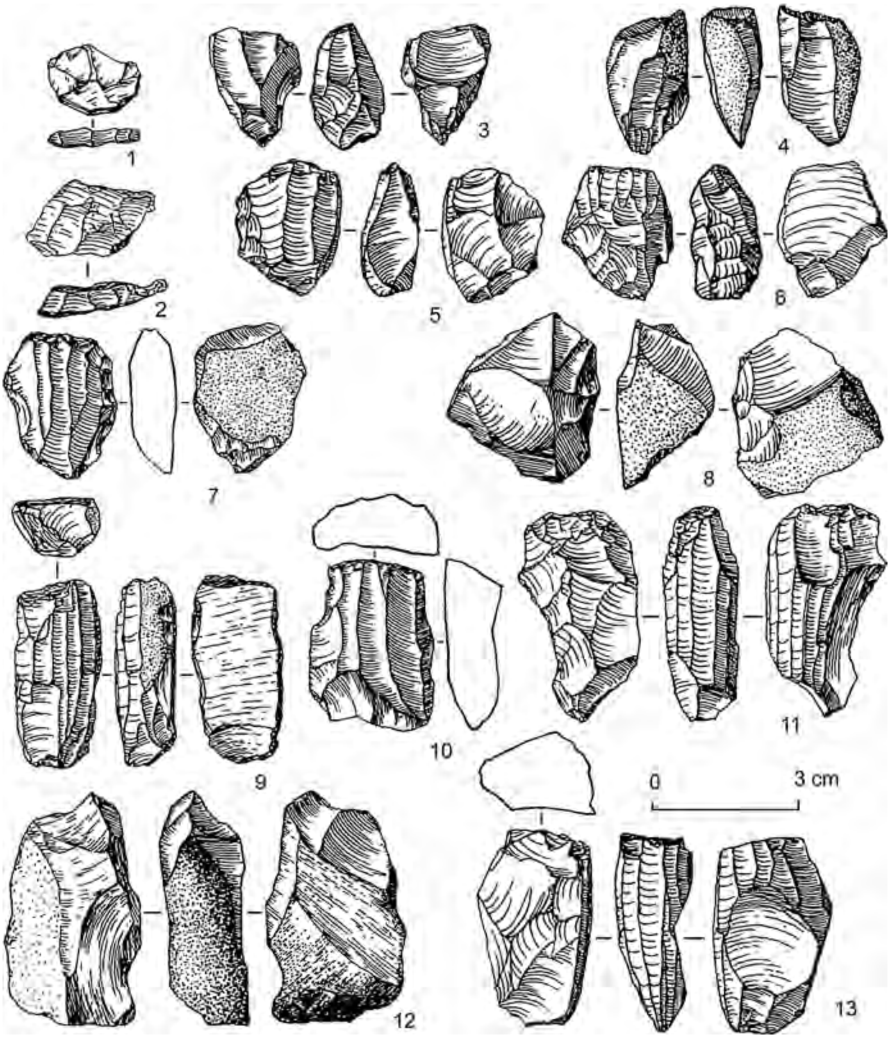

Fig. 4 Cores platform rejuvenation spalls (**1**, **2**) and cores (**3–13**) from Chikhen Agui. From Derevianko et al. (2003) (courtesy of Sergei Gladyshev and Andrei Tabarev)

were more common in the upper layer. The upper layer also yielded geometric microliths which are uncommon in Mongolian lithic assemblages and were not present in earlier strata (Derevianko et al. 2003). There is evidence of increased reliance on microblade technology over time. Horizons 2 and 3 show that 26% and 18%, respectively, of all used and/or modified flakes were made on microblades retouched along one or more lateral edges or ends using pressure-flaking techniques (Derevianko et al. 2003; Table 2, Fig. 5). Both layers indicate the regular use of microblades, and increased frequencies of both retouched and unretouched microblades in Horizon 2 underscore the growing importance of microblades within post-LGM tool kits. This widespread pattern of increasing post-LGM microblade use, possibly resulting in more efficient methods of manufacture, is likely interconnected with the gradual replacement of siliceous sandstone, basalt, and

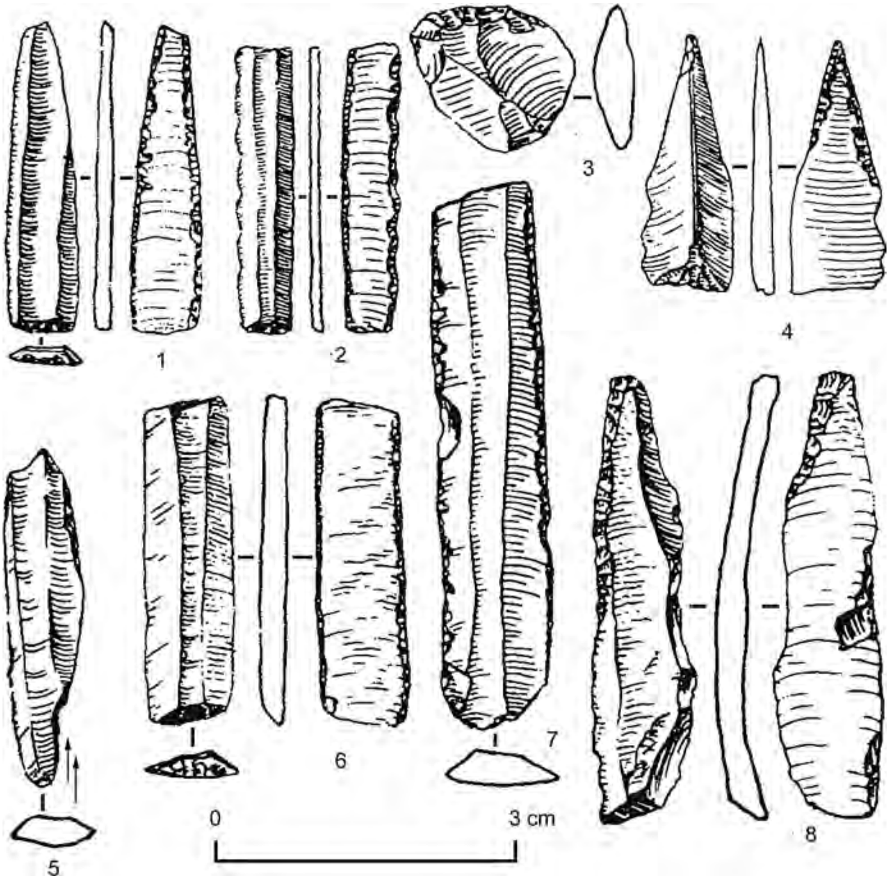

Fig. 5 Microlithic flakes and tools from Chikhen Agui. From Derevianko et al. (2003) (courtesy of Sergei Gladyshev and Andrei Tabarev)

quartzite typical of Palaeolithic assemblages, with a greater focus on cryptocrystalline stones such as jasper and chalcedony. This trend began as early as the Upper Palaeolithic (Derevianko et al. 2004) but reached its peak during Oasis 2 (Janz 2012). Pressure-flaking also became increasingly extensive and important for the production of new tool types.

Based on the clearly articulated description by Qu et al. (2013, pp. 40–44) of different microblade core types found in late Upper Palaeolithic sites in North China (but note the omission of cylindrical core types), we can assert that they are consistent with those from Gobi Desert sites. The range of morphological types and methods of manufacture common throughout Oasis 1–3 are illustrated in Fig. 6. Oasis 1 assemblages typically contain cores and less standardized platform preparation than that described for contemporary microlithic assemblages in other parts of Northeast Asia (Chen 2007), but this perception may be skewed by the tendency of researchers to over-represent standardized forms.

The Shara Kata assemblage, dated to 9.6 ka cal BP (Janz et al. 2015), contains lithics and pottery and is the only other excavated and dated Oasis 1 site (Fig. 3.O1b—for site description and additional information see Fairservis 1993, p. 97; Janz 2012, pp. 151, 453, 507). The two cores from Shara Kata were made on flat chalcedony cobbles with the exterior surface removed transversally from the sides and on the edges to create a rough

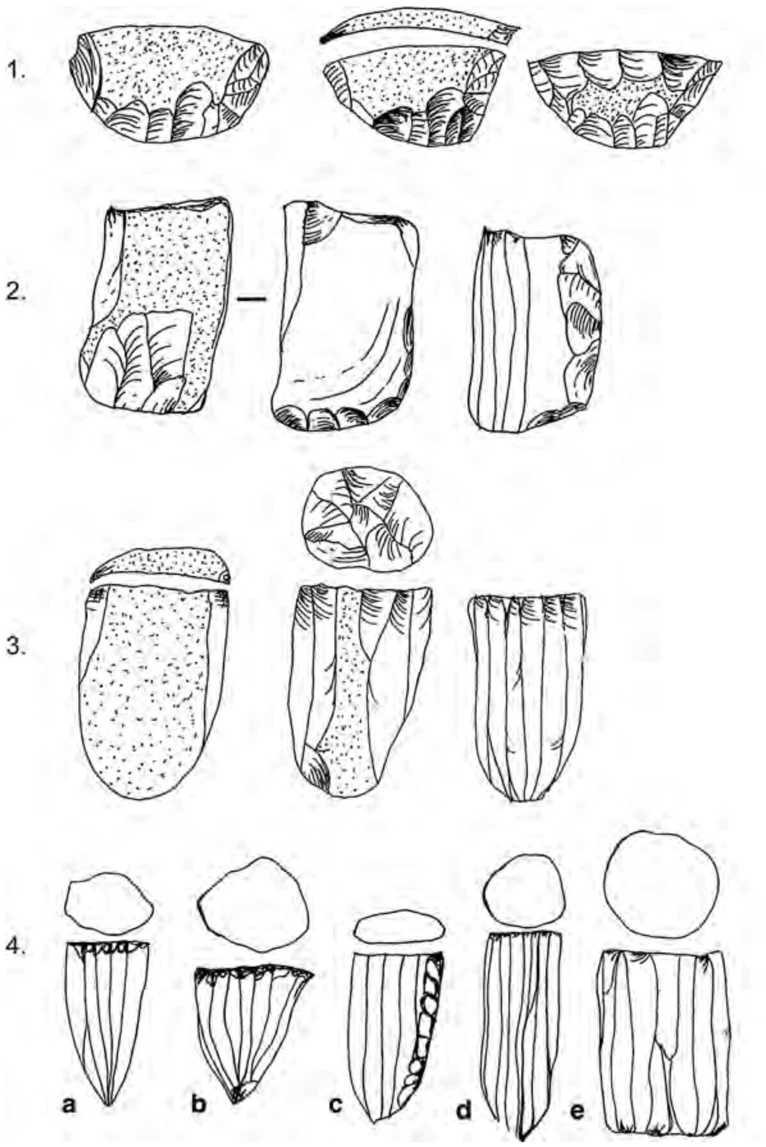

Fig. 6 Microblade core reduction strategies used in Gobi Desert assemblages: **1** boat-shaped core; **2** wedge-shaped core; **3** rounded core. Rounded core types: *a* conical; *b* pyramidal (funnel); *c* semi-conical; *d* pencil-shaped (*bullet*); e. cylindrical (specifically *barrel*-shaped) (Janz 2012; Qu et al. 2013)

D-shaped blank. Aside from the removal of short spalls, there was little or no platform preparation before microblades were detached from one end of the short axis. The reduction technique is most similar to the boat-shaped strategy (Fig. 6.1) illustrated in Qu et al. (2013, fig. 7), the 'broad-bodied wedge-shaped core' illustrated by Chen (2007, fig. 2.18), or the Togeshita (Yangyuan) technique reported from Hutouliang (Fig. 3.HTL) (Gai 1984; Seong 1998). The morphology compares well with wedge-shaped cores from other early sites such as Xueguan (Fig. 3.XG) (see Chen and Wang 1989; Chen 2007).

Although there has been little attempt to chronologically categorize differences in microblade core reduction strategies (but see Janz 2012, chapter 3), this type of core is rare in Gobi Desert assemblages and could be more typical of Oasis 1. Conversely, massive barrel-shaped types (Fig. 6.4e) are most common in Oasis 3 sites, suggesting that they represent a later development in working strategies (Janz 2012, p. 195). This type is related to the cylindrical core which is distinct from the conical core in that microblades are often removed from both ends and these microblades have parallel rather than convergent edges (Chen 2007, p. 26; Janz 2012, *contra* Maringer 1950; Morlan 1970). Researchers frequently comment on ‘refinements’ in existing methods of microblade core production over time (e.g. Maringer 1950; Gábori 1963; Dorj 1971), which could have been related to the emphasis on more uniform microblades. Perceived refinements could also result from more extensive reduction prior to discard, or the utilization of smaller nodules that require more precise working. Either way, this shift is probably connected with the increased reliance on higher quality raw materials.

One of the most notable characteristics of microblade core manufacturing processes is the high variability in reduction sequences (e.g. Sato and Tsutsumi 2007). In the Gobi Desert context, this variability can be seen as organizational flexibility (Janz 2012, pp. 151, 175–177, 267) aimed at exploiting the wide range of easily available, but sometimes small and irregularly shaped, cobbles of high quality stone. This categorical variability in reduction strategies can be simplified into two distinct methods of core preparation that distinguish the production of rounded (i.e. cylindrical, conical, pyramidal, semi-conical, pencil-shaped, barrel-shaped) from wedge-shaped microblade cores (Fig. 6) (Janz 2012, pp. 195–196). Wedge-shaped cores were often prepared on flatter cobbles, which sometimes had one side removed for thinning (Fig. 6.2). One end was then retouched to create a wedge, after which the platform and sides were prepared for the removal of blades (see also Chen 2007, fig. 3.18). Rounded cores were roughly prepared on more rounded cobbles, beginning with a series of trimming flakes and the creation of a platform surface. Extensive platform preparation and the removal of trimming flakes around the nodule circumference prepared the core for microblade production (Fig. 6.3). There is some morphological overlap between these basic types, usually when the shape of a wedge-shaped core was heavily modified through reduction. Most wedge-shaped cores are bifacially flaked on the opposite end of the flaking surface (or flute), which would have allowed them to be used as cutting tools (see Maringer 1950; Morlan 1976; Fairservis 1993) (though evidence of usewear is seldom visible to the naked eye).

Broad-Spectrum Foraging

Due to the nature of Gobi Desert assemblages, archaeobotanical and faunal data are lacking from these mostly surface-derived contexts; therefore, our best chance for recognizing diet breadth expansion is through the study of land-use and durable technologies. Intensive exploitation of r-selected prey requires a different organizational system than the pursuit of large game, because the prey are concentrated in distinctly different ecozones and their presence is often highly seasonal. Despite a lack of direct evidence for expanded diet breadth post-LGM settlement strategies are distinct. Of the 96 sites that Janz (2012) classified, seven low density sites belonged to Oasis 1 (Janz 2012, pp. 204–207). Three were associated with low elevation dune-field/wetland habitats and one was recovered from a river valley. The remaining three were recovered from upland contexts (mountains and hillslope). All were associated with a lake or a river/stream. In contrast, Palaeolithic sites are usually associated with springs and rivers (Janz 2012; see also Derevianko [Ed.]

2000; Tsogtbaatar and Bolorbat 2016). The distribution of sites suggests incipient use of—but not necessarily a preference for—wetland habitats. Such a pattern would result if hunter-gatherers reorganized land-use to include the occasional exploitation of lakes and associated wetlands.

Tool-kits associated with a broad-spectrum diet should reflect the use of technologies such as traps, nets, grinding stones, and/or pottery, which make the capture and processing of small prey more efficient. Some of the earliest evidence for the use of grinding stones comes from Pigeon Mountain Basin in the western Loess Plateau (Fig. 3.PMB), in a stratum bracketed by dates of 12,710 ± 70 BP and 11,620 ± 70 BP (15.1 and 13.5 ka cal BP) (Elston et al. 1997). Such definitive evidence has yet to be recovered from Oasis 1 sites. The earliest dates on pottery, cord-marked and reminiscent of that depicted in Elston et al. (1997, fig. 2), come from Shara Kata (Fig. 3.O1b) in the East Gobi with a date of 9.6 ka cal BP (8604 ± 51 BP). There is no additional evidence for specialized technologies used in hunting small prey, but the lack of such evidence is partially related to our inability to recognize and/or date most of these early assemblages (see Janz et al. 2015). Farther south, where floral and faunal data is better known, there is evidence at Shuidonggou 12 for either diet breadth expansion, or a new type of site-specific task specialization. At Shuidonggou 12 (Fig. 3.SDG), located on the southwestern edge of the Ordos Desert and dated by radiocarbon and OSL to 12.2–11.0 ka (Yi et al. 2014), thousands of lithics, fire-cracked rocks, and faunal remains were spread over an area of about 12 m^2. The lithic assemblage included fire-cracked rock, microblade and flake components, grinding stones ($N = 22$) and the fragment of a ground axe, while bone tools included a vertically-grooved composite haft for microblade insets (‘knife handle’), needles and awls (Yi et al. 2014). The authors report that 57.4% of the faunal remains were from *Lepus* sp. (hare) and 22.2% from *Procapra przewalskii* or Przewalski’s gazelle (cf. *Procapra subgutturosa*). Hare does occur in pre-LGM assemblages in Northeast Asia, but the frequency of remains from Shuidonggou 12 is notable.

There is also some evidence for plant use in North China. A recent synthesis of macro- and microbotanical data shows that grass and legumes are the most commonly evidenced plants used during the Upper Palaeolithic (33.0–19.0 ka cal BP) (based on starch grains from stone artifacts), with ample evidence for fleshy fruits and nuts during the terminal Pleistocene (14.0–9.0 ka cal BP) (Wang et al. 2016). Starches from geophytes (i.e. underground storage organs such as roots, tubers and bulbs) and grass seeds were also recovered from stone tools at Shuidonggou Locality 2 (<20.3 ka) (Guan et al. 2014). The presence of grinding stones in several terminal Pleistocene sites (Elston et al. 2011) does support the idea that diet breadth in China expanded during this time; however, the technology is also attested in LGM sites and was used irregularly throughout the Pleistocene.

Furthermore, the small, lightweight nature of early grinding stones suggests that extensive processing of such resources would have remained non-intensive until the early Holocene, when grinding stones become an integral component of the Neolithic tool kit (Guo 1995a; Shelach 2000; Cohen 2003; Keally et al. 2003; Jia 2007; Janz 2012). Grinding equipment is often multifunctional and widely used for processing domestic and/or wild seeds, nuts, sometimes geophytes, pigments, and herbs (Wright 1994; Dubreuil and Savage 2014; Hamon 2008). Aside from grinding, it has been suggested that small, flat slabs were used for cooking (Sériadès 2006); the presence of heat-altered starch grains and signs of heating on some specimens supports this possibility (Liu et al. 2013; Schneider et al. 2015, 2016). Although grinding stones have been used for processing pigment, including at Xiachuan (Elston et al. 2011), it is unlikely that such equipment would be widely manufactured and transported solely for this purpose. Dubreuil's (2004) study of usewear on grinding stones from a variety of Epipalaeolithic (Natufian) sites in the Levant has shown that while 'grinding stones' were associated with a wide range of tasks, the increasing use of large flat stones corresponded to an increase in the use of grinding stones for processing legumes and cereals. Several 'handstones' from Hayonim Cave were likely used for processing hides. Therefore, it is probable that small implements classified as grinding stones in late Pleistocene sites in North China were used in a variety of tasks, but the flat-topped morphology and evidence for plant processing at Shuidonggou 2 does give some credence to a relationship with new forms of more intensive plant processing.

Together, the data indicate that plant processing and the pursuit of *r*-selected prey became more directed in northern China as climatic conditions improved, but that these changes were gradual and perhaps sporadic rather than revolutionary. Farther north in the Gobi Desert, diet breadth expansion and concurrent organizational change is less clearly evidenced during Oasis 1 than in North China; however, we cannot definitively argue for or against broad-spectrum foraging during this period because the data is too sparse. What is clear is that there was a shift towards the exploitation of lake environments, something uncharacteristic of the Upper Palaeolithic. Although lithic technology during Oasis 1 is an extension of late Upper Palaeolithic microblade-based assemblages in Northeast Asia, Oasis 1 microlithic assemblages exhibit a greater emphasis on microblade relative to flake tools; a more flexible approach to reduction strategies; and an increasing preference for extremely homogeneous cryptocrystalline stone such as jasper. These changes are directly related to the changing focus of raw material procurement and reduction techniques and could be an indirect product of changes in land-use related to subsistence. More research is needed to support such a hypothesis. Either way, Oasis 1 organizational strategies represent a break from the Upper Palaeolithic, as hunter-gatherers adapted to and utilized post-LGM environments in new ways. Changes in microblade reduction strategies and raw material selection are clearly visible and changes in land-use are compelling: while Palaeolithic sites are more evenly distributed across different ecozones with a slight preference for upland environments, more than half of the later Pleistocene sites were recovered near wetlands or rivers in the low-lying plains and basins (Janz 2012; 2016, fig. 2). Persistence of low-density site assemblages and the lack of organizational emphasis around such resources underscores the point that the development of oasis-economies was gradual and firmly embedded in long-standing technological and organizational traditions. These changes formed the foundation of major shifts in land-use, technology, and subsistence evident during the following millennia. Considering the pace of climatic amelioration, our current sample of Oasis 1 sites will almost certainly be bolstered in coming years.

Middle Holocene: Oasis Economies

After 8.0 ka cal BP, hunter-gatherer land-use centered upon the intensive habitation of oasis environments. This change in settlement systems, combined with the adoption of elaborate plant-processing technology, offers incontrovertible evidence for the emergence of a broad-spectrum foraging economy. The timing of this shift in organizational strategies corresponds to a period of humidity comparable to the 'greening of the Sahara'. This substantial rise in effective moisture and vegetation cover resulted from a northward shift in the East Asian Summer Monsoon System, which is primarily responsible for summer precipitation into East Asia (Winkler and Wang 1993; Herzschuh 2006; Lee et al. 2013).

Early researchers recognized that the association of Stone Age habitation with dry lake basins indicated a much wetter environment in the past; however, Maringer (1963) hypothesized that these habitation sites were created when post-glacial environments grew progressively drier as glacial meltwater evaporated. Citing contemporary geological research (e.g. Berkey and Morris 1927), and following then-prominent theories of early twentieth century archaeologists (Pumpelly 1908; Childe 1928), he posited that desert foragers were 'forced back to areas along already shrinking rivers and lakes', while being 'confronted with increasingly barren lands around their living places' (Maringer 1963, p. 79). Janz's (2012; Janz et al. 2015) research now shows that these sites correspond to a time when lake levels throughout the Gobi Desert reached heights unprecedented since palaeolake expansion about 45–35 ka BP (see Wünnemann, et al. 2007).

Palaeoecology

Lake levels reached their height in the western desert around 7.5 ka cal BP, while this shift occurred much earlier in the east (see above). The Bayan Tökhömiin Nuur core shows relatively cool conditions and primarily lacustrine sedimentation between 7.5 and 6.5 ka cal BP. Moisture continued to increase between 6.5 and 5.0 ka cal BP, with pollen data producing the highest *Artemisia* values (up to 70%) of the whole record. Vegetation was characterized by meadow-steppe and closed vegetation cover around the lake. Lee et al. (2013) also found evidence of developed vegetation cover around Ulaan Nuur throughout the period 8.6–4.7 ka ago. Arboreal pollen was also relatively high and suggests the presence of shrubby riparian woodland: *Hippophae* (seabuckthorn), *Nitraria* (nitre bush or duneberry; the Mongolian scientific name is *Khotiriin ovog* and local names include *tovtsog*, *kharmag*, and *sonduul*), *Salix* (willow), and *Betula* (birch) (Felauer et al. 2012, fig. 5). Seabuckthorn and sonduul are both prized for their edible berries. This latter period of amelioration coincides with dates on early pottery from Yingen Khuduk, Ulaan Nuur (Ulan Nor Plain), and Shabarakh Usu 1, 4 and 10 (this archaeological locality is called Bayanzak in Mongolia and also spelled Bain-dzak or Bayan-dzak from the Russian transliteration) (see Janz et al. 2015). A short period of desiccation (5.0–4.5 ka cal BP) followed, with evidence of soil erosion, low water temperature, low lake productivity, and the reactivation of dune-fields in the middle of this period (Felauer et al. 2012). Dates on pottery from Shabarakh Usu 2 correspond with this dry phase (see Janz et al. 2015). Pollen data from Juyanze (Eastern Juyan) palaeolake, near modern Sogo Nuur, suggests a very different timeline with wetter conditions existing between 5.4 and 3.9 ka cal BP (Herzschuh et al. 2004; Mischke et al. 2005); however, these conditions were probably more closely related to major shifts in drainage that occur periodically in the Ruoshui–Hei river system (Lu et al. 1997; Hartmann and Wünnemann 2009; Mischke et al. 2003; Janz 2012, pp. 321–324). Peat layers from palaeolakes in the Badain Jaran Desert indicate an end to aeolian sedimentation at 8200 ± 400 BP (9.6–8.6 ka cal BP) and lacustrine deposition between 8.4–7.4 ka cal BP, with arboreal species represented by *Pinus* (pine), *Picea* (spruce), *Salix*, *Ulmus* (elm), *Cyperaceae* (sedges), grasses and desert plants and shrubs (Yang and Williams 2003). The earliest date (6.04–5.34 ka) from one site (Mantissar 12) in the nearby Gurnai Depression falls at the end of this wet phase, while later dates on pottery from Yingen Khuduk correspond to the Juyanze wet phase (see Janz et al. 2015).

High-resolution pollen analysis of a core from Diaojiao Lake near the foot of the northern Daqing Mountains (Daqingshan) in eastern Inner Mongolia indicates a warm-humid climate at 8.8–3.2 ka ago, with a climatic optimum at about 7.9–5.0 ka ago (Shi and Song 2003). Arboreal pollen included *Betula*, *Quercus* (oak) and *Ulmus* after 8.8 ka ago, as well as the appearance of *Pinus*, *Corylus* (hazelnut), and *Tilia* (basswood/linden), increases in *Quercus* and *Ulmus*, and declines in *Betula* at 7.9–5.0 ka ago. Cores from nearby Daihai Lake indicate a *Pinus* and *Quercus* dominated steppe forest at 8.0–3.0 ka ago (Xiao et al. 2004). Many records indicate the dominance of forest-steppe during the early to middle Holocene (Zhao et al. 2009). Although most of these records are 150–300 km from the East Gobi sites discussed in this text and are at the southeastern margin of the study area, they demonstrate that arboreal species were developed and widespread in the eastern zone. Dates from all pre-Bronze Age potsherds in the East Gobi (Janz et al. 2015) and Gobi–Steppe (Odsuren et al. 2015) correspond with this period of climatic optimum.

The close temporal relationship between archaeological sites and climatic amelioration supports the claim that the rise of wetland-centric land-use was closely related to the development of lake ecosystems. This relationship includes an apparent lag in the rise of oasis-centric land-use in the western desert, where the earliest Oasis 2 sites date to 7.0–6.0 ka cal BP in comparison to almost 8.0 ka cal BP in the east (Janz et al. 2015; Odsuren et al. 2015). A delay in the onset of Oasis 2 adaptations in the west could be the result of various factors: either the required environmental variables were not in place until much later; the western variants of Oasis 2 were the result of demographic expansion or diffusion of economic strategies from the east; or the earliest sites have not yet been dated.

Based on the palaeoenvironmental data, we know that the Gobi Desert would have been characterized by desert-steppe during the terminal Pleistocene and early Holocene, followed by periods of palaeosol formation (see Winkler and Wang 1993; Yang et al. 2008) linked to more steppe-like conditions and enhanced arboreal representation lasting into the middle to late Holocene (see Janz 2016). The recovery of Oasis 2 sites from loam and palaeosols supports this conclusion (Chard 1974, p. 82; Derevianko and Dorj 1992, p. 179). Pollen records from the Loess Plateau show that marshes, open lakes, grassy dunes, and mixed or deciduous woodlands then characterized settings now typified by mobile dune-fields and either completely dry or only seasonally wet lake basins (Yang et al. 2004). The distribution of pollen data from the northwestern Loess Plateau further indicates that the warmest/most humid phases following the LGM were characterized by forest, forest-steppe, or steppe with sparse trees along river valleys and terraces with elevation and hydrology playing a major role in the presence or absence of woodlands (Zhao et al. 2009). Similar patterns of forestation can be expected farther north in the Gobi Desert proper, with denser forestation that included species in the more humid eastern regions. Thus, we can infer that the Gobi Desert was typified by arid to semi-arid steppe with an open woodland to forest-steppe mosaic along river valleys, while mixed forests may have dominated mountain ranges. More developed wetland vegetation around lakes or slow-moving, shallow rivers would have further provided a range of resources attractive to hunter-gatherers, including reeds, tubers, waterfowl, eggs, and various small aquatic or semi-aquatic animals.

The number of sites corresponding with this period is remarkable—in contrast to the eight Oasis 1 sites, Janz (2012) identified 30 Oasis 2 sites and 47 Oasis 3 sites. Janz (2012, 2016) attributes this rise in the number of sites to changes in subsistence and land-use that correspond with changes in Holocene ecosystems, and demonstrates a relationship between the number of sites, their location, and a reliance on plant processing technologies. As noted by early researchers, the vast majority of Holocene sites are found within 1 km of contemporary wetlands. Evidence for the occupation of lake environs during Oasis 1 suggests that there was a gradual trend towards the more intensive use of the wetlands and associated dune-fields scattered across low-lying basins. Janz argues that extensive formation of stable wetlands, specifically in concert with the widespread development of woodlands at higher elevations and along riparian corridors (Janz 2012, pp. 338–339), was of major ecological significance to the trajectory of technological and economic change in the region. These environments created new opportunities for the intensive exploitation of diverse, highly-concentrated and reliable resources such as small game, fish, tubers, and grass seeds, which stabilized seasonal and inter-annual return rates and stimulated substantial population growth.

Technology

Along with evidence for intensive habitation of oases environments, technological change attests to major shifts in organizational structure. After 8.0 ka cal BP there is strong evidence for the intensive habitation of oasis environments (Janz et al. 2015; Odsuren et al. 2015). While microblade technology was replaced in much of southern Japan and Korea by about 12.9 ka cal BP (Aikens and Akazawa 1996; Seong 1998; Sato and Tsutsumi 2007) and declined considerably in China after 8.9 ka cal BP (Lu 1998), this technology remained the backbone of lithic tool kits across Mongolia, northeast and northwestern China into the Bronze Age (An 1992a, 1992b; Guo 1995b; Lu 1998; Xia et al. 2001; Janz et al. 2015). New types of specialized tools were used, including chipped and/or partially ground adzes and axes, and small points (or arrowheads) worked bifacially on expedient flakes. Tools characteristic of Oasis 2 are summarized in Table 1 and include large formal grinding stones, polished stone, chipped and/or partially polished adzes/axes and pressure-flaked unifacial microblade points; they later included a variety of bifacial tools such as small pressure-flaked points, knives and blades. Microblade core technology continued to dominate assemblages with a range of types, although boat-shaped cores were primarily restricted to the smallest cobbles such as those with core volumes of less than 20 cm^3. Expedient flake technology was also common. The thick rounded flakes used for thumbnail scrapers, bifaces, and other retouched flake tools were taken from large amorphous or bifacial cores, including some that have been categorized as microblade preforms. Thumbnail scrapers appear first in Oasis 1 sites and are much more common throughout Oasis 2 and Oasis 3. These microlithic scrapers are semi-circular flakes retouched along the curved distal end and sometimes made on the platform rejuvenation spalls of rounded microblade cores (e.g. Fig. 19.17, 19.18).

Unifacially retouched points made on microblades are found in several Neolithic sites in Northeast Asia and should be considered diagnostic of early Oasis 2 (Janz 2012, pp. 169–172). They are similar to some examples of perforators on microblades, but retouch on perforators is steeper. Retouch on small unifacial points is consistently executed and less steep than with the production of other microblade tools. Such artifacts are often found in East Gobi sites and were recovered from Horizon 1 of Chikhen Agui (Fig. 5.4). According to the youngest accepted dates from Horizon 2, Horizon 1 should post-date 8.7 ka cal BP (Derevianko et al. 2008). Such points were also found at Jira Galantu (Site 18); Baron Shabaka (Site 19); Baron Shabaka East (Site 21); Chilian Hotoga (Site 35); other sites in eastern Mongolia such as Dulaany Govi (Tseveendorj and Khosbayar 1978); Shavartain Bulag (Fig. 19.11); and the eastern steppe sites of Kherlen 9, Khuiten Bulag, Ovoot, and Tamsagbulag (Dorj 1971, pp. 111, 136, 156; Janz 2012). It is less clear from illustrations whether other unifacial points from Munkh Tolgoi and Dornogovi are similarly worked (Dorj 1971, pp. 112, 170). Some unifacial points from Jira Galuntu were shouldered (Janz 2012, fig. 3.5b). This style is represented at Yaojinzi and Yuanbaogou in Jilin province, China during the Zuojiashan I phase; at similarly aged Xinle I (Lower Xinle) period sites in the Lower Liao River region of northeast China [7.5–7.0 ka cal BP (6620 ± 150 to

6145 ± 120); see Jia 2007, pp. 74–75, 125]; in Neolithic assemblages elsewhere in China (Haila'er and Ang'angxi; see Chard 1974, fig. 3.46); and at Lake Baikal (Trans-Baikal), Siberia (Chard 1974, p. 86, fig. 2.27). Shouldered points are a distinctive trait of the Early Neolithic in southern Siberia, including the Maina site, attributed to the early Holocene climatic optimum (Vasil'ev and Semenov 1993, fig. 3). The presence of unifacial points at Chikhen Agui indicates that the technology was also distributed across the Gobi Desert. There is less evidence that these 'blade arrowheads' (Chard 1974, p. 86) were used during Oasis 3, and we tentatively suggest that they are diagnostic of Oasis 2. Janz (2012, pp.169–172) offers a date range of approximately 8.0–6.5 ka cal BP. Their occurrence at Shavartain Bulag, dated to 5.3–4.9 ka cal BP (Janz 2016; Odsuren et al. 2015), suggests the presence of earlier phases of occupation, or may indicate that these points were manufactured until the end of Oasis 2.

Small *bifacially* retouched tools are more indicative of Oasis 3. The process of unifacial retouch on points made from microblades probably anticipated the development of bifacial points and the two types overlap at, for example, the Oasis 2 site Baron Shabaka East (Site 21) (AMNH 73/2283). By the end of Oasis 2, lithic assemblages were typified by microblade cores, tools on microblades, and a range of bifacially flaked tools all manufactured on high quality cryptocrystalline stone. Many of the early points associated with unifacial types are very finely retouched (see Janz 2012, p. 172), while bifaces from later sites are often more roughly finished. Bifacial points are the most diagnostic lithic technology of Oasis 3 and are accompanied by the near ubiquitous use of fully-retouched rectangular blades, drills, awls, and knives. Bifacial knives are especially interesting as evidence of retouch and crushing on the distal ends of some curved knives suggests a hafting style reminiscent of bronze knives (Fig. 7). This shift represents a notable technological departure from laterally hafted blades.

Food processing technologies like pottery and/or grinding stones, are usually recovered from assemblages in dune-field and wetland settings. Pottery use became progressively more widespread and elaborate. During Oasis 1 and Oasis 2, pottery was characterized by the use of low-fired brown-wares with simple surface treatments. Oasis 2 vessels were often decorated with cord-marks and net-like impressions (which themselves likely derive from cord-marking; see Chard 1974, p. 115, fig. 3.4, after P. Bleed) (Fig. 8). Oasis 3 pottery assemblages are more internally variable and often contain high-fired wares and a range of more decorative surface treatments. Pottery and grinding stones were largely restricted to dune-field/wetland sites, although their environmental distribution increased slightly during Oasis 3 (Janz 2012, pp. 363–368, 2016). These changes correspond to the appearance of copper slags in microlithic assemblages across the Gobi Desert.

The Organization of Broad-Spectrum Foraging

The form of specialized broad-spectrum foraging represented by Oasis 2 and Oasis 3 is distinct from earlier systems because land-use represents a reorganization of settlement, subsistence, and technology around the use of environments rich in low-ranked and/or *r*-selected species. High density ('Residential A') and lower density ('Residential B') sites with evidence of cooking and multiple activities (see Janz 2012, pp. 248–254) are almost always situated around wetlands and/or associated dune-fields, with smaller task sites spread out across a range of environmental settings (Janz 2012). Archaeological remains are most dense at these residential sites and are usually represented by multi-component surface scatters (Nelson 1925; Maringer 1950, 1963; Janz 2012). These high-density Residential A sites were not present during Oasis 1 (Janz 2012, pp. 254–256).

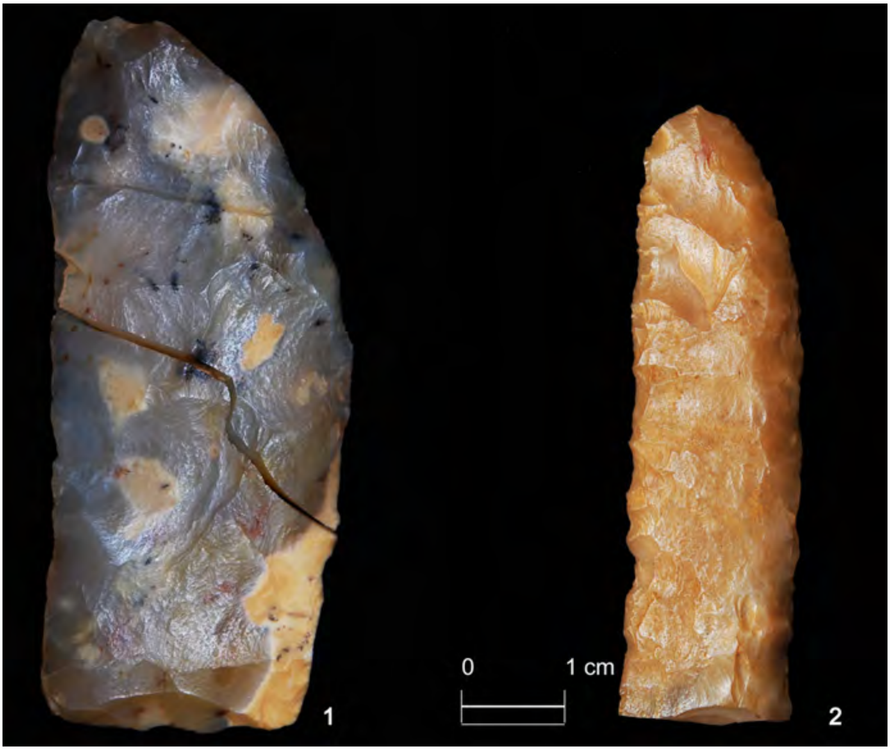

Fig. 7 Two examples of bifacial knives: **1** large bifacial knife from Bayanzak/Shabarakh Usu Site 4 (AMNH 73/881); and **2** slender bifacial knife from Sogo Nuur (MFEA K.13249). Used with permission from the AMNH and MFEA

This organizational shift in also evidenced in lithic reduction sequences. Based on the archaeologically demonstrated relationship between the ample availability of raw material and less conservative reduction strategies (Andrefsky 1994; Parry and Kelly 1987; Torrence 1989), it seems probable that base camps positioned around dune-field/wetlands were regularly provisioned with raw materials and reoccupied (see Kuhn 1995, 2004; Wallace and Shea 2006). Informal cores are frequently associated with reduced mobility since they represent a less conservative approach to flake production (Shott 1986; but see Morgan et al. 2011); therefore, organization across the landscape can be understood by looking at the relative frequency of informal versus formal core types. Higher relative frequencies of informal cores can be associated with the stockpiling of raw materials, facilitated by increased sedentism or redundant occupation of site localities, while microblade cores should be associated with restricted access due to high mobility (Shott 1986; Parry and Kelly 1987; Andrefsky 1994; Kuhn 1995; Blades 2003; Wallace and Shea 2006). Residential A sites in oases have the highest frequencies of informal vs. formal (i.e. amorphous flake vs. microblade) core types in comparison to other environments and site types (Janz 2016, Table 3). With the exception of sites in the raw-material-rich Gobi–Altai, there is a consistent pattern of greater remnant cortical surface and larger core size at Residential A sites, compared to Residential B sites. Inhabitants of Residential A sites tended to use cores that were less formally designed and less extensively reduced (see Janz 2012, pp. 281–283). Residential A and task sites show comparable frequencies of informal versus

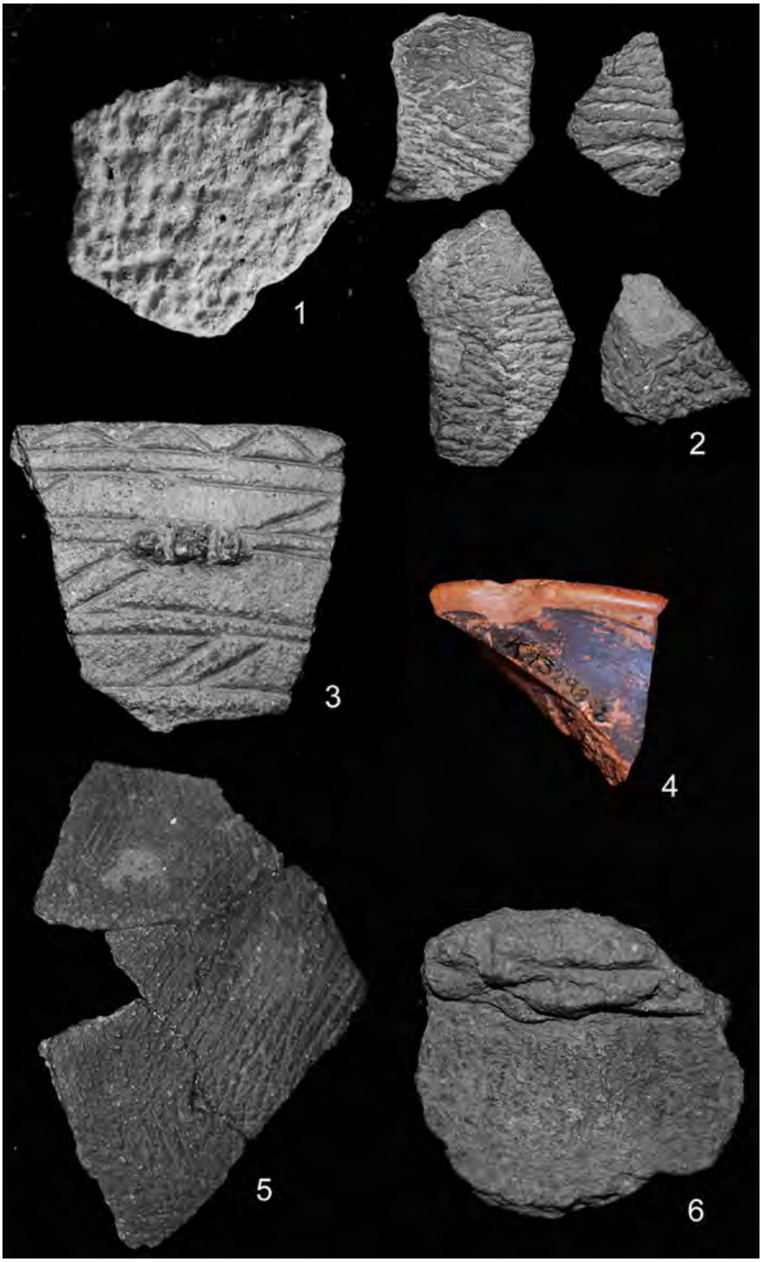

Fig. 8 Diagnostic pottery types from Oasis 2 and Oasis 3: **1** net-impressed (AMNH 73/2229A, Baron Shabaka) (6388 ± 47 cal yr BP); **2** cord-marked (MFEA K.13298:15; Mantissar 12) (6610 ± 730 ka); **3** geometric-incised (AMNH 73/608, Shabarakh Usu 1 and 2); **4** painted (MFEA K.13298:2, Mantissar 12); **5** string-paddled (MFEA K.13207:1; Gashun) (3634 ± 48 cal yr BP); **6** raised band (moulded/pie-crust) (AMNH 73/658, Shabarakh usu 1). Dates from Janz et al. 2015. Images are not scaled. Used with permission from the AMNH and MFEA

microblade core types, suggesting many task sites were either created by individuals well-provisioned by associated residential sites or were themselves associated with raw material procurement (Janz 2012, pp. 280–283). In contrast, the importance of microblade cores at Residential B sites indicates that these could have been created by logistical foraging groups radiating from Residential A-type base camps and contending with uncertain access to raw materials and longer duration trips. Interestingly, although Oasis 3 sites reveal a marked increase in the importance of tools made on expedient flakes, such as bifacial projectile points (Janz 2012, pp. 173–175, 192–194, 200), the relative frequency of microblade cores is consistently greater during Oasis 3 (Janz 2012, p. 287, Table 4.13).

Lower residential mobility in connection with dune-field/wetland habitation sites is reflected not only in the less conservative use of tool stone in some residential sites, but also in the manufacture of large formal grinding tools (e.g. saddle querns, knobbed rollers or pestles), which during Oasis 2 are found almost exclusively at dune-field/wetland sites (Janz 2012, pp. 364–365, Tables 6.3 and 6.5; Janz 2016, Table 2). The use of these tools shows an investment in processing technology that indicates an organizational commitment to predictable dune-field and wetland resources over encounter-based foraging (Binford 1979, 1982). Likewise, the presence of pottery implies limited down-time (a week or two might be sufficient), since mixing clays, building pots, drying, and firing are all time-consuming tasks that need to be undertaken before pottery is transported (Arnold 1985; Brown 1989). Despite this, the transport costs of pottery rarely seem to have deterred mobile groups from using it. Studies of pottery-use amongst late Holocene hunter-gatherers in the western Great Basin indicate that the vessels were primarily used for boiling seeds, and intensity of pottery production was not related to residential mobility (Eerkens 2003). Eerkens (2003) suggests that pots were cached in low elevation wetlands, and that people regularly returned and used the pots. Large grinding stones are even more difficult to transport without domesticated beasts of burden and are indicative of an investment in site furniture. The fact that the more portable components of tool kits, such as adzes/axes and pestles, were the ones more carefully finished (see Dorj 1971, p. 59) implies that the greatest investment in manufacture was reserved for portable tools and that ‘down-time’ may have remained limited. During Oasis 3, the presence of grinding equipment and pottery outside wetlands suggests differential resource use or perhaps improved transport technology.

Nevertheless, the larger picture presents an overwhelming impression of continued high residential mobility and a diverse subsistence strategy that includes unpredictable high-ranked resources (e.g. large game). Microblade cores exemplify highly portable, flexible core-tools, which produce standardized components for easily-maintained composite tools (see Elston and Brantingham 2002). Such maintainable and flexible hunting equipment is associated with ‘search and encounter’ procurement—where tools can be modified, maintained and employed on a daily basis and in whatever capacity required—rather than the type of specialized and predictable use exhibited in the Neolithic groundstone assemblages of North China or the elaborate bone tool kits of Inuit hunters (*sensu* Bleed 1986; Ellis 2008). Raw materials are relatively abundant in the Gobi Desert, including widely dispersed small cobbles of high quality jasper and chalcedony, but the ubiquitous microblade reduction strategy suggests an overarching conservative use of raw materials and therefore the type of limited access to tool stone characteristic of persistently high mobility at some organizational scale and a flexible foraging strategy in which hunters pursue a wide range of species (Janz 2012, pp. 166–269, after Nelson 1991; Bamforth and Bleed 1997; Kuhn 1994, 2004, 2007; Wallace and Shea 2006). The lack of midden accumulation or evidence for architectural structures in excavated sites likewise points to the maintenance of highly mobile systems. Combined with an emphasis on site furniture and raw material provisioning, we assert that this period was characterized by the regular movement of base camps across dune-field/wetland systems with a complementary system of logistical foraging. Therefore, core reduction strategies and the preferential distribution of pottery and grinding stones indicates that the commitment to exploiting dune-field/wetland habitat was interleaved with an organizational commitment to residential mobility.

The pattern illustrated here can be accounted for by a dualistic approach to subsistence and settlement: reduced residential mobility based upon the use of predictable wetland and dune-field resources and high logistical mobility associated with the strategic exploitation of large game. Accumulations of high quality raw material at oases is explained by high levels of logistical mobility where task groups habitually procure tool stone and bring it back to central base camps (e.g. Binford 1979). Reoccupation of such locales over millennia would provide ample raw material on site. It is not yet clear whether this pattern of land-use had a distinct seasonal component, but the lack of residential sites (both A- and B-type) outside oases suggests that residential moves occurred within and between oases while other ecozones were logistically exploited. This oasis-centric pattern of land-use was related to the intensified use of low-ranked resources and clearly diverges from the less habitat-specific mode of land-use practiced during the Upper Palaeolithic and Oasis 1.

Archaeological Sites

Below, we present a summary of some of the most important archaeological sites in each sub-region in order to highlight important technological and, potentially, economic differences across the Gobi Desert. The majority of sites contain components from both Oasis 2 and Oasis 3.

The Gobi–Altai

The Gobi–Altai is the best studied of these sub-regions. Aside from the major collections assembled during the Central Asiatic Expeditions, Mongolian and Russian archaeologists working in the Gobi–Altai have carried out extensive survey, collection, and some excavation of microlithic sites (see also Mania 1962; Gábori 1962, 1963; Kozłowski 1972). These studies have been published in Russian and Mongolian, but the vast majority are only discussed at length in research reports submitted to their respective institutions. Most Gobi–Altai sites come from the region south of Ulaan Nuur, around Arts Bogd, and were found in similar environmental contexts: eroding from reddish-brown loam or sand in dune-fields bordering stream channels or next to former lake beds. Such dune-fields are sparsely vegetated with *Haloxylon ammodendron* and a few other shrubs, including *Nitraria sibirica*, which produces an abundance of sweet berries in the late summer (see Nelson 1925; Jigjidsuren and Johnson 2003; Baasan 2004). Large average core volumes for sites in this sub-region (327.3 cm^3 compared to the region-wide average of 231.5 cm^3) emphasize the availability of raw material. Tsakhiurtin Höndi (Flint Valley) (Fig. 3.TsH) was identified by JMRAAE (Derevianko et al. [Eds.] 1996, 1998a) and fits the description of Nelson's (1925) massive raw material procurement site originally named by its geographic location: Ulan Nor–Arts Bogd Plain (see Fairservis 1993). This locality represents a procurement and working site stretching over many square kilometers with concentrations of lithics reaching up to 15 cm deep (Derevianko et al. [Eds.] 1996, pp. 122–123). Ancient sediments in the valley contain tabular flint horizons that were exploited for raw material over tens of thousands of years. Wetlands on the valley floor were created by drainage from the Arts Bogd range and would have offered suitable conditions for extended habitation.

The most famous Gobi Desert site is Bayanzag/Shabarakh Usu (Figs. 3.1, 8.2), in Ömnögovi *aimag* (Berkey and Nelson 1926; Nelson 1926a, 1926b; Gábori 1962; Okladnikov 1951, 1962; Kozłowski 1972; Fairservis 1993). The site was first discovered and collected by Nels C. Nelson in 1925 and was later excavated by Mongolian and Soviet researchers. The environmental setting is characteristic: extensive dune-fields associated with one or more small lake basins at the transition to lowland steppe. Numerous surface and subsurface sites were found around dune-field margins in the vicinity of a small, seasonally-wet lake or playa. The densest surface scatters were often a palimpsest of artifacts that included remains from hunter-gatherer occupations as well as the metal ages and historic periods. Smaller, sometimes partially buried, artifact clusters often surrounded hearths or ash pits and are most likely to have represented single-component sites. Ostrich eggshell fragments, beads, and bead blanks, sometimes in the hundreds, were recovered from several sites (Nelson 1926c, pp. 31–79). The shells themselves were probably collected from older nests or from the refuse of earlier occupations as the majority date to 9.6–8.2 ka cal BP, while dates on associated pottery span 6.4–2.5 ka cal BP (Janz 2012, pp. 122–125; Janz et al. 2015).

Excavations revealed two levels of occupation (Okladnikov 1951, 1962; Maringer 1963; Kozłowski 1972; Chard 1974, p. 82). The first was considered to be Early Neolithic based on analogies with Serovo-type pottery (6.2–5.4 ka cal BP, after Weber et al. 2002) from the Lake Baikal region (Okladnikov 1951, 1962; also see pictures of vessels from Bel'kachi and Ulan-Khada [Chard 1974, figs. 2.7, 2.11, 2.26]). These layers were excavated from a 2 m deposit of reddish-brown loam overlain by 'one meter of light grey buried soil, three and a half meters of sand, a Late Neolithic occupation, and more sand on top' (Chard 1974, p. 82). Nelson (1925) suggested that variation in the relative importance of red jasper versus white chalcedony in these sites was related to chronological change, with earlier inhabitants exhibiting a preference for jasper; however, this pattern of raw material use is probably more closely tied to biface manufacture than to temporal changes in the availability of raw material (Janz 2006). Okladnikov (1962) reports recovering painted potsherds from the upper levels, but these are not included in portions of the collections housed at either the Russian Academy of Sciences in Novosibirsk or the Mongolian Academy of Sciences in Ulaanbaatar. There are many sherds in this collection which feature incised geometric designs (Fig. 8.3) reminiscent of Andronovo sherds from Kazakhstan (cf. Frachetti 2008, p. 166), but also resemble contemporary vessels elsewhere in Northeast Asia, including the Lake Baikal region of Siberia (cf. Weber 1995, fig. 4.d). Such sherds are scattered throughout the Gobi Desert but are most numerous in the Gobi–Altai and Alashan. Fairservis's (1993) monograph on Nelson's and Pond's collections contains many beautiful illustrations of artifacts from Bayanzak/Shabarakh Usu.

Several other important sites have been collected in the Gobi–Altai region. Khoyor Khairkhan (Baruun Zuun Khairkhan) (Fig. 3.3) and Ergiin Khooloi (Fig. 3.2) farther south were both discovered in the southern part of Arts Bogd, in 1971 and 1972 respectively, by a team of Mongolian–Soviet archaeologists (Okladnikov and Dorj 1976, 1978; Odsuren 2014). As with most Gobi Desert sites, stone tools were densely scattered on a sandy cut. Artifacts were derived from several loosely-spaced scatters. At Ergiin Khooloi, the scatters were centered on hearths with fire-cracked rocks in a pattern similar to Bayanzak and many other Gobi Desert sites. Assemblages from Khoyor Khairkhan are earlier than those from Ergiin Khooloi (Okladnikov and Dorj 1978; Odsuren 2014). Core forms included boat-shaped and wedge-shaped preforms and microblade cores (Figs. 9, 10). Similar boat-

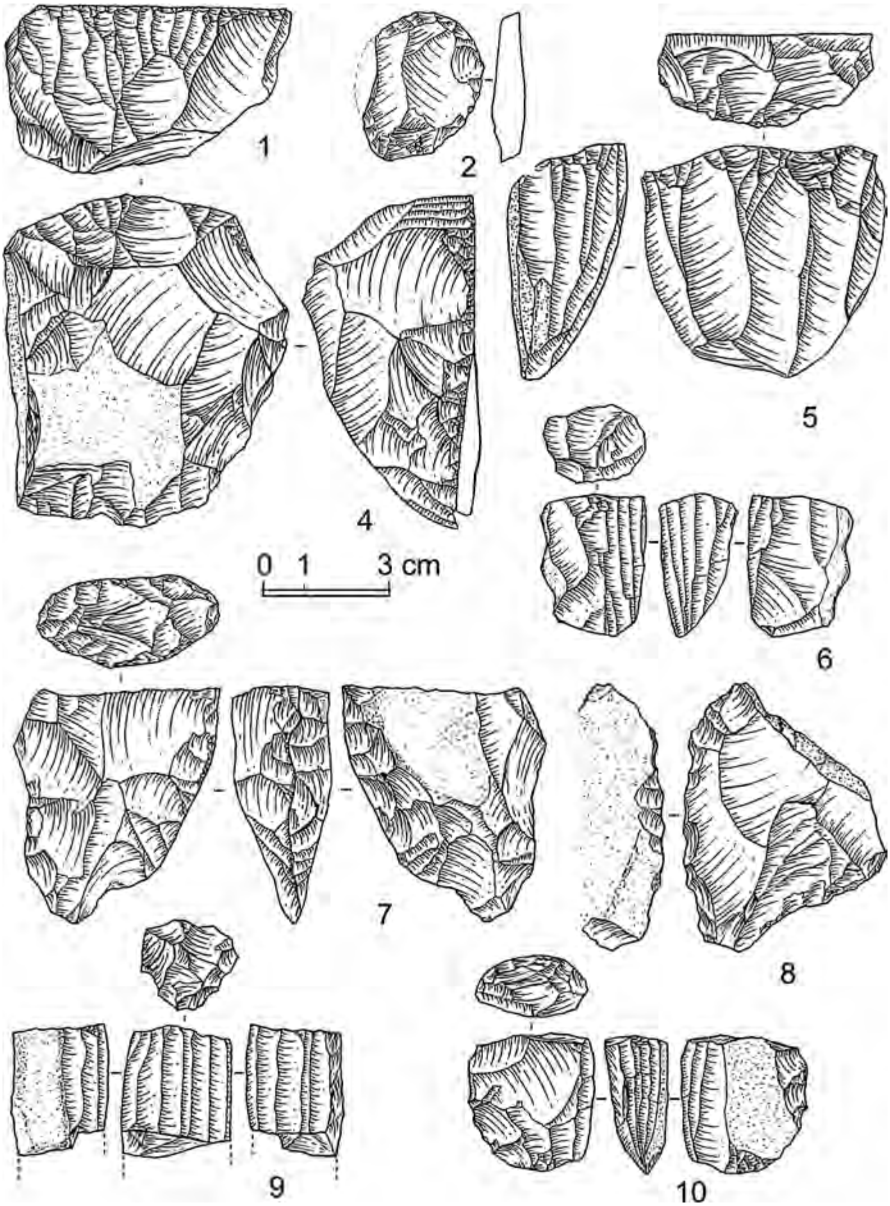

Fig. 9 Selected cores and thumbnail scraper from Khoyor Khairkhan

shaped cores were recovered from Layer 1 of Tölbör 15, which dates to c. 18.2–17.1 ka cal BP (Gladyshev et al. 2010, 2012; Odsuren 2014). There was also an array of microblades, borers (lightly retouched microblade points), scrapers, notched tools, knife-shaped tools, burins, points, large biface preforms, projectile points, denticulate tools, backed flakes and retouched spalls. The emphasis on boat-shaped and wedge-shaped cores over cylindrical and conical forms, grinding stones, and net-impressed pottery sherds (see Fig. 8.1), as well

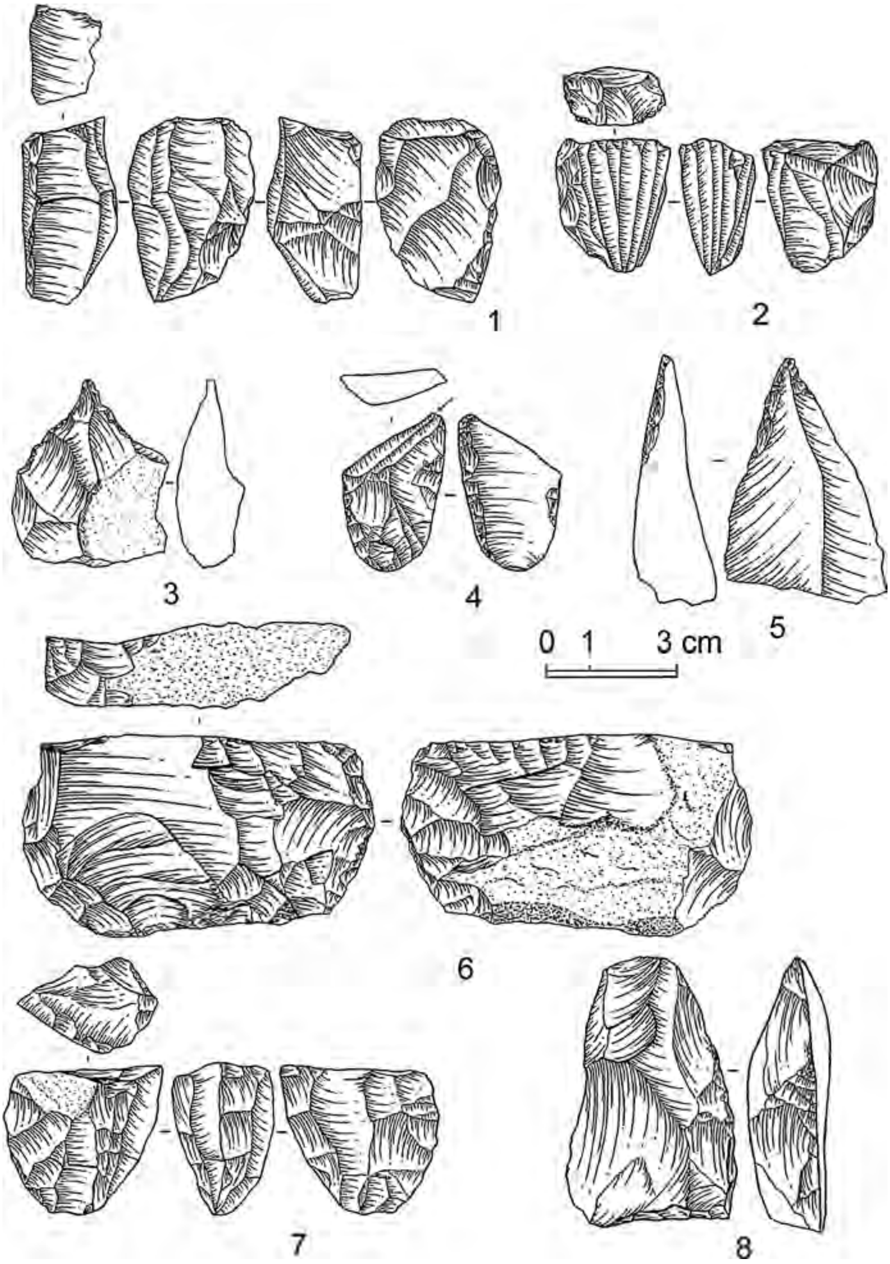

Fig. 10 Cores and flake tools from Khoyor Khairkhan

as the presence of a small, fine bifacially-chipped point (Fig. 11.4), all suggest that the assemblage included occupation episodes during both Oasis 1 and Oasis 2. Three thick bottom pieces of pottery vessels indicate the use of flat-bottomed vessels.

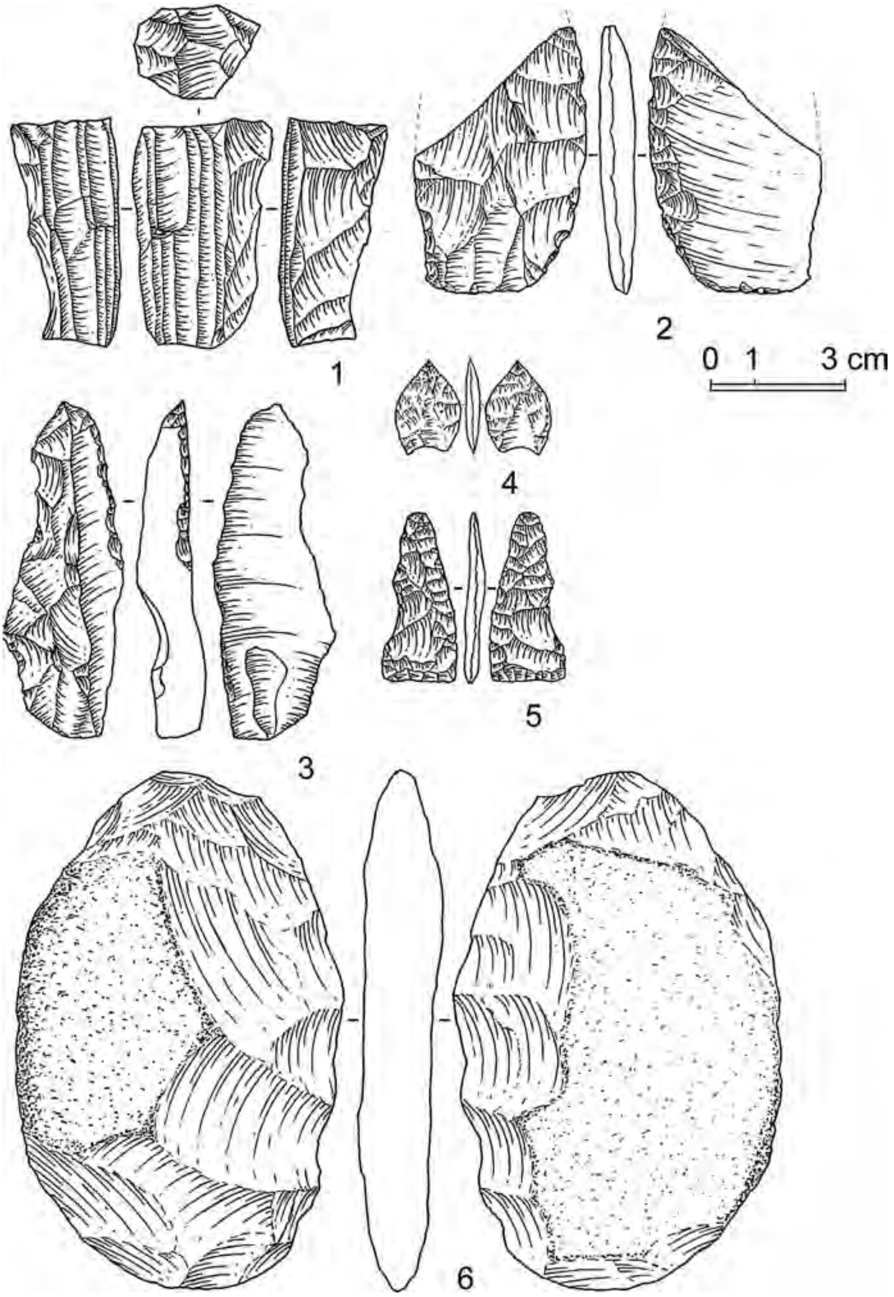

Fig. 11 Additional selected lithics from Khoyor Khairkhan

In contrast, the Ergiin Khooloi assemblage (Figs. 12, 13) was more consistent with Oasis 3 (Okladnikov and Dorj 1976, 1978). There were many massive microblade cores (including pyramidal forms) but only a few microblades, small bifacial points, and small

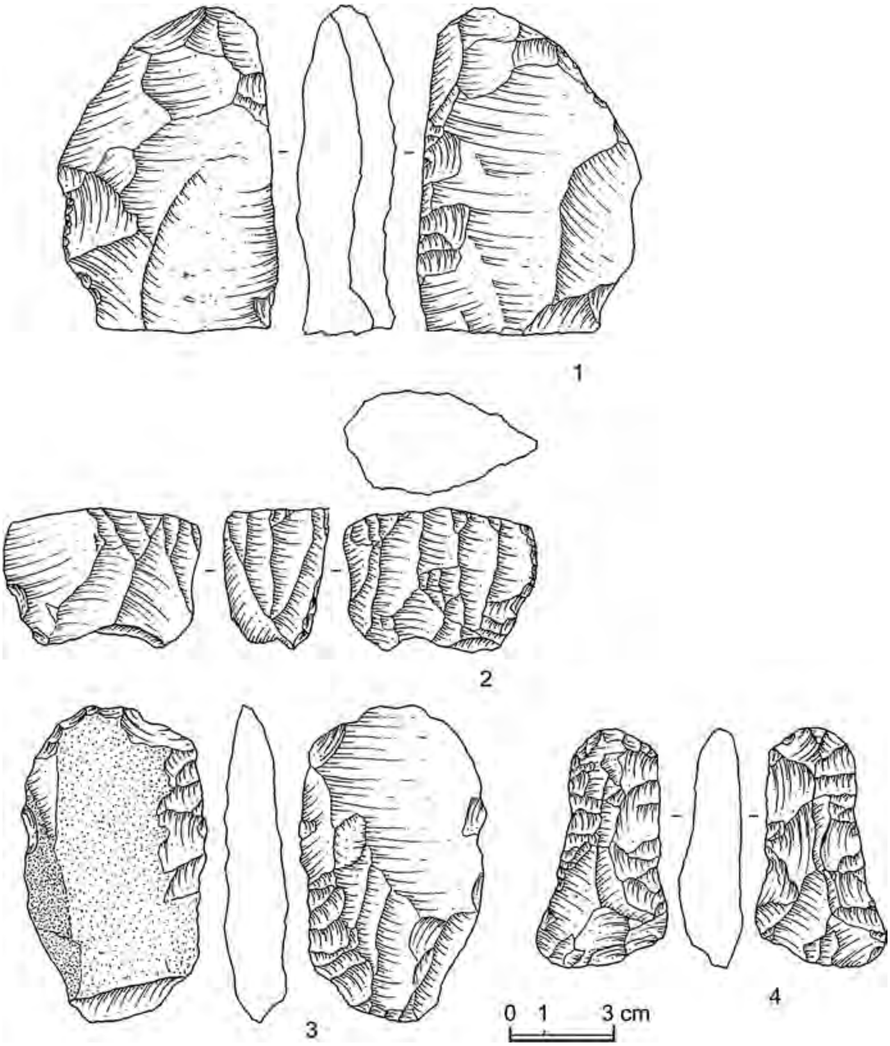

Fig. 12 Selected lithics from Ergiin Khooloi

scrapers (Fig. 13). The excavators suggested that the site was a place of raw material procurement. Pottery sherds had net-impressions on the body and incised lines around the upper circumference. String-paddled sherds were also recovered. This style of sherd is associated with a much longer temporal range, but often specifically with Oasis 3. Based on these pottery types and the presence of bifaces (see Tables 1, 2), it can be proposed that this site dates to the end of Oasis 2/beginning of Oasis 3, or represents multiple occupations spanning these periods. Test excavations revealed charcoal and poorly preserved equid bones (prob. *Equus hemionus* or *Equus ferus przewalskii*).

Another important site is Zuukh (Fig. 3.4), located on the eastern bank of the river Zoogiin Gol in the Arts Bogd valley. Excavations in 1985 and 1995 uncovered four campsites identified as belonging to vastly different periods: one to the Upper Palaeolithic,

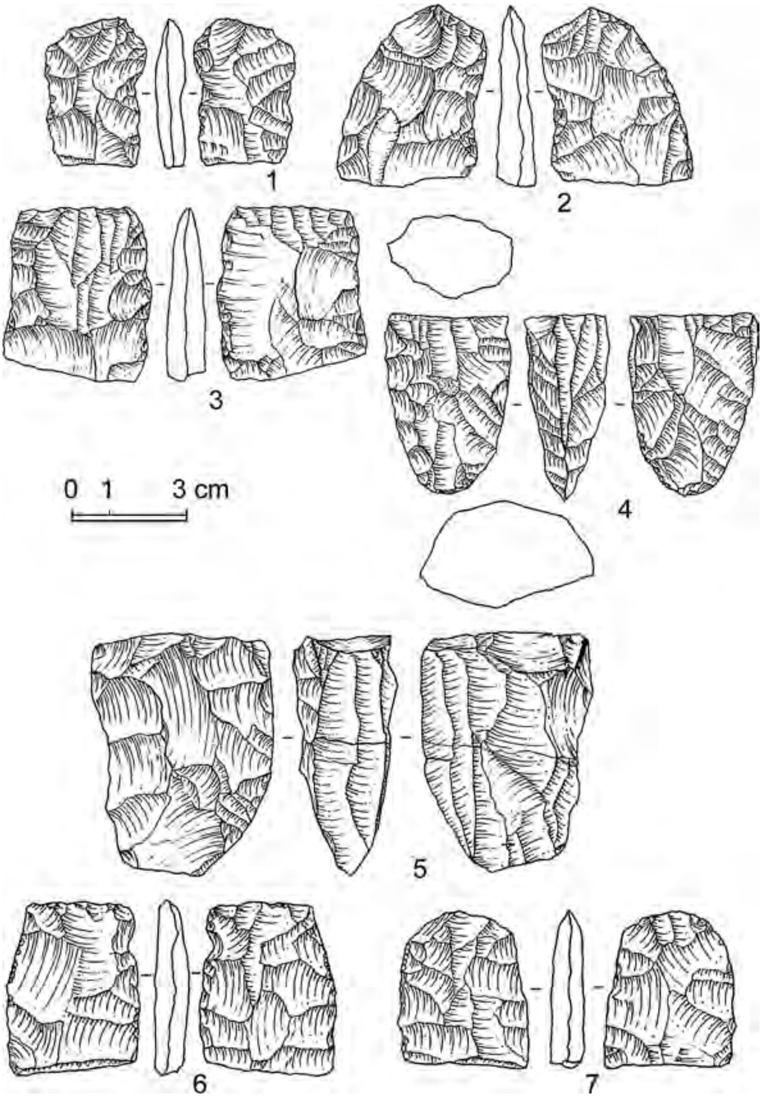

Fig. 13 Bifacial lithics from Ergiin Khooloi

two to the Neolithic (Oasis 2 and/or Oasis 3), and one to the Bronze Age (or possibly Oasis 3) (Derevianko et al. 1986; Gunchinsuren 1998). Verbal reports suggested that there may have been a copper smelting furnace at the site, although this is not included in the written reports and has not been verified. The Neolithic sites yielded 8567 stone tools, including cores, blades, flakes, scrapers, large and small bifacial points, and grinding stones. Wedge-shaped microblade cores were the most common type. Twenty-two pieces of animal bone, ostrich eggshells, and pottery sherds were also found. Based on artifact types, the researchers suggested that occupation of the site began at 10.0–8.0 ka ago and continued until about 4.0 ka ago.

The Alashan Gobi

The geological and environmental context of Alashan sites largely mirrors that described for the Gobi–Altai. In this sub-region, the majority of Stone Age studies known by Western and Mongolian scholars revolve around collections made during the Sino–Swedish expedition (Maringer 1950), although Chinese researchers have since made additional discoveries (for summaries see Wang and Olsen 1985; Lu 1998). Since the early 1990s, a substantial body of data has also emerged from American and Chinese scholars working south of the Alashan (Bettinger et al. 1994, 2007; Madsen et al. 1996, 1998; Elston et al. 1997; Morgan et al. 2011; Yi et al. 2014), including quantitative analysis of Maringer's report on the Sino–Swedish expedition's research in Inner Mongolia (Bettinger et al. 1994). This analysis sought to distinguish land-use patterns. All sites were considered broadly contemporaneous with differences between the assemblages driven by site function. The authors concluded that there were several types of Neolithic site represented: residential bases, seasonal base camps, temporary camps, and procurement locales (Bettinger et al. 1994). These conclusions were driven in part by the mutually exclusive presence/absence of bifaces relative to adzes/axes. Using direct and indirect dating, Janz (2012) later attributed much of the diversity to chronology, but agreed that several site types were represented, including short-term residential sites, longer-term residential sites, and task sites of various kinds.

The archaeological assemblages themselves contain the range of artifact types typical in the Gobi Desert and much of Mongolia; however, there are notable differences in pottery production and artifact frequencies. Despite consistently similar surface decorations, sherd temper varies considerably as Alashan sherds have very low organic content and are mostly tempered with sand or gravel. This makes it more difficult to precisely date Alashan sites (Janz et al. 2015). There are many instances of high-fired red-ware, including some with a homogenous or untempered paste and occasionally red slip and/or black painted designs (Fig. 8.4). This high-fired red-ware was found from sites in Ömnögovi *aimag*, but only collections from the Gurnai Depression can be confirmed to contain evidence of clearly painted sherds. Other distinguishing characteristics are the more regular presence of specialized Oasis 3-type artifacts such as fully polished adzes and axes (see Maringer 1950, pl. XXXVI).

Many of the sites in the Alashan are congruent with those from the Gobi–Altai. The Yingen Khuduk locality (Fig. 3.9) is a good example, representing a rich collection of surface scatters comparable to those from Bayanzak/Shabarkh-usu, which is located about 100 km to the north. Straddling the Mongolian/Chinese border, the locality is lined on the north with red cliffs and represents an oasis of scrub in a vast dune-filled basin north of an ancient lake bottom (Bergman 1945, p. 158; Maringer 1950, pp. 127, 130). Luminescence dates on pottery span Oasis 2 and Oasis 3 [5690 ± 350 ka, 3910 ± 300 ka, and 3910 ± 230 ka (Janz et al. 2015)]. Essentially identical dates of 3.9 ka were derived from two different sherds: the first a fragment of red high-fired, string-paddled pottery (see Fig. 8.5) with porous paste lightly tempered with sand/gravel; and the second a fragment of high-fired plain red-ware with a homogeneous, untempered paste. Darker patches of red on the latter sherd are suggestive of a worn red slip or paint. Such sherds are found throughout the Alashan Gobi and are reminiscent of painted sherds from the Gurnai Depression. Surface finishes at Yingen Khuduk include, in descending order of frequency, textile or basket impressions (often smeared), paddled, plain or slipped, and net-impressed. A variety of vessel shapes are represented, including large jars with a narrow-mouth, flat-bottomed pots, and a high-fired, thick-walled globular vessel. Geometric-incised pottery was also recovered at Yingen Khuduk. Various other sherds resemble those from Shabarakh Usu 4, Jabochin Khure, and Gashun (Janz 2012). Core forms include conical, cylindrical and wedge-shaped types, as well as informal flake cores and large bifacial cores. Tools were made on microblades and expedient flakes and included scrapers, awls, heavily-worked drills with expanded bases, and scrapers made on microlithic flakes, microblades, cobbles or chips, and thick elongated flakes. Two knives made on retouched blades were also found. Formal macrotools include two fully polished adzes or axes and one roughly chipped specimen that narrows at the neck and is hoe-like in form. Two hand-stones (or runners), as well as partially finished beads and worked fragments of Pleistocene ostrich eggshell were also recovered (Janz 2012, pp. 419–420).

Ukh Tokhoi (Fig. 3.10) is another important find locality situated along the northern margin of the Badain Jaran Desert. The extensive valley, dominated by the four-peaked limestone mountain Soyan Khairkhan, is flanked by a high basalt plateau and low basalt hills (Maringer 1950, pp. 103–121; 1952). Multiple habitation sites were recovered from this high-elevation landscape of drift sands, relict marshes, and high-quality raw material. Most of the sites were collected from the valley, although some were found on the basalt plateau. One cave site was found near a spring high on the slope of Soyan Khairkhan. The site contained numerous fragments of coarse reddish ceramic both inside and around the outside of the cave. The most notable component of this assemblage was stone beadmaking equipment, including a quartz slab with grinding grooves, raw chalcedony from veins near the cave, and several partially finished chalcedony beads (Maringer 1952). The lack of typical microlithic tools at the cave site and the absence of chalcedony from the habitation sites suggest that bead-making activities date to a later period than the habitation sites in the valley (Maringer 1952, p. 893). Maringer (1952, pp. 893–894) compared these beads to one unfinished 'marble' bead from Bayan Khuduk (Fig. 3.7) farther west, as well as beads from the Bronze Age burial sites of Hsin Tien in Gansu, which J. G. Andersson (1943) had estimated to date to 1300–1000 BC. In contrast, most of the camp sites around Ukh Tokhoi contain artifacts typical of Oasis 2. Only two fragments of bifacial projectile points were found, along with two sherds of high-fired red-wares comparable to ones found in the Gurnai Depression (Maringer 1950, pp.106–107). The remainder of bifaces and 'knives' are consistent with the chipped macrotools used frequently during Oasis 2. Grooved slabs made on silicified sandstone, glassy feldspar, and petrified wood rather than quartzite have also been found at Altat and Bayanzak. At the latter site the artifacts are referred to as arrowshaft straighteners or smoothers (Fairservis 1993, p. 39; Janz 2006). Although a small sandstone slab and handstone were also found at Ukh Tokhoi, Maringer (1950) asserts that most of the assemblages are more characteristic of workshop sites.

The cave assemblage may represent logistical use by groups camped some distance from the site. The presence of grooved slabs at Altat (Fig. 3.10), an Oasis 3 site located on the plains 7.5 km to the south, makes it a good candidate for this. The presence of hammerstones and many unfinished knives and axes at Altat indicates that inhabitants were processing raw materials procured from Ukh Tokhoi, while a hand-stone for grinding and abundant microblade flakes and tools suggest a residential site. Four spinning whorls made on potsherds (Maringer 1950, pp. 109–110, 120–121) are intriguing as they could indicate manufacture of woolen yarn. The spinning whorls also could be related to the use of bast fibers such as nettle (*Urtica dioica*) or hemp (*Cannabis* sp.). Impressions of simply twined cordage are evidenced in Eurasia as early as the Upper Palaeolithic (Olsen and Harding 2008), and are likely the source of corded, and probably 'net', impressions on Oasis 2 ceramics. The production of hemp cloth was likely known among agricultural groups in

North China by the time of Oasis 3 (Barber 1992; Lu and Clarke 1995; Olsen and Harding 2008); however, the more elaborate production of fine-gauge bast cloth suggested by the use of spindle whorls is more typical of sedentary or semi-sedentary communities due to the time-intensive nature of processing the plant fibers (see Olsen and Harding 2008, p. 87). The unprecedented appearance of spindle whorls in Oasis 3 sites therefore suggests wool processing. An association with herding would explain habitation on the open plains as grazing became more highly prioritized.

Sites in the Gurnai Depression likewise contain tantalizing evidence that Gobi Desert groups were closely tied to region-wide economic changes. Archaeological finds are dense along the shores of this enormous erosion basin, spanning 50 km from east to west and bounded, respectively, by the Badain Jaran Desert and Ruoshui–Hei He drainage system. The most deeply eroded regions reach ground-water level, which Sino-Swedish team members found overgrown with reeds (Maringer 1950, p. 151). Aeolian processes had redeposited sand from the depression across the southern and eastern border of the basin, in the form of a dune belt almost 40 m high, broken intermittently by spur-like formations. Along this stretch (reportedly c. 100 km north–southwest), a ‘nearly uninterrupted series of small prehistoric sites’ was discovered within the scrub and reeds or along the reed–saxaul transitional zone (K. 13277–13319) (Maringer 1950, pp. 151–152). Many of the sites were collected within about 10 km of a small lake or playa feature called Ulaan Nuur (Ulan Nor) (Fig. 1.6). Gurnai Depression sites are notable for the high frequency of ostrich eggshell fragments used in bead manufacture. Fragments of unusually large disk beads (up to 2.5 cm dia.) were found alongside smaller specimens. Radiocarbon dates on ostrich eggshell artifacts verify that inhabitants were collecting and modifying Pleistocene ostrich eggshell (Janz et al. 2015). These sites likely represent limited seasonal encampments (Janz 2012, pp. 79, 185–186, 292–293). The presence of high-fired painted pottery, ostrich eggshell beads, copper slags, and rare nodules of petrified wood and raw turquoise indicate some level of economic distinction, but it is difficult to classify. Janz (2012) has suggested that the inhabitants may have been linked through trade to agropastoralists in the Hexi Corridor.

Mantissar 12 (Fig. 3.5) was one of many small scatters collected here and two pottery sherds have been dated by luminescence to 6.5 ka (6460 ± 700) and 3.9 ka (3870 ± 340). The first was cord-marked (Fig. 8.2) and the second was a plain brown burnished sherd. About 22% of the 169 sherds from this site are high-fired and untempered or lightly sand-tempered red-ware with traces of painted black lines, including a checkered or lattice design. Amongst the untempered sherds, the striking homogeneity of the fabric, including uniform coloration revealed in cross-sections of the interior paste, indicate that the clay was probably cleaned of impurities before use and then fired in a kiln under controlled conditions (cf. descriptions of Banshan pottery manufacture in Palmgren 1934, pp. 1, 3–4 and *contra* 5–6). This collection of sherds is distinct in the quality and investment in manufacture. These small sherds are difficult to compare with the complete vessels used in Chinese typology, but seem related to Qijia (4.2–3.8 ka—after Debaine-Francfort 1995) and/or Majiayao (4.7–4.3 ka ago [2700–2300 BC]) pottery, which was often red and painted in black zoomorphic or geometric designs. Qijia pottery is characterized by fine red-ware, coarse reddish-brown ware, and some grey-ware. Surface treatments include rare occurrences of burnishing, smoothing, cord impressions, basket-impressions, and moulded applications—all of which are represented at Mantissar sites. Painted pottery is rare, but designs include lines and checks (An 1992b). Luminescence dates from Mantissar 12 bracket both periods.

Surface treatments are highly variable for such a small site. Plain-ware is most common, making up 36% of all sherds. Vessel surfaces are often smoothed. Decorative treatments include burnished brown-ware; intersecting and parallel incised lines; hand-moulded undulating rims (beneath which several sherds are ringed by distinct vertical clusters of small circular punctates); intersecting rows of parallel rolled cord impressions; faint textile impressions; textile or basket impressions; and cord-paddling. One sherd is decorated with vertical rows of parallel rectangular grooves subtly reminiscent of channeled ware from Shabarakh Usu 4 and 10 (Janz 2012, p. 190, fig. 3.8a). Vessel forms include handles (also at Bayanzak), flat-bottomed, and globular with a constricted neck and flared rim. Thick, well-rounded rims are plentiful and bear fine uniform striations, suggesting that they may have been formed on a slow wheel (see Palmgren 1934, p. 3). Drill holes are very common in sites from this region and suggest extensive repair and curation of vessels.

Conservation of resources is even more marked in the lithic assemblage. The average core volume for this locality is 15.6 cm^3, compared to 179.1 cm^3 for the entire Alashan zone and 231.5 cm^3 for the Gobi Desert-wide sample. The smallest core from Mantissar 12 measures 0.4 × 1.4 × 1.1 cm, and the largest only 3.2 × 2.1 × 1.4 cm. Keel flakes from initial core preparation range in length from about 2.5 cm to under 1.0 cm, suggesting some variability in the size of the original prepared cores. There is a limited range of raw materials. Chalcedony (either yellow and white, or translucent) is most common and was used alongside some poor quality jasper or siliceous sandstone nodules and quartzite. It is possible that the diminutive core size was related to small nodule size and that inhabitants practiced intensive conservation of raw material due to a lack of local sources. Only three of the 25 analyzed cores retained any of the cortex, suggesting that nodules were heavily reduced from their original size before discard. Core morphology is consistent with the Oasis 2 and Oasis 3 reduction sequences that result in semi-conical and cylindrical microblade cores (Fig. 6). Those on very small cobbles are often boat-shaped or wedge-shaped. Other components of the assemblage include unused and retouched flakes, perforators on microblades, drills on microblades, scrapers, and two small splinters of polished stone implements. Amorphous flake cores are exceptionally rare. Drills were extensively retouched and there are distinctive forms like the double-ended drill. Only six scrapers are included in this collection: four on amorphous microlithic flakes; one on the end of a microblade; and one on a thick elongated flake. No bifaces were recovered from Mantissar 12, but a few fragments of blade knives and bifacial projectile points were collected in Gurnai Depression sites, including one stemmed point and one with a straight base.

Dottore Namak (Fig. 3.8; Maringer 1950, p. 127) is the only dated Bronze Age or early Iron Age site in the Alashan zone and has two luminescence dates of 2210 ± 320 ka and 2810 ± 240 ka (Janz et al. 2015). The dated pottery is a high-fired red-ware tempered with coarse sand and decorated with a moulded band on the shoulder. Two fragments of pottery with copper slag melted into the exterior surface were recovered from the same site around a spring in the Goitso valley. This valley is described by Bohlin (1945, p. 268) as an especially lush, oasis-lined area on the southern edge of the same major depression where Yingen Khuduk was located. Microblade core reduction strategies were used, but core morphology was unclear as platform rejuvenation spalls were the only evidence of microblade cores. Copper or bronze smelting was a defining feature. The assemblage is significant in that it represents a very low density (98 artifacts recovered [Maringer 1950, p. 127]) pottery-bearing site from a valley near a spring, as opposed to a dune-field/wetland setting. Dottore Namak exemplifies the trend towards more even dispersal of specialized food processing equipment across ecozones.

The East Gobi

Artifact assemblages in the East Gobi are broadly consistent with those in the west, but there are a number of notable differences that may be related to geographic locality and proximity to different food-producing groups. While Alashan and Gobi–Altai sites contain geometric-incised and high-fired red-ware analogous to that produced by neighboring pastoralist or agro-pastoralist groups, such artifacts are less common in East Gobi sites. In contrast, these assemblages boast a greater abundance of formal milling equipment. This is an intriguing feature, considering that the sites are within 300 km of the northernmost Neolithic villages in China, such as Shihushan (Fig. 3.SHS) (beginning 6530–6440 cal yr BP) near Daihai Lake (Liu et al. 2014, 2015, 2016). Inhabitants of Shihushan are thought to represent the northward migration of Yangshao Neolithic farmers into territory formerly occupied by hunter-gatherers (Liu et al. 2015, 2016). The presence of microblade technology is thus notable since this technology had largely been replaced by groundstone and bone technology in central China by this time, although microblades were used for much longer in northeastern China (Lu 1998). Gobi Desert microlithic sites are distinct from the types of assemblages described by Liu and colleagues—there is currently no evidence of semi-permanent or permanent structures and inhabitants were reliant on microblade-based tool kits. Occupation at Baron Shabaka began prior to the establishment of Neolithic villages at Shihushan, with the earliest ceramic dates of 6795 ± 57 cal yr BP (5954 ± 52 BP, see Janz et al. 2015) preceding the earliest dates from Shihushan by more than 200 years, although the grinding equipment may be from later occupations. Nevertheless, the clear investment in formally designed and polished milling tools during Oasis 2 underscores the importance of plant processing among desert foragers and perhaps an awareness of Neolithic farmers who were settling in nearby territories. The spatial and cultural relationship between sedentary agriculturalists and desert hunter-gatherers has yet to be elucidated. Comparative studies of raw material use, additional chronometric dating, and a more comprehensive analysis of Gobi Desert subsistence have great potential in this regard.

The most significant locality in the East Gobi, in terms of sheer volume of material, is Baron Shabaka (Site 19) (Fig. 3.13), with almost 7000 artifacts recovered and curated by the AMNH, including: 402 ceramic sherds; stone and ceramic spindle whorls or circular disks; fragments of an iron cooking vessel; fragments of a mollusk shell; mica flakes; beads and fragments of ostrich eggshell; a partially drilled piece of talc; red paint stone; the fragment of a stone ring; 116 grinding stones (e.g. grinding slabs, hand stones, saddle querns, pestles, stone vessels/mortars); chipped and/or partially polished adzes/axes/-gouges; hammerstones; unifacial and bifacial points; bifacial knives; perforators, drills, burins; a diverse array of endscrapers; microblade cores; microblades; rough flake cores; and flakes (Janz 2012, pp. 385–393). Collections were made in 1928 by Alonzo Pond (n.d.). Artifacts were spread over an area of about 0.4 × 1.2 km, with most of them collected from blown-out wind hollows. Smaller quantities of material were collected from the surface of the dunes and the top of the valley, whence the historic materials in the collection were likely derived. Many distinct hearth sites were reported but the integrity of these sites was not maintained during curation (as done at Shabarakh Usu by Nelson). At one site, fire-cracked rocks partially embedded in dark grey soil formed a loose group near a partially buried adze/axe. A broken rectangular hand-stone was found alongside a knobbed grinding bar or pestle in the ashes of another hearth. Several other small, distinct groups of lithics and sometimes ‘very crude’ pottery were found in areas of less than 1 m^2.

In some cases all the lithics were made on the same material (Pond n.d.). Such scatters likely represent single occupation episodes.

Dates on pottery show that at least two phases of occupation occurred between 6.8 and 3.3 ka cal BP. Ostrich eggshell fragments and unfinished beads from Baron Shabaka are much older than the pottery, with dates ranging from 14.5 to 15.0 ka cal BP (Janz et al. 2009, 2015). Despite the unreliability of ostrich eggshell in dating Neolithic sites, a number of artifacts do support such an early phase of occupation, including boat-shaped microblade cores (some similar to those from Shara Kata [Fig. 3.O1b]), retouched blades, and unifacial tools on large flakes or flat-backed cobbles. There is a wide range of pottery types, consistent with the long history of site use. Pottery was often heavily tempered with some combination of coarse to very fine sand, mica, and/or shell. Surface decorations include string-paddled, geometric-incised, stamped, textile-impressed, net-impressed, moulded rims, and cord markings. Moulded rims or applications (Fig. 8.6) are typical of Oasis 3 and early Bronze Age sites. Handle fragments and miniature lugs were recovered, along with the thick, flat bottoms of some vessels and one fragment of a pedestal-bottomed vessel.

High frequencies of polished and chipped macrotools and grinding stones were present, and the labor invested in the manufacture of many of these artifacts underscores the local importance of milling tools. Grinding tools (Fairservis 1993, Plate 8) included more-portable small stones, massive saddle querns, hand-stones, the fragment of a possible stone vessel, and pestles or knobbed/ball-headed rollers. As at Yingen Khuduk, hoe-like tools were found, as were a large pick (30 cm × 5 cm wide) and fragments of thick polished stone rings (described elsewhere as 'counter-weights') (cf. Fig. 17). Macrotools were mostly made on basalt, although there were also some small chipped adzes made on jasper. Many of the roughly chipped adzes exhibit localized patches of light polishing, perhaps from use or resharpening. Polished versions of similarly shaped tools were also recovered, including a broken axe with a bulbous proximal end that was roughly polished and bore numerous deep striations. Large bifacially flaked tools were used, with proximal ends flattened for hafting (Janz 2012, Figure B.1). Finely chipped bifaces include projectile points with concave, convex, and straight bases; awls or drills; and small, fully retouched knives or inset segments on blades. Most of the scrapers were microlithic and typical of Oasis 2 and 3, but there were also many thick, heavy-duty specimens, such as large rectangular scrapers with squared distal ends. The emphasis on milling equipment and the presence of possible hoes (also recovered at several other Gobi Desert sites, including Sogo Nuur [Sogho Nor]) mean that Baron Shabaka offers better evidence for food production than any site in the Gobi Desert, although Janz (2006, 2012) argues that there remains insufficient evidence to support such a claim (see below). Nevertheless, analysis of residues, phytoliths, and usewear on the Baron Shabaka collection would offer an interesting comparative dataset for nearby Chinese Neolithic sites.

Chilian Hotoga (Site 35) (Fig. 3.14), one of many sites in the Hunshandake Sandy Land, is a very special assemblage because it contains identifiable faunal remains and bone tools. Net-impressed pottery from this site (Fairservis 1993, Plate 11) was radiocarbon dated to 7601 ± 36 cal yr BP and plainware was dated to 5950 ± 390 ka by luminescence (Janz et al. 2015), indicating that the site was occupied throughout Oasis 2. Some of the undated sherds and artifacts might date to Oasis 3. Collection-based intermixing could have occurred, as artifacts found embedded were mixed with those collected from all over the eastern half of a large wind hollow. On the south side of the hollow at the foot of an escarpment, Pond's team recovered a bone awl; bone needles; a bird (*Aves* sp.) bone incised with several parallel rows of transverse grooves (Fig. 14.1); pierced fox (*Vulpes* sp.)

Fig. 14 Selected bone artifacts from Chilian Hotoga: **1** incised bird bone (AMNH 73/2809); **2** fox tooth pendants (AMNH 73/2804). Used with permission from the American Museum of Natural History

canines (Fig. 14.2); and drilled shells. Excavations at the site revealed a hearth 2.5 m in diameter with burned stone, bone fragments, charcoal, and one roller for grinding (Fairservis 1993, Plate 10). Both bifacially and unifacially pressure-flaked points were found, along with a bifacially-flaked bladelet knife. Microblade cores included sub-prismatic, conical and cylindrical forms. The remainder of the lithic assemblage covered the full range of amorphous flake cores, typical scrapers, flakes, and perforators, as well as chipped and partially polished adzes, and also included a lightly flaked bifacial semi-lunar knife, rough cores, and a stone pendant. A fragment of 'red paintstone' and ostrich eggshell fragments, were also present. The bone and shell inventory distinguish this site. Faunal remains included hare (*Lepus* sp.) (MNI = 6); *Equus* sp. (including teeth, long bone fragments, phalanges, an astragalus, and a sesamoid); frog/toad (Anura); and a small Galliforme (identified by spur), likely *Perdix dauuricae* (Daurian partridge) or *Phasianus colchicas* (common pheasant).

Several other AMNH sites were collected in the Hunshandake Sandy Lands: 8/8A/8B/8C and 24/24A to 35. Both Oasis 2 and Oasis 3 are well represented here. A burial characteristic of the early Bronze Age was excavated at Tairum Nuur (Fig. 3.TN*) (Pond 1928; n.d.; Fairservis 1993, pp. 166–167, 191, 196–197) and was one of the few grave sites to produce human remains. OSL dates on aeolian sands and palaeosols in the Hunshandake Sandy Land indicate a wetter, more stable climate in the western edge of the formation by at least 9.6 ka, and by 10.2 ka farther east (Yang et al. 2013), lasting until around 3.0 ka (Yang et al. 2008, 2013). Dates on pottery indicate that Chilian Hotoga was occupied when the wetter Holocene environments were stable and well-developed.

The Gobi–Steppe

Sites from the Gobi–Steppe region (Fig. 2.3, 2.4) have been less well studied than those from other regions of the Gobi Desert, and there are currently no palaeoenvironmental studies of the region. Researchers at Ikh Nart have dated dark, organic geological sediments containing a typical Neolithic assemblage to 4422–4284 cal yr BP, and these localized sediments may be the remnant of Middle Holocene marshes upon which later peoples camped (Schneider et al. 2015). The more extensive lake and river systems and relatively stable arid grasslands distinguish the Gobi–Steppe from the East Gobi. Today, the more verdant pasturage supports small herds of cattle, horses, camels, sheep and goats, whereas herders in the southern Gobi Desert are more reliant on camels, sheep, and goats. Much of the topography is flat and punctuated with volcanic cones and small island mountain ranges. Survey has revealed that lithic scatters are less densely concentrated and more evenly dispersed than farther south (Odsuren et al. 2015). Dune-fields and lake wetlands may have been preferentially exploited, as at Dariganga and Ongon (Fig. 3.18, 19) (Dorj 1971, pp. 55–63; Okladnikov and Dorj 1973; Derevianko and Dorj 1992), but microlithic sites are not confined to these habitats. The comparative lack of research in the sub-region means that our understanding of the material culture is at an earlier stage, but the chronology of technological change seems consistent. One important characteristic of the Gobi–Steppe is that there is greater potential for the recovery of subsurface remains because the more abundant ground cover reduces aeolian deflation.

The dispersed nature of sites in better-vegetated regions of the Gobi–Steppe is reflected in the findings of systematic surveys conducted since 2004. These focused initially on Baga Gazryn Chuluu, Dornogovi *aimag* (2003–2006) (Fig. 3.BGC), and more recently on Delgerkhaan Uul (Fig. 3.DKU), Sükhbaatar *aimag* (Wright et al. 2007; Amartuvshin and Honeychurch 2010; Honeychurch 2015, p. 251). Survey at Ikh Nart, another granitic ridge system between Baga Gazryn Chuluu and Delgerkhaan Uul, commenced in 2010 (Schneider et al. 2015). All three localities are distinguished by systems of granite ridges that rise above the surrounding plains in a striking fashion and create ideal habitats for medium-bodied game such as Argali sheep (*Ovis ammon*) and ibex (*Capra sibirica*). The landscape outside Baga Gazryn Chuluu features arid grasslands, playa basins, and salt marshes, while the landscape in and around the ridges is composed of brown coarse granitic ridges, towers, canyons, and well-watered valleys that offer reliable hunting grounds and pasturage for herds (see Honeychurch 2015, pp. 100–101). Microlithic sites typically occur in low densities around the rocks, and around the playas and marshes beyond (Wright et al. 2007). Delgerkhaan Uul is located in a much less arid region and the surrounding plains support greater vegetative biomass (Fig. 8.4). Former water courses include a seasonally-dry river with many minor channels, and the entire landscape is dotted with shallow wet basins that may have once supported permanent marshes. Preliminary analysis indicates that wetlands were preferentially selected for occupation by early and middle Holocene groups, but the low density of lithic scatters suggests that habitation was heavily dispersed. Bifacial projectile points were regularly recovered from the surface of rocky plateaux overlooking valleys and plains, which suggests that the lowlands were favored for campsites, while hunting occurred across the higher elevation ridges (Odsuren et al. 2015).

The dispersed low density sites and lack of extensive surface scatters contrast sharply with Zaraa Uul (Fig. 3.15), about 70 km to the south. Zaraa Uul 2 (DMS 070) was identified by William Honeychurch and Joshua Wright in 2013 during survey of the area between Delgerkhaan Uul and Chandmani Khar Uul. The authors surveyed the site in 2013 and began excavations in 2015 (Odsuren et al. 2015). The site is characterized by a high density of surface scatters at the base of an eroded volcanic cone that extends outwards from the eastern slope of a low north–south trending mountain range punctuated by drainage channels and stretching over several kilometers (Figs. 15, 16). The sheltered areas of this range now serve as winter camps for pastoralist families and could have served a similar purpose in prehistoric times. Clusters of Bronze Age burial structures extend across the eastern ridges, overlooking the plains below, but lithic scatters are concentrated over a stretch of about 500 m along the eastern edge of the low mountain range (Fig. 16). The artifact scatter covers part of the hillside and extends a few hundred meters from the base of the hill across the colluvial plain towards the beach ridge of a large, dry lake basin. Outside this area, lithic sites are few and/or low density, with two notable exceptions. The first is a dense pavement of chalcedony flakes and shatter on a relict beach ridge 1 km southeast of the main site. There are few finished artifacts in this scatter, which represents a site of primary and secondary reduction. The second is approximately 1 km southwest of Zaraa Uul 2, where mostly Upper Palaeolithic tools are concentrated downhill from an especially rich cluster of burial cairns made of massive stones. One of these structures is composed of multiple smaller cairns surrounded by a fence, which corresponds with Ulaanzuukh burials recovered by Tumen and colleagues (2014) at Delgerkhaan Uul.

Two test units were excavated at Zaraa Uul 2, each representing a different phase of occupation. At Test 1, widely varied dates on bone (2737 ± 12 cal yr BP [2580 ± 25, UGAMS 22329] and 1784 ± 36 cal yr BP [1850 ± 20, UGAMS 22330]) and pottery (3442 ± 27 cal yr BP [3230 ± 25, UGAMS 22328]) suggest that there was either extensive bioturbation from roots or redeposition from the top of the slope (Odsuren et al. 2015). Fragments of bifacially flaked points and blades (Fig. 15.4, 15.7), microblades, flakes and debitage were recovered, along with microblade cores, a small semi-lunate grinding slab (Fig. 17.1), and bone fragments. Since the dates on pottery are consistent with the lithic assemblage, it is possible that much of this component dates to Oasis 3 or the early Bronze

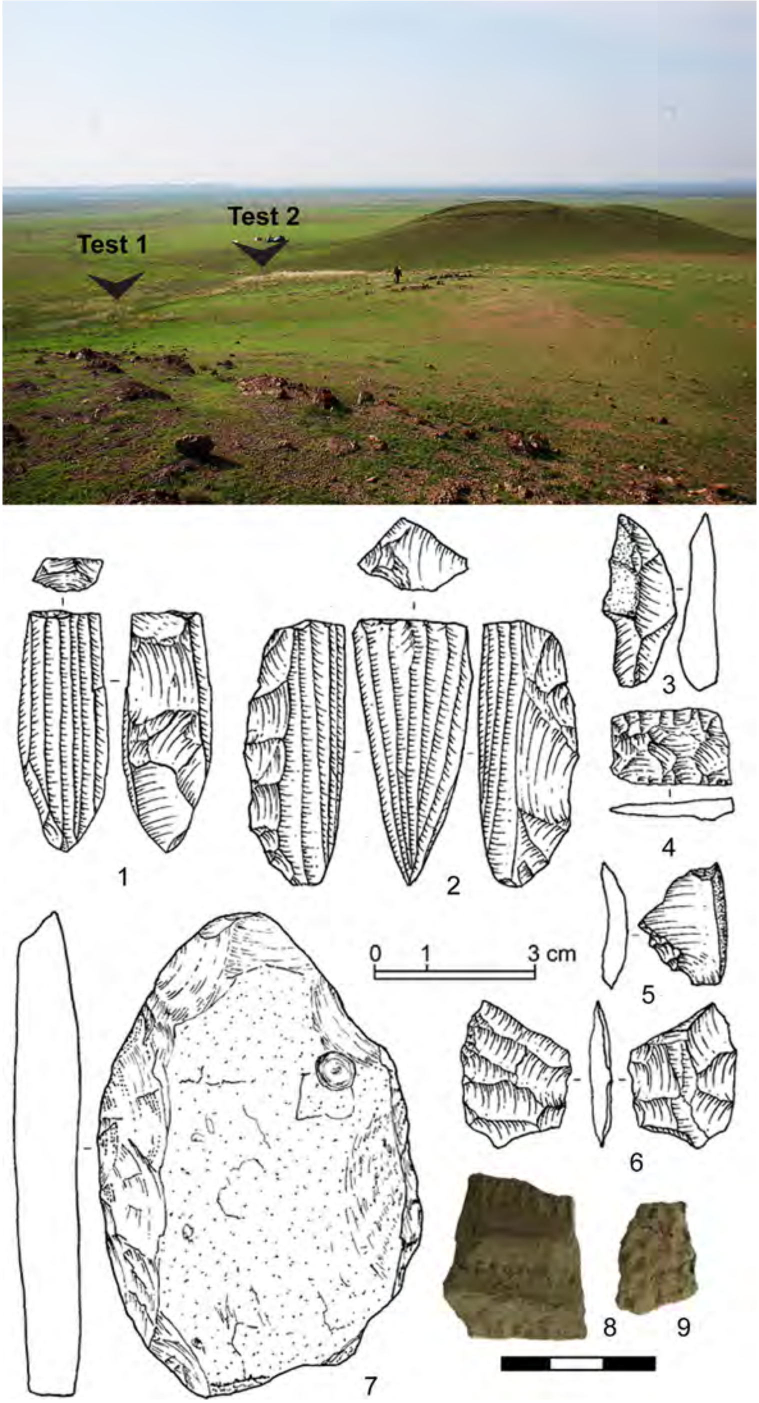

Fig. 15 Photo of Zaraa Uul locality and selected artifacts

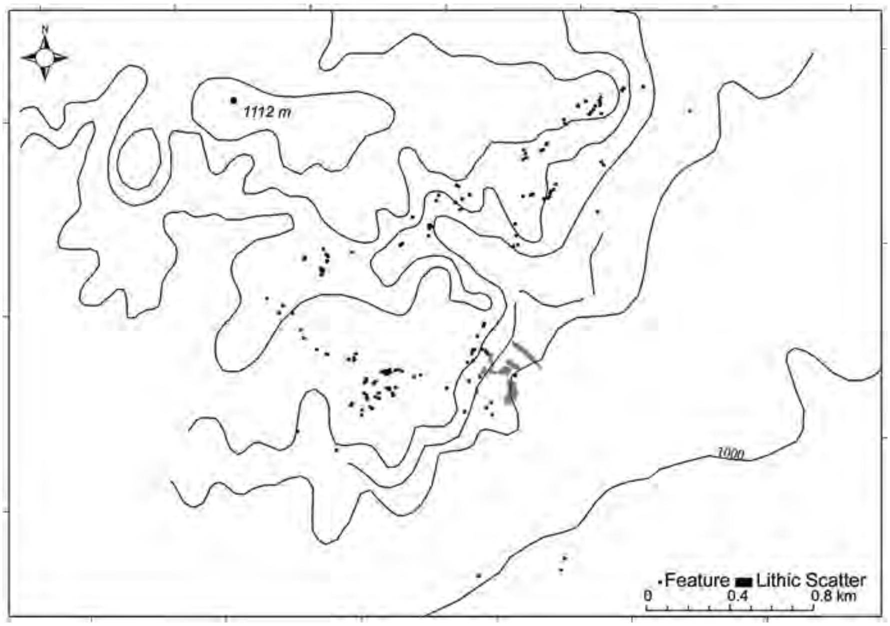

Fig. 16 Map of lithic scatters and burial features around Zaraa Uul

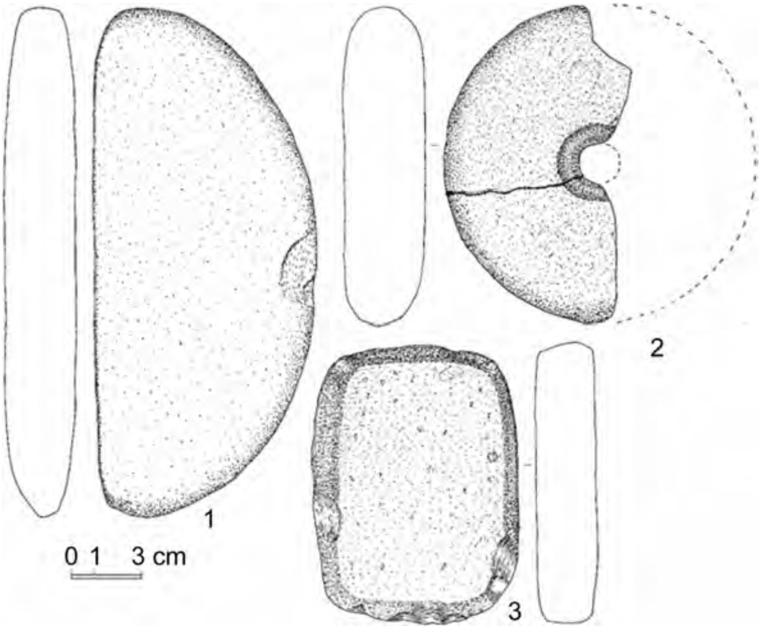

Fig. 17 Grinding stones from Zaraa Uul

Age. At the same time, there is no clear understanding of assemblage typology for later periods and we cannot discount the possibility that many of the lithics are contemporaneous with the Iron Age bone. The faunal assemblage contains medium- and large-bodied species, including cattle (Bovinae) and *Equus* sp. Considering the dates, it is probable that these belong to domesticated cattle (*Bos taurus*) and horses (*Equus caballus*). The dates from pottery slightly pre-date Ulaanzuukh burials. The presence of Bronze Age burial cairns at Zaraa Uul is intriguing, and further excavation of both burial and habitation sites will elucidate the relationship between habitation and burial ritual.

Test Unit 2 was excavated a few meters away at the base of the hill and within an area of extensive surface scatter. The three dates on ceramics and bone collagen from Level 3 range from 7848 ± 52 cal yr BP (6990 ± 30, UGAMS 22331) to 6731 ± 39 cal yr BP (5910 ± 30, UGAMS 22334) (Odsuren et al. 2015). Two decorated potsherds were recovered from Level 2, one with raised bands and punctates (Fig. 15.8) and the other with net-impressions (Fig. 15.9) similar to those on the dated Shavartain Bulag sherd (see below). Preliminary analysis shows a wide range of large-, medium- and small-bodied animal species, including *Equus* sp. (horse or ass), Caprinae (sheep/goat), *Lepus* sp. (hare), *Vulpes* sp. (fox), and *Aves* sp. (bird). The lack of a comparative collection for wild Mongolian species makes it difficult to more accurately identify many of the fauna. The artifacts are consistent with the Oasis 2 dates, including microblade cores and flakes, scrapers, preforms, adzes, working debitage from flake and microblade production, ceramics and the fragment of a grinding stone. Based on the dates from Tests 1 and 2, we hypothesize that surface scatters lying at a stratigraphic level intermediate to the two test units are a composite of differently aged scatters spanning the end of Oasis 2 and the beginning of Oasis 3. Auger tests show that artifacts are sparse at a stratigraphic level deeper than Level 3, or older than 8.0 ka cal BP, supporting a start date of 8.0 ka cal BP for the onset of Oasis 2 (Janz 2012; Janz et al. 2015).

One distinctive characteristic of the site is that the surface scatter contains a high number of chipped adzes, adze preforms, and similar macrotools (Fig. 18) (Odsuren et al. 2015). These were also recovered from Test 2. Many of the adzes show abrasion polishing on the ventral surface. These could have been used for a wide range of activities, but since there are currently stands of *Ulmus* along the drainage channels at Zaraa Uul, it is possible that the tools were used for woodworking. Usewear analysis of these and other macrotools from the Gobi Desert would be extremely helpful in understanding local manufacturing processes. High quality raw materials such as jasper and chalcedony are found on site and the high volume of adzes suggests that tools may have been manufactured for distribution.

Another site of interest is Shavartain Bulag (Figs. 3.16, 19), which was first discovered by researchers with the Cultural Heritage Center of Mongolia (2008). A team of Mongolian scientists from the Mongolian Academy of Sciences later conducted a preliminary reconnaissance. The site is located in the western reaches of a major valley to the south of Darkhan Uul, the largest mountain in the area, which gradually flattens into plains along the eastern slope. The spring Shavartain Bulag feeds a small river that cuts across the plain. Lithic and ceramic scatters are spread over the bank of the sandy riverbed north of the spring. Net-impressed sherds from Shavartain Bulag date to 5.1 ka cal BP (4435 ± 41 BP) (Odsuren et al. 2015), which is consistent with the later end of dates on similar sherds at Bayanzak/Shabarakh Usu (Janz et al. 2015). No formal excavation has been conducted at the site, but comparative analysis of the surface finds, including cylindrical microblade cores and fine unifacial and bifacially-flaked oval and triangular projectile points (Fig. 19), supports the idea of a late Oasis 2 occupation.

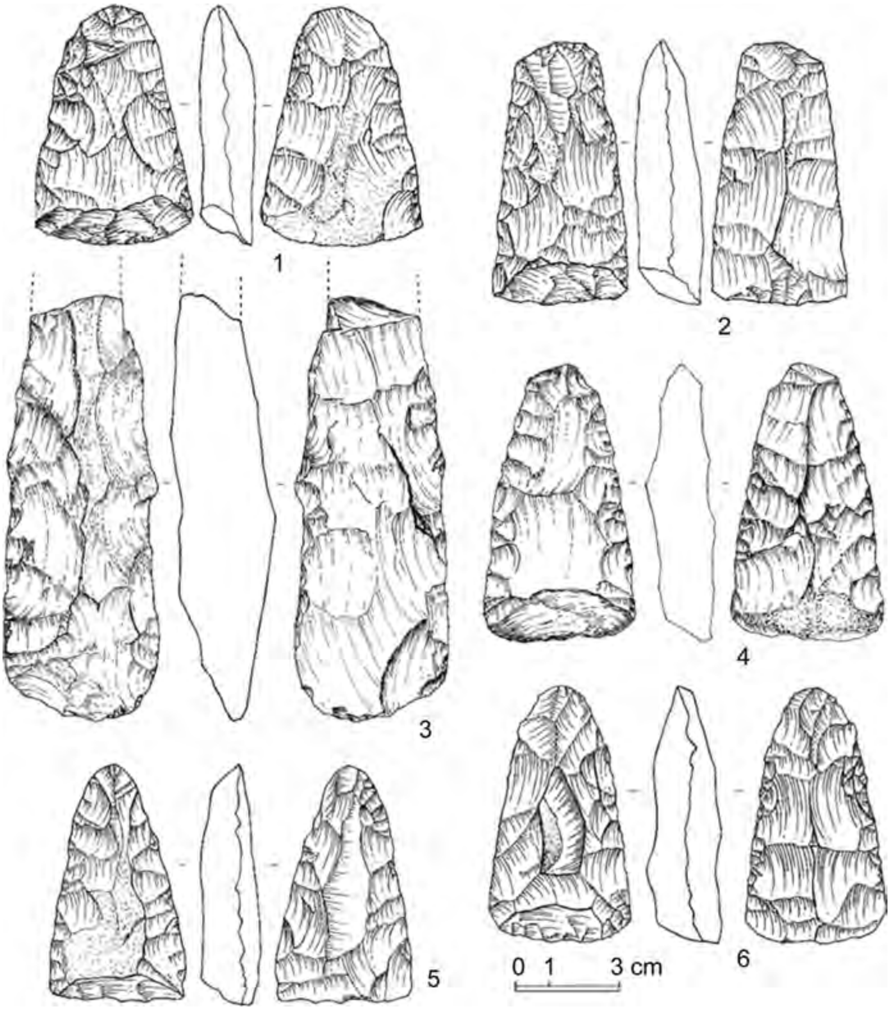

Fig. 18 Selection of chipped macrotools from Zaraa Uul surface scatters

One of the most intriguing Gobi–Steppe sites is Dulaany Gobi (Fig. 3.17), about 220 km south of Zaraa Uul. This site was discovered in 1955 near an ancient lake basin surrounded by mountains, clay terraces, and *zag* forests. The environment is thought to have once been characterized by wetlands, streams, and woodland. The site was investigated by Mongolian archaeologists Perlee and Ser-Odjav (1957), who discovered hearths and lithic scatters, as well as copper or bronze slag and the fragment of a carved stone fish. The many stone tools included microblades, projectile points, flakes, adzes and axes, grinding stones, a pickaxe, a spindle whorl, ostrich eggshell, and decorated potsherds. Based on the artifact assemblage, researchers suggested that the locality was occupied during the fourth and second millennium BC and that inhabitants practiced a mixed economy of hunting and gathering, fishing, and low-level agriculture. As at many other Gobi Desert sites, the presence of adzes, axes and other large tools suggested to researchers that woodworking was an

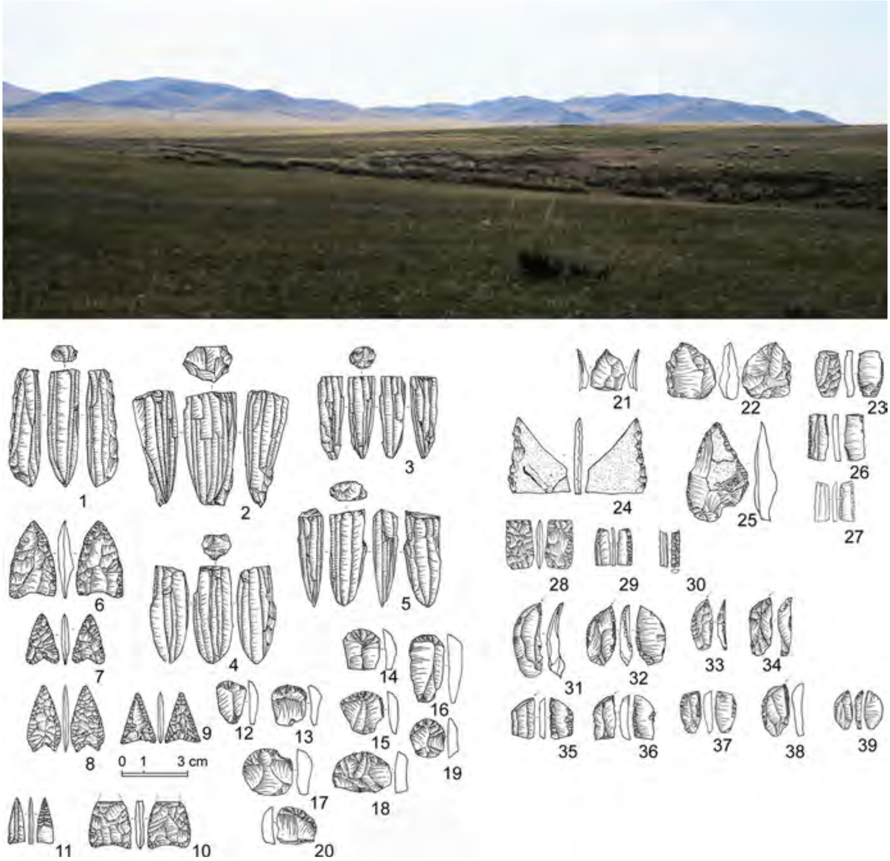

Fig. 19 Photo of Shavartain Bulag locality and selected artifacts

important activity (Perlee and Ser-Odjav 1957). Retouched microblades were more common in lower levels, while bifacial flake tools and unifacially-flaked points were characteristic of the upper cultural level (see illustrations in Tseveendorj and Khosbayar 1978). This supports the idea that the main site occupation occurred around 5.0 ka cal BP, or the end of Oasis 2, with both earlier and later phases of habitation. Later archaeological and geological survey in the area identified several distinct layers of Holocene sedimentation (Tseveendorj and Khosbayar 1978).

Wild cattle remains were also recovered. Cattle were an important resource in eastern Mongolia and are common in steppe sites farther north. At Tamsagbulag (Fig. 3.20) numerous cattle bones were buried together in a pit, and at Kherlen 9 (Fig. 3.21) the skull of a wild bull was buried about 50 m northwest of the campsite in a pit 70 cm in diameter and 40 cm deep (Dorj 1971). It has also been reported that a Neolithic grave excavated at Ovoot Mountain (Fig. 3.22) contained a 'buffalo' skull and stone tools (Dorj 1969; Gunchinsuren and Bazargur 2009). Petroglyphs at the East Gobi site Jisu Honguer (Fig. 3.JH), found near burial structures in the East Gobi, show at least one cattle image (Fairservis 1993, pp. 199–201). Domesticated and possibly wild cattle were also depicted in rock art from the Gobi–Altai, including Bayanleg Khad (Fig. 3.BK; Derevianko et al. [Eds.] 2000, pp. 229–237, 330–365) and Getseliin Us (Fig. 3.GU; Derevianko et al. [Eds.] 1998a, pp. 122–123, 301). One image from Bayanleg Khad shows two people plowing the soil using an ox (Derevianko et al. [Eds.] 2000, p. 231). Wild cattle are now extinct in Mongolia and it is not clear whether Neolithic remains belong to *Bos primigenius* (aurochs) or *Bison priscus* (steppe bison).

As in other parts of the Gobi Desert, dune-field environments were an important component of hunter-gatherer land use. Some of the best known localities include Ongon (Fig. 3.19) and Dariganga (Fig. 3.18) (Dorj 1971, pp. 55–63; Derevianko and Dorj 1992, p. 179). Descriptions of these find sites tend to be brief and indicate artifact assemblages similar to those found across the Gobi Desert, including the presence of microblade cores, flakes, scrapers, burins, grinding stones, pestles, and net-impressed pottery. Analysis of the existing collections, along with preliminary survey in 2013, reinforces the idea that assemblages in the Gobi–Steppe dune-fields are consistent with other dune-field sites in the East Gobi. Derevianko and Dorj (1992, p. 179) further mention the remains of dwellings with extensive grinding equipment and hoe-like tools embedded in highly organic palaeosols nearby the dune-dweller sites at Dariganga. Reports on the findings from such sites are not available.

Overall, middle Holocene habitation sites in the Gobi Desert indicate a wetland-centric mode of land-use and technological assemblages consistent with a highly mobile form of broad-spectrum foraging. During that time, the region was probably broadly characterized by desert-steppe and arid steppe with riparian woodlands. The expansion of wetlands and forests would have created distinct altitudinal variation and internally diverse biomes. Enhanced precipitation and stable wetlands supported higher biomass productivity, which we can speculate would have supported denser concentrations of edible plants like greens, berries, nuts, geophytes, and grass seeds, as well as amphibians, fish and waterfowl. Expanded habitat ranges would have existed for species such as bear (*Ursus arctos baikalensis*, *Ursus arctos isabellinus* [or *U. a. gobiensis*]); raccoon dog (*Nyctereutes procyonoides*); badger (*Meles leucurus*, *Arctonyx collaris*); polecat (*Vormela peregusna*); marten (*Martes foina*); weasel (*Mustela* spp.); wolf (*Canis lupus*); felids (*Lynx lynx isabellinus*, *Otocolobus manul manul*, *Felis silvestris*, *Panthera uncia*); and solitary ungulates like red deer (*Cervus elaphus*), wild boar (*Sus scrofa nigripes*), and roe deer (*Capreolus pygargus* or *C. capreolus tianschanicus*) (see Allen 1938; Batsaikhan et al. 2010). A single elk/moose (*Alces alces*) is depicted in rock art at Getseliin Us in the Gobi–Altai (Derevianko et al. [Eds.] 1998a, pp. 23, 305), while red deer are also depicted in rock art from the region (Derevianko et al. [Eds.] 1998a, 2000). Based on the limited faunal assemblage, equids remained the most important prey species. Establishment of wooded areas and the expansion of wetlands would have restricted the distribution of grassland ungulates, but offered unparalleled diversity in foraging opportunities, especially at the juncture of multiple ecozones (see Janz 2016).

Hunter-gatherers responded to the greening of the Gobi Desert by consolidating land use around oases and exploiting other environments on a logistical basis (sensu Elston and Zeanah 2002; Elston et al. 2014). The inclusion of fox, hare, and bird in faunal assemblages supports the idea that smaller prey were incorporated, but is so far insufficient to support an interpretation of wetland-intensive subsistence. Equids remained the most important prey species. Nevertheless, shifts in technology—the adoption of elaborate grinding equipment, more regular use of pottery, and a rise in the frequency of expedient cores and macrotools—indicate the increased importance of plant foods and highlight the organizational impact of this strategy. Palaeoenvironmental data indicate that resources in the East Gobi and Gobi–Steppe would have been very different from those available to hunter-gatherers in the Gobi–Altai and Alashan Gobi. For example, the presence of *Quercus* and *Corylus* trees in the east may have been an important resource that stimulated the production of formal grinding equipment. Limited quantities of *Quercus*, along with *Pinus*, *Picea*, *Tsuga* (hemlock), and *Betula* pollen were present in sediments dating to between 5454 ± 103 and 4627 ± 137 from mountain environments in the Gobi–Altai (Miehe et al. 2007), so it seems reasonable to expect the species to have colonized areas of the less arid East Gobi. Liu and Chen (2012, pp. 127–128) posit that acorns were one of the primary resources exploited by early sedentary communities in northern China, based on the relationship between site distribution and high concentrations of *Quercus* pollen. The relationship between mast resources and sedentary villages in Northeast Asia is widely attested (Shelach 2000, p. 380; Habu 2004; Fuller and Qin 2010). Future research will undoubtedly clarify the varied nature of both environmental and human response. The peak in effective moisture varied at the local level but was generally in place between 8.0 and 5.0 ka ago. Aridity became more pronounced at 5.0–3.0 ka ago and generally more severe since 3.0 ka ago (Xiao et al. 2004; Herzschuh 2006; Zhao et al. 2009; Felauer et al. 2012; Lee et al. 2013; Yang et al. 2008, 2013).

Holocene Subsistence, the Spread of Herding and the Rise of Bronze Age Cultures

One of the most commonly-cited inferences about Gobi Desert groups is that dune-field sites with grinding equipment and digging tools highlight an economic reliance on low-level cultivation (e.g. Okladnikov 1962; Dorj 1971; Derevianko and Dorj 1992; Cybiktarov 2002). Bettinger and colleagues, working in the Hexi Corridor, argue for a continuity between intensive plant exploitation among desert hunter-gatherers during the terminal Pleistocene and the eventual establishment of millet agriculture. Based on surveys of sand dunes, alluvial fans, stream margins and lake-marsh shorelines along the foothills of the Helan Mountains (Fig. 1), they have argued that post-LGM organizational strategies were characterized by a trend towards reduced residential mobility over time and a progressive intensification in the use of the lower to middle reaches of alluvial fans in response to increasingly abundant resources at the end of the Pleistocene (Madsen et al. 1996). This more intensive use of alluvial fans has been interpreted as an indication of early agricultural endeavors, which they posit were abruptly terminated by the Younger Dryas (Madsen et al. 1996; Bettinger et al. 1994, 2007; but see Bettinger et al. 2010a, 2010b). Bettinger and colleagues have hypothesized that desert hunter-gatherers familiar with the exploitation of millet were driven southward after the early Holocene by successive intervals of drought (Bettinger et al. 2007; Bettinger et al. 2010a; Bettinger et al. 2010b). There is sufficient evidence that post-LGM hunter-gatherers exploited grass seeds and other plant foods, but insufficient evidence to support the finer details of their hypothesis. Specifically, assemblages they refer to as evidence of a climate-driven southward migration occur largely within a 'moderately developed Holocene loess soil sequence' (Bettinger et al. 2010b, fig. 3), and dates from the underlying Pleistocene loess are discontinuous (see Bettinger et al. 2010a, p. 14, fig. 3).

Despite a significantly different timeline, the Gobi Desert record outlined here broadly traces a trajectory of ecological response that highlights the continued importance of large game alongside predictable small game and plants. Evidence from microbotanical analysis, faunal remains, and land-use patterns suggest that hunter-gatherers in Northeast Asia exploited a range of plant and animal foods during the Late Pleistocene, but targeted large herd animals as their primary source of food. The data presented here show a clear relationship between climatic amelioration and the intensity with which complementary resources were exploited. Although large game remained economically important, mobility and technology changed in a way that facilitated the use of other resources. Whether or not these groups were managing plant resources such as millets (broadly understood as wild Panicoid grasses) is of secondary importance to the fact that an expansion in diet breadth continued to be associated with high residential mobility and a preference for large game; therefore, as Bettinger and colleagues (2010a, p. 13) suggest, the pattern of elaborate sedentism that emerged and spread from sites like Cishan, Peiligang, and Xinglongwa (Fig. 3.XLW) was geographically limited. Experimentation in management, storage, and sedentism in these regions occurred under ecological, and probably societal, conditions very different to those that were present in the Gobi Desert.

The importance of variation in ecological conditions is even more compelling when we consider the best evidence for possible sedentism and plant and animal management in Mongolia during the Neolithic, which comes from the more verdant far eastern steppes to the north. In contrast to the oasis-dwelling Gobi Desert peoples, contemporary groups in the eastern steppe (including Mongolia and Inner Mongolia) established small settlements, such as those now known as Tamsagbulag and Ovoot (Dorj 1971), where by 5600 BC (Odsuren et al. 2015) the bones of horse and cattle indicate that they hunted large game and fished, as well as presumably gathering plant foods (Derevianko and Dorj 1992; Séfériadès 2004, 2006). At Tamsagbulag (Fig. 3.20) people lived in rectangular semi-subterranean dwellings located along the elevated southern bank of an ancient riverbed now covered in marshlands (Séfériadès 2004, 2006). Under the floor of one of the five excavated dwellings, researchers found the remains of a young woman seated in the narrow burial pit. The site has been interpreted as belonging a group whose economy relied on millet cultivation and cattle husbandry along with foraging (Derevianko and Dorj 1992). Although numerous cattle bones were recovered, the claims of domestication should be viewed with caution as they were never verified. There is likewise no clear evidence for domesticated millet. Despite a lack of definitive evidence for plant husbandry, these sites reflect a distinct variant—probably focused along the Kherlen and Khalkh rivers which drain into Hulun Nuur in Inner Mongolia—of the widespread trend towards sedentism and mixed subsistence strategies emerging across the far eastern steppe/forest-steppe, extending to sites in China like Yaojingzi, Jilin province (Liu, Z. 1995b; Tan et al. 1995a).

Considering the data observed herein, we see changes in technology and land-use after 8.0 ka cal BP as a predictable response to significant post-LGM ecological change. The close geographic proximity of East Gobi groups to Neolithic farmers may have meant that these groups were familiar with millet agriculture, but there is currently insufficient data to support this assertion. Evidence for permanent settlements, subterranean houses, and villages typical of the intensive broad-spectrum foraging and resource manipulation that preceded early agriculture in China may be present in northeastern Mongolia, but is currently missing in the Gobi Desert. Instead, hunter-gatherers maintained a pattern of residential mobility and large-game hunting, but mapped this strategy onto dune-field and wetland habitats where water was plentiful and the diet could be supplemented by a wide range of predictable, high-density resources. Janz (2016) argues that the strategy was an organizational response to changes in resource distribution that broadly characterize Holocene landscapes. Similar processes occurred globally, but more productive environments (those with higher biomass and more dense concentrations of *r*-selected prey) such as the lower reaches of the Yellow River and the once forest-steppe regions of far eastern

Inner Mongolia preferentially supported reduced residential mobility, higher population densities, and the more intensive levels of resource extraction that characterized the formation of agricultural communities. The origins and spread of pastoralism in East Asia are poorly understood but had a direct and profound effect on the trajectory of Gobi Desert economies. There is currently no convincing evidence that animals were locally domesticated, despite the fact that the territorial ranges of the wild progenitors of camels, horses, and cattle (*Camelus ferus*, *Equus ferus*, and *Bos primigenius*, respectively) all extend into the region. It is clear that horses, cattle and ovicaprids were first domesticated farther west, but it is possible that local species played a role in establishing early herds, as molecular studies increasingly show complex genetic histories with multiple domestication episodes and/or extensive introgression from wild stock (Vilà et al. 2001; Hiendleder et al. 2002; Mannen et al. 2004; Meadows et al. 2007; McKay et al. 2008; Chessa et al. 2009; Felius et al. 2014; see Larson and Fuller 2014). This complicated history has led East Asian researchers to seriously investigate evidence for the possibility of local domestication of cattle, ovicaprids and horses.

The genetic history of cattle is most compelling in light of several new lines of evidence. The first is a recently identified haplogroup (T4) specific to domesticated Northeast Asian cattle (*Bos taurus*) dating to about 6.9 ± 1.8 ka (Achilli et al. 2008). Cai et al. (2014) suggest that this divergence is the product of a founder effect, while other researchers have suggested that local *Bos primigenius* were incorporated into the gene pool of domestic cattle either through a separate domestication episode or incorporation of wild female animals into existing herds (Mannen et al. 2004; McKay et al. 2008; Felius et al. 2014). Our understanding of this process is handicapped by a lack of current research in regions like the far eastern steppe, where a separate domestication episode is most likely to have occurred. Recent claims of cattle management based on osteological data from a single *Bos* sp. mandible in northeast China dating to 10.8–10.6 ka cal BP (Zhang et al. 2013) are speculative, and the report lacks archaeological context. Analysis of mtDNA from this specimen indicates that it is most closely allied with taurine cattle and represents a distinct haplogroup. Unfortunately, the authors did not include native *Bos primigenius* mtDNA in a comparative sample that included *Bos indicus*, *Bos grunniens*, *Bison bison* and *Bison bonasus*. More recently, DNA analysis of bovine oracle bones from Longshan period archaeological sites in central China has shown that scapulae from both *B. taurus* and *B. primigenius* were used in divination rituals between 3600 and 2000 BC (Brunson et al. 2016). The *B. primigenius* specimens belonged to the same *Bos* haplogroup C identified by Zhang et al. (2013) and two of them overlap in size with *B. taurus*. There is currently insufficient evidence to posit systematic management or domestication of indigenous cattle, but it is notable that cattle were used intensively in eastern Mongolia (Dorj 1971; Derevianko and Dorj 1992) and are also reported from Neolithic (5458 ± 101 cal yr BP [4726 ± 76 BP]—see Liu, Z. 1995b, pp. 109–111, 114) and Bronze Age contexts (Liu, J. 1995a, p. 221) in the Jilin province of northeast China. These data contrast with Neolithic sites in the Chifeng region of southeastern Inner Mongolia (Guo 1995a, p. 29; 1995b, p. 160) and Korea (Lee 2011), where cattle are both extremely rare and poorly documented. Fauna from Neolithic sites in eastern Mongolia and northeastern Inner Mongolia should be prioritized in future research, particularly with regard to DNA analysis.

Cai and colleagues (2009, 2011) have used ancient samples to make interesting arguments for separate domestication episodes in East Asia for sheep (*Ovis aries*) and horse (*Equus caballus*). Findings of discrete East Asian sheep lineages mostly reconfirm earlier studies pointing to the adoption of several distinct lineages derived from diverse domestication episodes farther west (Hiendleder et al. 2002; Meadows et al. 2007; Chessa et al.

2009). These studies also show a clear discontinuity with local wild populations that contradicts either local domestication or introgression from wild populations; a very early introduction and subsequent genetic isolation is therefore more likely (see Avise et al. 1987; Hiendleder et al. 2002). Moreover, the geographically significant pattern Cai and colleagues observe in *E. caballus* phylogenies probably reflects a distinct domestication episode in nearby Kazakhstan (Olsen 2003; Outram et al. 2009). Honeychurch (2015, pp. 205–211) makes a substantial argument for the introduction of domesticated horses from Central Asia, introgression with wild populations in Mongolia, followed by their introduction farther south in China at the end of the second millennium BC.

Currently, the most plausible source for the introduction of herd animals into Mongolia and other parts of East Asia are dispersals through Inner Asia by herding groups such as the Afanasievo (5.3–4.5 ka cal yr BP [Polyakov and Svyatko 2009; Svyatko et al. 2009; Kovalev and Erdenebaatar 2009; Matuzeviciute et al. 2016; *contra* Frachetti 2008, 2012]). The Afanasievo are the earliest embodiment of metal-using hunter-gatherer-herders in East Asia and are often recognized through their elaborate burial architecture (Svyatko et al. 2009; Kovalev and Erdenebaatar 2009; Frachetti 2008, 2012; Honeychurch 2017). At around 4.5 ka cal BP, Chermurchek-type burials emerge and overlap with Afanasievo in the Mongolian Altai, becoming widely distributed across the Altai in parts of Mongolia, Kazakhstan, Russia, and northwest China. Burials contain evidence for the use of bronze, bone and lithic technology (including arrowheads and polished stone tools) and a stone statue or pillar was erected on the middle of the southern or eastern side of the cairn (Kovalev and Erdenebaatar 2009). Bergman described a similar type of burial architecture near Bulung Khuduk (Fig. 3.BKh) (Dzun Gung) in the East Gobi (Maringer 1950, p. 32), but it is not until 3.4–3.1 ka cal BP (Fitzhugh 2009; Tumen et al. 2014; Honeychurch 2015) that there is clear evidence for the spread of Bronze Age herders, or at least their burial culture, into the Gobi Desert. These dates overlap with the Karasuk in the Minusinsk basin (Svyatko et al. 2009, p. 253, Table 10) and the inclusion of Karasuk-style bronze knives in burials and depictions on Mongolian deer stones suggests some type of long-distance interaction (Houle 2016). Burial types associated with this diffusion include *khirigsuurs* (stone monuments; see Wright 2007); slab burials; and a group of related burial types—including *dörvöljin bulsh* or 'shaped burials,' Ulaanzuukh, and Tevsh variants—which Honeychurch (2015, 2017) refers to as Ulaanzuukh–Tevsh (see also Houle 2016). Khirigsuurs are concentrated in western and central Mongolia and often considered to have spread from there, while slab graves are concentrated in the east. Both are more widespread than previously recognized and are distributed across Mongolia and beyond (Honeychurch 2015, pp. 122–131, cf. Cybiktarov 2003; Erdenebaatar 2004). The distinctive stone structures are reported from intermontane meadows in the Gurvansaikhan range (Arts Bogd, Baga Bogd, Ikh Bogd) of the Gobi–Altai region (Nelson 1925; Fairservis 1993, pp. 169–172; Derevianko et al. [Eds.] 1996, pp. 118, 298) and at least one *khirigsuur* has been found at Zaraa Uul on the Gobi–Steppe.

Ulaanzuukh–Tevsh burial types are common in the eastern Gobi–Steppe but are also found in the central, west-central, southern, and eastern provinces of Mongolia and are widespread in the Gobi Desert (Amartuvshin et al. 2015; Kovalev and Erdenebaatar 2009; Tumen et al. 2014; Honeychurch 2015). The burials feature masonry-like construction of the side walls, primarily an east–west orientation of the burial and an eastern orientation of the head, and prone ('face-down') interment (Erdenebaatar and Kovalev 2008; Honeychurch 2015, pp. 122–126). The earliest dates are from Ulaanzuukh (Fig. 3.UZ*) at 3332 ± 41 to 3213 ± 49 cal yr BP (Tumen et al. 2014). Burials at Tevsh Uul (Fig. 3.TU*) in Ovorkhangai and the Gobi–Altai are probably only a few hundred years younger

(Kovalev and Erdenebaatar 2009). Individuals were adorned with garments decorated with, and necklaces made from, carnelian, lazurite, limestone, shell and bone beads (Fairservis 1993; Kovalev and Erdenebaatar 2009; Tumen et al. 2014; Honeychurch 2015, 2017; Yeruul-Erdene et al. 2015). There are even examples of animal-style gold ornaments from a burial at Tevsh Uul (Fig. 3.TU*) in Övörkhangai *aimag* and from Chandmani Khar Uul (Fig. 3.CKU*) in Dornogovi *aimag* (Novgorodova 1989, pp. 137–138; Honeychurch 2015, pp. 123–124). Pond (1928) was the first to discover a burial of this type near microlithic sites on the shores of Tairum Nuur (Fig. 3.TN*), Inner Mongolia. The burial contained over 5000 shell or bone beads that had decorated the individual's cape (Fairservis 1993, pp. 166–167, 191, 196–197; Pond 1928, n.d.), but no other grave goods. Likewise, shaped burials were discovered first by Bergman in 1927 in the Beli Miao region (Fig. 3.BM) on the left bank of the river Aibaghin Gol (Chugungtai Gol/Yang-chang-tze-ku) in Inner Mongolia and are reported to have been found in groups the whole way to Shande Miao (Fig. 3.SM). Bergman reported seeing only a few single graves as far west as Hoyar Amatu/Gashun (see Fig. 3.12) (Maringer 1950, pp. 13–14). At Hoyar Amatu, Bergman discovered several bronze artifacts (a buckle, a pendant, a pin, and a fragment of a vessel or some similarly shaped artifact) alongside typical Oasis 3/Bronze Age pottery, a full range of microblade cores, tools, and microlithic flakes, and a polished greenstone axe (Maringer 1950, pp. 93–97). He believed these to have derived from a destroyed burial, but the burial that he excavated at Beli Miao contained only sheep bones (*Ovis* sp.). The inclusion of remains from domesticated herd animals, particularly ovicaprids, was common during the Bronze Age, and cattle and horse have also been recovered (Amartuvshin et al. 2015; Honeychurch 2015). Many of the remains from herd animals found in Bronze Age burials are likely to be domesticated or a mix of domesticated and wild species, but there is no data on population-wide morphometrics, which means that most determinations of domesticated ovicaprids should be considered 'likely' rather than conclusive.

The rise of highly visible monuments and burial structures across Mongolia and the Gobi Desert represents a significant shift in burial practice: Neolithic burials are unknown in the Gobi Desert and contemporary groups at Tamsagbulag, Ovoot, and Norovlin Uul in the eastern steppes (Fig. 3.20, 3.21, 3.NU*) buried the dead under the floor of their dwellings or possibly in unmarked graves (Okladnikov and Derevianko 1970; Dorj 1969, 1971; Novgorodova 1989; Derevianko and Dorj 1992; Cybiktarov 2002). This shift in burial practices arguably underscores significant societal changes (Wright 2007, 2014).

Oasis 3 covers this entire period of Bronze Age development and appears to end just prior to the beginning of the Iron Age. Temporal and spatial overlap between late Stone Age sites and Bronze Age ritual and burial monuments suggests two possibilities: either Gobi Desert groups had contact with the Bronze Age groups who constructed these monuments; or they are one and the same. The frequent association of burial cairns with microlithic-based habitation sites strongly suggests continuity between oasis-dwelling hunter-gatherers and the first metal-using herders interred around oases. The presence of *khirigsuurs*, including massive multicomponent structures, in intermontane meadows and valleys of the Gobi–Altai (e.g. Nelson 1925; Fairservis 1993, pp. 169–175; Derevianko et al. [Eds.] 1996, p. 298), and the frequent occurrence of geometric-incised potsherds in western desert microlithic sites, suggests a relationship between Altai herders and desert-dwelling groups that could have encouraged the spread of domesticates and influenced indigenous developments in burial custom. Either way, the spread of new technological and economic developments would have impacted Gobi Desert groups.

Consequently, analysis of Oasis 3 land-use and material culture should inform our understanding of the processes leading from the Stone to the Bronze Age. Despite numerous indicators of significant organizational and ideological change, there is little evidence of any statistically significant divergence in land-use and technology between Oasis 2 and Oasis 3. Likewise, despite irrefutable evidence for the spread of Bronze Age burial ritual and tentative evidence for increased contacts with other herding groups after 4.5 ka cal BP, habitation sites suggest neither an in-migration nor a change in land-use. The more notable change is a minor expansion in the distribution of grinding stones and pottery. These technologies are found in other environments more often than during Oasis 2 (Janz 2012, p. 365, Table 6.5; Janz 2016). With regard to lithic assemblages, only those from the Alashan Gobi reveal any statistically significant divergence between Oasis 2 and Oasis 3: Oasis 3 sites tend to have smaller microblade cores and contain higher ratios of microblade to informal core types (Janz 2012, p. 287, Table 4.13), implying a decline in the availability of raw material. Such a change might be related to increased residential mobility or changes in mobility that reduced access to tool stone. A lack of similar evidence in the East Gobi and Gobi–Altai does not preclude shifts in land-use or subsistence, since access to raw material was variable. While we might expect to see a re-prioritization of land-use with the advent of herding, including dispersal of settlement into the grasslands, the only potential evidence of such is a slight expansion into drier habitats in the Alashan zone (Janz 2012, pp. 227–236, 240). Again, current analysis suggests that modes of land-use between periods are statistically indistinguishable. More extensive spatial analysis of site distribution and tighter chronological controls might elucidate variation that is otherwise invisible.

Changes in material culture during this time are much more intriguing. First, there are specific artifacts that link Oasis 3 groups with Bronze Age burial remains: the increased visibility of bead-making, particularly at the Ukh Tokhoi cave site is significant, as are finds of cylindrical and disk-shaped stone and bone beads frequently recovered from early Bronze Age burials (Kovalev and Erdenebaatar 2009; Tumen et al. 2014; Amartuvshin et al. 2015; Yeruul-Erdene et al. 2015; Honeychurch 2015). Oasis 3 sites containing clay spindle whorls, painted pottery (with motifs very similar to those used by agropastoralist groups farther east), and copper slag not only hint at close connections with these burial sites, but suggest similarities in technology and material culture that supersede generalized, region-wide stylistic changes. The presence of spindle whorls indicates that fibers of some sort were being spun: two candidates are wool or bast. The use of fully and finely polished adzes/axes is also comparable to the use of such technologies among Bronze Age groups. One particularly notable find is a fully polished axe from Yingen Khuduk (Fig. 3.9) made on semi-translucent greenstone (Maringer 1950, pl. XXXVI.12). A broad polished greenstone axe was also recovered from Hoyar Nuur (Hoyar-Nor) and fragments of a bronze vessel and polished axes were recovered from Sogo Nuur (Fig. 3.6) at the northern end of the Ruoshui–Hei He drainage system (Maringer 1950, pp. 139–148). Copper slags are sometimes recovered from microlithic sites in other parts of the Gobi Desert (Dorj 1971; Cybiktarov 2002; Park et al. 2011; Janz 2012), but the presence of bronze artifacts in clear association with microlithic elements is even more distinct. A bronze knife tip similar to one recovered from a shaped burial (EXO7.23) has been found in a microlithic assemblage at Baga Gazryn Chuluu (Honeychurch 2016, personal communication). The greater abundance of such finds in the Alashan zone suggests that the region could have played a primary role in the development of Bronze Age economies in East Asia. End-hafted bifacially-worked rectangular blades and curved knives at sites like Bayanzak/Shabarakh Usu and Sogo Nuur (Fig. 7) further highlight the probable familiarity of microblade-using oasis dwellers with contemporary bronze knives associated with herders.

Secondly, this period is related to a region-wide trend towards greater reliance on pottery and more varied surface treatments on these vessels. Some vessels were fired at a much higher temperature than we see in Oasis 2 (Palmgren [1934] estimated that Majiayao Banshan–type pottery was fired at temperatures of 900–1000 °C). Oasis 3 residential sites in the East Gobi are notable in that they appear to contain fewer large formal grinding tools than Oasis 2 sites. Janz (2012, pp. 185–186) suggests that these developments could be related to a decline in the importance of milling plant foods and an attendant rise in the importance of boiling. Such a shift could be tied to a decline in the importance of intensive plant processing as new sources of equally or more reliable foods became available. Food preparation also seems to have been less spatially constrained, as evidenced by the presence of grinding stones and pottery within a wider range of environments during Oasis 3. This is probably related to a shift in the environmental range of habitation sites.

Finally, there is more frequent use of specialized hafted microblade tools like shouldered drills and endscrapers on microblades (Janz 2012, p. 370). These tools are likely related to the production of decorative artifacts such as beads, as the emphasis on decorative elements is one of the most striking aspects of technological change in Oasis 3. Manufacture of finely polished adzes/axes and eggshell and stone beads is especially time-consuming. Burnishing, painting, and creating raised and moulded rims on high-fired Oasis 3 pottery all require additional effort, but produce a more striking appearance than that of earlier vessels. Finer tools like shouldered drills and endscrapers on microblades would have been used in more detailed tasks, which may have included some type of decorative work (e.g. drilling holes in beads, engraving, and carving). Though not directly related to mobility and land-use, increased emphasis on decorative arts underscores a shift in time allocation. High-fired pottery and finely polished tools suggest that durability was valued and longer-term curation intended.

A peak in the production of traditional goods has been frequently witnessed in situations of new contacts between hunter-gatherers and food-producing groups (see examples in Sadr 2005), and the shift in production of material culture might be related to contact with neighbouring herding groups as their influence in the region increased. Though there is currently insufficient evidence to support a claim for trade between Gobi Desert hunter-gatherers and nearby groups, it is not unusual for hunter-gatherers to trade local products with food-producing neighbours (Lukacs 1990; Spielmann and Eder 1994; Junker 1996, 2000; Zvelebil 1996; Sadr 2005). Furs, feathers, skins, tool stone, clay, wild meat, turquoise, raw copper, chalcedony beads (such as those being manufactured at Ukh Tokhoi), and seasonal labour (see Paterson 2005) are all products that might have been appealing to contemporary pastoralist, agro-pastoralist, and even agriculturalist neighbours. Products like grain/flour, pottery, bronze tools or ornaments, milk products, hemp, wool, and even domesticated animals might have been valued items among hunter-gatherer groups. Such interactions could have facilitated the introduction of domestic herd animals into the Gobi Desert. Many of the sites that Bergman investigated lay along a well-trodden caravan route linking Hami with Zhangjiakou/Beijing. As such, this zone and its inhabitants may have served as a conduit for trade and travel linking early Chinese settlements with goods from Central and Inner Asia.

Another route is proposed by Honeychurch (2015, pp. 188–189). He argues that evidence of Ulaanzuukh–Tevsh burial customs across the Gobi Desert point to the movement of ideas and artifacts—and domesticated horses—from the Khangai Mountains into the Gobi–Altai, farther south to the Ordos Plateau, and ultimately into central China (Honeychurch 2015, pp. 208–209). Such a route emphasizes the contribution of groups on the periphery of agricultural China, such as the Qijia and Siba (northwest China), Zhukaigou

(Ordos Plateau), and Xiajiadian (northeast China) in the spread of bronze technology and Northern Zone artifacts. Bronze artifacts spread across south-central and southeastern Inner Mongolia and Jilin province beginning around 3.6 ka cal BP (Guo 1995c; Liu, J. 1995a; Tan et al. 1995b; Shelach 2000, 2009). While small bronze artifacts are sometimes recovered from Lower Xiajiadian sites (see Fig. 3.XLW) (c. 4.2–3.6 ka cal BP [2200–1600 BC]), both Zhou and northern-style bronzes (including horse fittings) are abundant during the Upper Xiajiandian phase. The latter period corresponds with the adoption of slab-lined burials and the abandonment of defensive structures and earthworks across south-central and southeastern Inner Mongolia (c. 3.2–2.6 ka cal BP [1200–600 BC]) (Shelach 2000, 2009; Drennan et al. 2014). Similar evidence for the spread of stone-cist burials and horse-riding, along with the use of domesticated barley and wheat, appears around 3.5 ka cal BP far to the south in the highlands of western Sichuan (d'Alpoim Guedes et al. 2016). The rise of sedentary communities in the Ordos Plateau during the second millennium BC and the contemporaneous spread of varied bronze metallurgy traditions across continental East Asia suggests a 'process of gradual transfer of technologies and styles synthesized with local innovations' (Honeychurch 2015, p. 189). These widespread changes, particularly a shift towards more long-distance interactions, may have been tied to innovations in horse-harnessing technology for which we have clear evidence by at least 1300 BC (Yuan and Flad 2005; Taylor et al. 2015). These pervasive changes highlight the potential importance of understanding the context of contemporary microlithic sites scattered across the eastern and western desert, both with regard to understanding local developments and elucidating the relationship between pastoralists, oasis-dwellers, and more sedentary food-producing groups scattered along the upper and middle reaches of the Yellow River.

In fact, the close relationship between microlithic sites and Bronze Age burial sites strongly suggests that it was microlith-using oasis-dwellers who constructed the burial cairns. A lack of distinct 'Bronze Age' habitation sites further supports the possibility that Bronze Age herders were also Stone Age hunter-gatherers; however, it is also possible that the rich signature of Oasis 2 and 3 hunter-gatherers obscures evidence for herder habitation sites. In the absence of pottery, sites like Dottore Namak could potentially be confused with Neolithic/Eneolithic assemblages. A direct relationship is better suggested by the occasional inclusion of microblades and frequent appearance of Oasis 3-type pottery in Ulaanzuukh burials (Amartuvshin et al. 2015; Wright 2016, personal communication). Microblades are usually not reported because they are considered intrusive, and their context relative to the burials is never clearly discussed.

Elucidating the relationship between Oasis 3 groups and the burial cairns containing bones of ovicaprids, and occasionally *Bos* and *Equus*, is imperative and should include more definitive analysis of the wild or domesticated status of those species. Likewise, goats and goat-hunting are common themes in Mongolian petroglyphs (Fairservis 1993, pp. 192–201; Derevianko et al. [Eds.] 1996, 1998a, 2000; Tseveendorj et al. 2005; Jacobson-Tepfer 2013), and it is not always clear whether the images depict ibex (*Capra sibirica*) or domesticated species (*Capra hircus*). The presumed importance of ibex hunting might also suggest that some individuals from mortuary contexts had been hunted. The lack of comparative faunal collections for wild species in Mongolia and potential species-specific variation in size means that when key species occur in archaeological contexts their status as wild or domesticated is often assumed depending on the context (specifically inclusion in Bronze Age burials or monuments). Rigorous attention to distinguishing morphometric variation is similarly important when categorizing faunal remains, such as equids, from microlithic sites where they are assumed to have been wild.

Despite the rather sudden appearance of a profoundly different burial ritual, we do not argue that this shift corresponded to sweeping and uniform changes to the broader organizational strategies of oasis-dwellers. Instead, we speculate that herding developed gradually in the Gobi Desert within the context of region-wide changes in social organization and subsistence, and that changes in burial practice were either the culmination of this transition or the product of pastoralist migration or cultural diffusion into the region. Moreover, economic change probably varied and may have been more abrupt, more intensive, and more complete in some regions than in others. These interpretations are based on the aforementioned patterns in land-use and technology, as well as the pace of these processes in other world regions (Smith 1992; Vanmontfort 2008; Linseele 2010; Lesur et al. 2014). Future research should include residue analysis of pottery vessels (Evershed et al. 2008) and sediment micromorphology from habitation sites (Shahack-Gross et al. 2004), both of which are important methods of recognizing herding signatures in the archaeological record. Finally, the possibility that Slab Grave complexes arose from Gobi-centered Ulaanzuukh–Tevsh complexes (Honeychurch 2015, pp. 126–131) holds special importance in understanding the influence of Gobi Desert groups on the trajectory of Bronze and Iron Age social change and exchange networks across East Asia. Groups in this region inhabited a geographical range central, rather than peripheral, to increasing materialism and burgeoning interaction between communities across Northeast Asia. This would have presented many potential opportunities for Gobi Desert groups to take a key role in facilitating trade and other activities.

Environmental Degradation, Deforestation and the Decline of Oasis-Dwellers

Regardless of the economic nature of oasis habitation sites during Oasis 3, there is a clear decline in the use of such habitats between 3.5 and 3.0 ka ago. The dates correspond with a period of heightened aridity across the Gobi Desert (Janz 2012; Janz et al. 2015; also Wright et al. 2007) and there are multiple lines of evidence for environmental degradation beginning around 4.5–3.0 ka cal BP. Aridification was largely due to the southward regression of the East Asian Summer Monsoon (Kniaziev 1986, as cited in Starkel 1998; Starkel 1998; Li et al. 2002; Shi and Song 2003; Jiang et al. 2006; Zhao et al. 2009; Felauer et al. 2012; Lee et al. 2013; Yang et al. 2013). This trend is exhibited in archaeological contexts with Late Neolithic (Oasis 3) sites often encased in several feet of sand, whereas earlier sites are associated with loam and palaeosols. Several sites from Bayanzak/Shabarakh Usu dating to 4.9–3.4 ka cal BP occur below high water strandlines, further illustrating that post-glacial drying progressed throughout the course of occupation.

Anthropogenic Factors

Recently, the contribution of human land-use practices to environmental degradation has gained increased attention. In desert regions, vegetation, including trees, plays a key role in the maintenance of oasis systems (for dune-based ecosystems see Zou et al. 2002; Pan and Chao 2003; Pankova 2008). Enhanced aeolian activity is one of the primary proxies for the onset of post-climatic-optimum aridity in Mongolia and northern China (e.g. Li et al. 2002; Feng et al. 2007; Yang et al. 2013). Even during the Neolithic, intensified human use of fragile dune-based landscapes may have impacted ecological systems as the destruction of vegetation cover in oasis environments leads to a loss of surface soils and groundwater retention capacity (*sensu* Pan and Chao 2003), resulting in increased aeolian activity and run-off. We would expect more extensive degradation, often recognized in local palaeoenvironmental records as aeolian deposition, in later periods, as climate-induced reductions in vegetation made these ecosystems more vulnerable.

Overgrazing has been cited as contributing both to increases in wind-blown sediment and to deforestation in the Gobi Desert (Cermak et al. 2005; see also Starkel 1998; Hedin 1943, pp. 143–144), including the degradation of dune-fields (Pankova 2008). Examining this aspect of anthropogenic involvement is then especially important in the Gobi Desert. However, studies addressing the relative contribution of grazing and climate change to desertification are highly variable, politically charged (Zhang et al. 2007; Yang 2008; Harris 2010), and largely disconnected from a time-depth relevant to archaeological interpretation (but see Cermak et al. 2005; Miehe et al. 2007, 2014). Even in the longer-term studies, relationships between overgrazing and grassland degradation are extremely difficult to decouple from climate-forcing, largely because arid grasslands were heavily grazed by, indeed evolved under the pressure of, ungulate herds prior to the adoption of pastoralism. Researchers are so far unable to distinguish changes in the type of ungulate activity occurring at these sites from climate-induced degradation (but for centennial-scale analysis see Schültz et al. 2008).

Although there are similar problems when decoupling anthropogenic from climate-induced deforestation, a number of recent studies have focused on the impact of human activity on arboreal ecosystems in Inner Asia. The current treeless and strikingly barren landscape of the Gobi Desert makes it difficult to imagine significant forestation during the middle Holocene; however, post-LGM forest expansion was likely much more extensive than that of earlier periods, perhaps due in part to the decline of niche-constructing herbivores like Elephantinae species (see Bakker et al. 2016). Recent research on relict forests in the Gobi–Altai shows that by the middle Holocene there was a continuous corridor of riparian and/or high elevation forests spanning the entire Gobi–Altai region and extending southwards to the Qinghai–Tibetan Plateau (Cermak et al. 2005; Miehe et al. 2007). The palynological records summarized in our synthesis of middle Holocene environmental conditions attest to the formation and expansion of riparian woodlands in the west, as well as the establishment of high-elevation mixed forests and mixed or deciduous forest-steppe in the east. While reduced precipitation almost certainly contributed to reduced range and shifts in forest structure (Gunin et al. 1999; Tarasov et al. 2000; Miehe et al. 2007), climate change does not entirely account for extensive deforestation in the late Holocene (Cermak et al. 2005; Wesche et al. 2011). Studies of the reproduction and genetic structure of Siberian elm (*Ulmus pumila*) stands (single trees and woodlands) in the Mongolian Gobi Desert suggest that the trees are actually well adapted to modern conditions of high aridity and extreme seasonal variation in cold and heat. Considering their ability to reproduce normally, they should be more commonplace along potentially suitable habitats like drainage lines, riverbeds, and ravines (Wesche et al. 2011; see also Miehe et al. 2014). Researchers have further shown that isolated birch–willow forests growing above 2400 m. a.s.l. in the Gobi–Altai mountains are capable of sustaining and protecting themselves even under modern conditions of high aridity, though present conditions largely impede re-establishment once deforestation occurs (Cermak et al. 2005; Miehe et al. 2007).

The authors of a more extensive study of relic forests on the southeastern Tibetan plateau propose that widespread forestation after 10.0 ka cal BP was repressed through human use of fire (Miehe et al. 2014). Extensive deforestation did not commence until 6.0 ka cal BP, at the height of climatic amelioration, and then became more extensive around 1.3 ka cal BP after the appearance of the invasive plant *Tribulus*, which the authors associate with herding (Miehe et al. 2014). There is ample evidence that both hunter-gatherers and pastoralists use fire to alter landscapes (Lewis 1977; Lewis and Ferguson 1988; Peden 2006; Solomon et al. 2007; Bliege Bird et al. 2008; Lightfoot et al. 2013), but these instances tend to focus on encouraging the localized rejuvenation of grasslands, growth of favored species, and/or clearing out of less economically important ones (as opposed to complete removal of arboreal species). Notably, the earliest date for sedentary occupation and farming practices on the Tibetan Plateau, from Kha Rub at 5917–4145 cal BP (Aldenderfer 2007), coincides with extensive deforestation (Miehe et al. 2014). The dates suggest that widespread forest clearance was more likely to have been associated with sedentary agriculture than with pastoralism (see also Meyer et al. 2009).

This supports the idea that anthropogenic forest clearance is a more plausible explanation for large-scale deforestation than overgrazing of domesticated herds. While grazing can inhibit forest expansion and regrowth, none of the local domesticated species has a severe effect on mature trees. In contrast, human tree-felling targets established individuals which are key to ecosystem structure. The idea that humans were directly involved in deforestation is especially important when we consider the archaeological evidence: the introduction of adzes and axes after 8.0 ka cal BP, with an increase in the number of polished types around 5.0–3.0 ka cal BP (the inclusion of these in Bronze Age burials might suggest they mostly date to the later end of that phase); and the rising importance of pyrotechnology, including high-fired ceramic vessels after 5.0 ka cal BP and the spread of metallurgy during Oasis 3. Beginning around 5.0 ka cal BP, charcoal layers from forest fires at Yolin Am in the Gurvansaikhan range of the Gobi–Altai region have been interpreted as human landscape modification through the use of fire (Miehe et al. 2007). If this is the case, opening additional land for grazing in a region largely dominated by grasslands seems counterintuitive. Cermak et al. (2005) suggest that the goal might have been the succession of alpine meadows that replace birch–willow forests at high elevations (Cermak et al. 2005). Therefore, the intensification of herding practices during the Bronze and Iron Ages could be seen as contributing to widespread deforestation after 2.6 ka cal BP (2.5 k yr BP) (see Gunin et al. 1999), while more intensive harvesting of trees and brush from riparian and dune-field environments is more likely to have been associated with hearth fires and craft production. Climate change would have heightened the effects of human activity through increasingly frequent and intense fire regimes and the inability of denuded riparian and higher elevation ecosystems to re-establish woodlands under conditions of heightened aridity.

Decline of Oasis Adaptation

The scarcity of recognizable Iron Age habitation sites suggests a decline in population density after Oasis 3 or a substantial shift in material culture and settlement that made such sites more ephemeral. Increased mobility and a decline in the use of lithic technology, both of which are expected to have occurred during the Iron Age, could contribute to reduced visibility in the archaeological record. Finds at Dottore Namak support this idea of a trend towards more even dispersal of habitation across ecozones, including clearer evidence for transportation of specialized food processing equipment such as pottery, which were previously seldom transported beyond wetlands. New transportation aids might be partially responsible for this pattern. Beasts of burden such as cattle, camels, or horses (the latter were being harnessed in Mongolia by at least 2.3 ka cal BP/1300 BC [Taylor et al. 2015]) would allow groups to easily travel and transport goods between distant foraging patches.

Increased prevalence of pottery and a decline in caching behaviour would be possible signatures of such practices. Considering the decline in wetland habitation after 3.0 ka cal BP, we view expansion in the distribution of pottery and grinding stones as the result of changes in land-use that preferenced pastoralist products and necessitated greater emphasis on pasturage, thereby influencing settlement in environments outside oases. Adopting more intensive pastoralism as an alternative to wetland-based systems would have seemed more viable if inhabitants were already familiar with domesticated herd animals. Active aridification may have prompted reorganization, but region-wide social change likely provided more substantial impetus for organizational changes at the end of Oasis 3.

A shift away from wetlands during a period of environmental degradation might also indicate that the use of these habitats was becoming less productive, whether as a result of climate change or human-induced degradation. At the same time, we must remember that despite enhanced aridity, the Gobi Desert was still much wetter than it is today and aridification did not reach modern levels until long after these changes in land-use systems (Lu et al. 1997; Felauer et al. 2012; Lee et al. 2013). Current levels of aridity even exceed those of historic times: some lakes along the southeastern edge of the Badain Jaran Desert (Fig. 1) had high levels as recently as 0.8 ka ago (Yang and Williams 2003); notable declines in the lake levels at Gashun Nuur and Sogo Nuur were recorded as late as the seventeenth century AD (Lu et al. 1997; Mischke 2001, p. 16; see also Debaine-Francfort et al. 2010); and historic travelogues recount a Gobi Desert that was less arid and better populated by game only eighty to ninety years ago (Nelson 1925; Allen 1938). Therefore, even if the lakeshores were not used for daily habitation, many of the oases would have remained centers of relative environmental productivity in spite of dune-field destabilization and the desiccation of permanent lakes. Still, the abandonment of wetland habitation sites indicates a major change in land-use.

Conclusions and Recommendations for Future Research

We are still at an early stage in understanding the prehistory of the Gobi Desert. Despite the last century of heightened archaeological inquiry in East Asia, little work has been done with the vast collections of archaeological materials. The dominance of surface assemblages and the inaccessibility of contextual data have inhibited research. Museum collections hold a wealth of information that could not be replicated under the contemporary logistical, political, and financial constraints of fieldwork, and are an excellent place to begin applying methodologies such as chronometric dating, analyses of organic residues, isotopes, phytoliths, and usewear, alongside traditional methods of lithic, faunal, and ceramic analysis. Based on the research that has already been done, several assertions can be made with relative confidence:

- Beginning around 8.0 ka ago, Gobi Desert hunter-gatherers began practicing a new mode of broad-spectrum subsistence and land-use centered on wetlands and dune-fields with logistical exploitation of other ecozones
- This shift was stimulated by environmental changes related to post-glacial climatic amelioration, including heightened forestation and wetland expansion
- Oasis-centric land-use continued throughout the Bronze Age until about 3.0 ka cal BP
- Subsistence during this time focused on the complementary use of large ungulates and small game, and the more intensive processing of plant foods, as evidenced by faunal data and the more intensive use of large, flat-faced grinding stones

- Wild equids were economically important, as were cattle (in the east)
- Residential mobility remained high, but was redundant
- Material culture of Oasis 3 groups indicates familiarity with pastoralist technologies, which could have resulted from increased contact with neighbouring groups and/or local ethnogenesis
- Post-glacial lithic and ceramic technologies are consistent with trends among hunter-gatherers throughout Northeast Asia.

Additionally, there are a number of questions which we will pursue in the coming years. A combination of systematic collections analysis, landscape-based survey, and multidisciplinary excavation of carefully selected sites is needed to gain a comprehensive understanding of region-wide trajectories in subsistence, technology, and land-use. One essential aspect of our research is building a site-based understanding of ecosystems and subsistence in order to understand region-wide variation and/or continuity in diet. The basic question is what dietary choices people made based on what was actually available. This will require the combined efforts of specialists in zooarchaeology, archaeobotany, geoarchaeology, ecological modelling, and residue analysis. Examining processes of post-LGM settlement in the Gobi Desert is another important challenge, as settlement of the region underscores the limitations of adaptation as well as the motivations behind the use of arid lands. Considering the lack of known stratified sites, particularly with remains post-dating the Holocene, understanding recolonization requires the development of a strategy for locating more and earlier buried remains. There is also a great deal of work to do in elucidating technological processes and raw material use. Raw material resources, particularly high quality tool stone, can tell us a great deal about land-use preferences, interaction networks, and overall mobility; however, very little is currently known about the distribution of such resources in the Gobi Desert (but see Kulik et al. 2006). The impetus behind and timing for the introduction of bifacial technology is particularly important because it is one of the few diagnostic markers that persists in the abundant surface assemblages characteristic of local archaeological landscapes.

Finally, the origin and spread of herding is a pressing concern in East Asia and it is impossible to understand the pan-Northeast Asian spread of domesticated herd animals and resulting ethnogenesis without understanding that process in a location that geographically divides Central Asia and northwest China from northeast China and Korea. A recent paper by Zhang et al. (2013) on cattle domestication highlights the problem very well: there is a clear lack of archaeological context for transition to food producing economies in Northeast Asia. One of the most important steps in resolving this issue is to more intensively investigate the chronology of human activity in these poorly understood geographic regions. In Mongolia, understanding plant and animal use, including domestication, requires local comparative collections of both wild and domesticated fauna in order to understand species morphology and better distinguish between hunting, husbandry, and domestication. Due to its unique geographic and cultural setting, the Gobi Desert region has great potential for illuminating our understanding of human adaptational, behavioural, and socio-cultural processes. This study is intended to lay a foundation for future research on post-LGM Gobi Desert hunter-gatherers, and to contribute ideas and knowledge to a budding interest in the transition to nomadic pastoralism in Mongolia. It is our hope that the models outlined here for technological and economic change, chronology, and palaeoecology will be refined—corrected and enriched—as more data becomes available and multiple voices emerge.

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