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Expanding frontier and building the Sphere in arid East Asia

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ABSTRACT

Recent research on the origins of domesticated herd animals and bronze metallurgy in China suggests that the Ejiin gol in western China was a primary conduit of trade between northern pastoralists and southern agriculturalists (Jaang, 2015). It is within the context of long-distance trade in luxury goods that we see the shift from isolated populations of pastoralists in the mountains of western Mongolia to the widespread adoption of pastoralist cultural traditions. Based on evidence of interaction between Gobi Desert groups and agrarian villages to the south, we see this desert region as the geographic core of cultural transformations among indigenous populations, and at the forefront of a third stage of advance in the spread of East Asian pastoralism. Evidence presented here for increased trade in luxury goods at the beginning of the second millennium BC, when production was at its height, combined with the rapid pace of transformations in burial culture during the mid-second millennium BC suggests that the movement of goods held extreme significance for the spread of pastoralism. Therefore, the role that Gobi Desert groups played in the formation of early trade networks is vital for understanding the spread of pastoralism in Mongolia. Here, we present new evidence for stone bead production and dairying in the Gobi Desert, and discuss the full range of evidence for the role of Gobi Desert groups in emerging long-distance trade networks.

ТОВЧЛОЛ

Сүүлийн үед Өвөр Монгол болон Шинжааны нутагт гаршуулсан мал амьтан болоод хүрэл боловсруулах технологи хэрхэн нэвтэрсэн талаарх судалгаа эрчимтэй хийгдэж байгаа билээ. Эдгээр судалгаанаас харахад неолитийн төгсгөл, хүрлийн эхэн үед Өвөр Монголын Эзнээ хошууны нутаг буюу Эзнээ голын хөндий нь малчин нүүдэлчид болон өмнөд зүгийн газар тариаланч нарын хоорондын худалдаа, солилцооны гол суваг болж байжээ (Jaang, 2015). Тэгэхлээр говийн бүс нутаг нь нүүдэлчид болон өмнөдийн суурьшмал иргэд хоорондын хамгийн эртний (НТӨ III мянган) гэж хэлж болохуйц харилцаа, худалдааны төвд тооцогдоно. Эзнээ голын хөндий дэх үйлдвэрлэлийн түүхтэй холбоотой хэд хэдэн дурсгалаас НТӨ II мянганы эхээс эхлэн умард болон өмнөдөөс гаралтай олдворуудын хоёр талт хөдөлгөөн илт нэмэгдэж байгаа нь харагддаг. Тиймээс говь нутагт амьдарч байсан хүмүүс нь эртний бүс нутгийн худалдаа, солилцооны сүлжээ үүсэхэд чухам ямар нөлөө үзүүлсэн гэдгийг тодруулан судалснаар бид Монголын мал аж ахуйн үүсэл гарал, хөгжлийн зүйл тогтолыг ойлгох нэгэн боломж бүрдэнэ хэмээн үзсэн юм. Тиймээс бид энэхүү судалгаандаа тухайн үеийн говийн оршин суугчид бүс нутгийн хэмжээнд худалдаа, солилцоо хийж байсныг харуулах баримт эх хэрэглэгдэхүүнийг тусгайлан авч үзэв. Мөн Монголын мал аж ахуйн үүсэл гарал, он цагийн талаар болон Зүүн Азийн хүрлийн үеийн хөгжилд томоохон нөлөө үзүүлсэн малчин нүүдэлчдийн аж ахуй, нийгмийн байгууламжийг судлахад чиглэгдсэн хэд хэдэн саналууд дэвшүүлж байна.

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1. Introduction

The adoption of herding, bronze metallurgy and the rise of monumental mortuary architecture is an important topic of research in northern East Asia. In Mongolia, this research is about understanding the origins of pastoralist identity and the rise of pastoralist states, while in China, research focuses on the rise of complex urban states. The two lines of research are so closely connected because the rise of pastoralist states in the northern steppe was closely related to the rise of increasingly powerful and opulent dynasties within China, both built upon larger networks of interaction, materialism, trade, and warfare. Ascension of these early states relied partially on the acquisition, controlled distribution, and reinvention of technologies that were, in the context of East Asia, steppe-based technologies. Luxury goods associated with steppe cultures, such as chariots, bronze, and horses, were used to display and support imperial roles. Historical evidence indicates sustained trade for furs, horses, and a range of pastoralist products, while the grain, gold, bronze mirrors and silks that flowed northwards contributed to the formation of hierarchies among pastoralist peoples (Di Cosmo, 2002: 131–134).

The fundamental technologies associated with these developments originated through trade with groups outside China (Honeychurch, 2015; Jaang, 2015). The most important of these developments were arguably bronze working and domesticated herd animals and their spread across East Asia is closely intertwined with major societal changes across the region. The Late Bronze Age in East Asia represents a transformation characterized by heightened intensity in inter- and intra-regional relationships. Its beginning is marked by the regular incorporation of foreign-derived material culture, including domesticated herd animals, which accompanied the spread of bronze metallurgical traditions. While there is some evidence for the use of both bronzes and domesticated herd animals in the third millennium BC, most of the current evidence for emerging interactions between the north and south dates to the beginning of the second millennium BC (Brunson et al., 2020; Honeychurch, 2015; Jaang, 2015; Owlett, 2016; Lu et al., 2017). This period corresponds to the establishment of pastoralism across Xinjiang, as evidenced most famously in the Xiaohe and Gumugou cemeteries of Lop nur.

Here, we explore the establishment of long-distance exchange networks tied to steppe-based technologies from the perspective of the region geographically intermediate to farming societies along the southern alluvial plains and pastoralist groups in the arid northern steppe. We synthesize existing data on the spread of pastoralism in East Asia and the emergence of long-distance trade networks in western China, and present new data for both the emergence of pastoralism and the production and transmission of trade goods within the Gobi Desert. Our data strongly support the idea that Gobi Desert peoples were already engaged in region-wide economic transformation prior to the widespread adoption of pastoralist cultural traditions across Mongolia at about 1600 BC.

2. Regional setting

Spanning southern Mongolia (Mongol Uls/Outer Mongolia), the Gobi Desert covers a vast area of northern China (including much of the Inner Mongolia Autonomous Region [Nei Menggu Zizhiqu], northern Gansu, and the northeastern portion of the Xinjiang Uyghur Autonomous Region [Xinjiang Weiwuer Zizhiqu] (Fig. 1). The desert region is bounded on the south by the Qilian Mountains, the Hexi Corridor, and the North China Plain, on the west by the Altai Mountains, and on the north by the Khangai Mountains and Mongolian steppe. Topography is characterized by extensive mountain ranges, plateaux, erosional basins, large and small dry lake basins, gravel plains, and 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

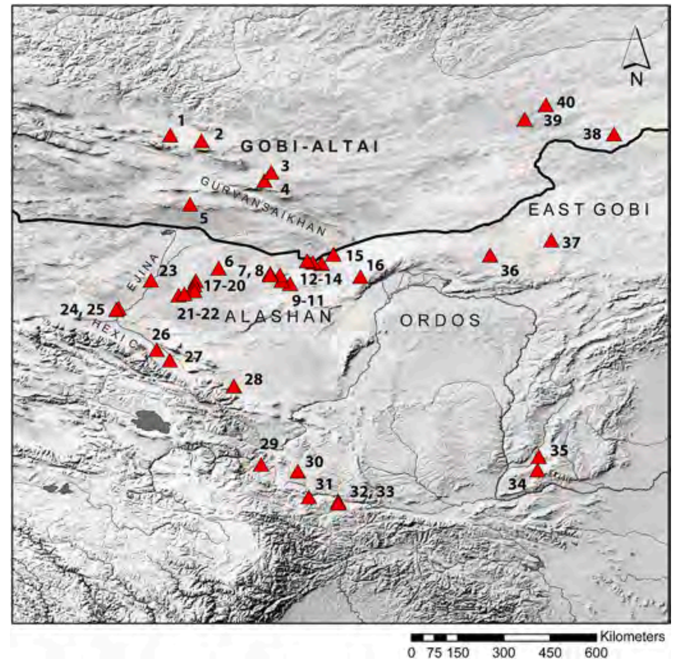

Fig. 1. Sites mentioned in the text: 1) Orok nur; 2) Baruun davan; 3) Bayanzak; 4) Salt Creek; 5) Javkhlant; 6) Dottore namak; 7) K.13230; 8) K.13240; 9) K.13222, K.13223; 10) K.13218; 11) K.13216; 12) Yingen khuduk; 13) K.13210; 14) K.13209; 15) K.13208; 16) Hoyar nur; 17) K.13277; 18) K.13280; 19) K.13287; 20) Mantissar sites; 21) K.13303; 22) K. 13307, K.13311; 23) Baishantang; 24) Huoshiliang; 25) Ganggangwa; 26) Xichengyi; 27) Donghuishan; 28) Huangniangniangtai; 29) Linjia; 30) Buziping; 31) Fujiamen; 32) Shizhaocun; 33) Xishanping; 34) Zhoujiazhuang; 35) Taosi; 36) Bulung khuduk; 37) Jira Galuntu, Site 18; 38) Salaa bulag; 39) Chandman khar uul; 40) Zaraa uul.

the summer and −40 °C in the winter. The continental desert environment separates the arid steppe from more verdant alluvial plains to the south. These distinct ecological zones support very different economic activities and underscore historical cultural differences between peoples inhabiting the fertile Central Plains of agricultural China and the vast northern steppes of pastoralist Central and Northeast Asia.

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: East Gobi, Gobi-Altai, and Alashan. 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 Ömnögov' and most of Dornogov' provinces (*aimag*) in Mongolia. The easternmost bend of the Yellow River (Huanghe) borders the southwestern edge of the East Gobi, while the northeastern edge is bordered by the Hushandake Sandy Land in Northeast China (Manchuria). The Gobi-Altai is a desert to desert-steppe environment surrounding the easternmost foothills of the Altai Mountains and extending over Ömnögov' and the southern portions of Övörkhangai, Bayan, and Gobi-Altai provinces. The region is characterized mostly by sparsely vegetated gravel pavements (gobi or *gov'*), but is interspersed with dune-field accumulations. Extinct or shallow internally-drained lake basins, brackish seasonal lakes, and wetlands are scattered throughout lowland habitats. Large alluvial fans and scattered west-to-east-trending ranges divide the Gobi-Altai and Alashan Gobi regions. The Alashan Gobi is largely located within the western reaches of Inner Mongolia between the Yellow River and the terminal lake basin of the Ejina river system. Local palaeoecology is distinct but similar to the Gobi-Altai: a semi-

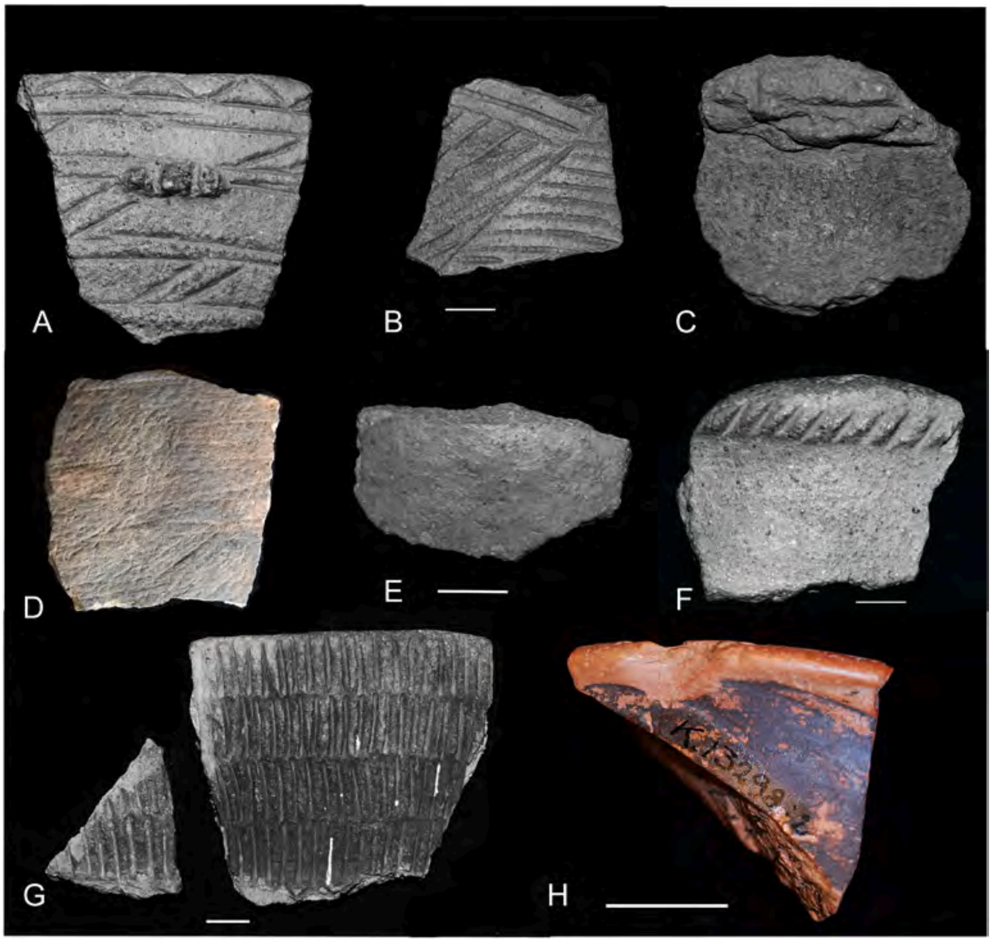

Fig. 2. Oasis 3 pottery types from Shabarakh-usu/Bayanzak (73/ …) and Mantissar 12 (K.13298): A) geometric-incised (73/605); B) geometric punctate (73/605); C) raised moulded band (73/658); D) string-paddled with dairy residues (73/1194A, MON006, 1614–1439 BC [AA89878]); E) burnished (K.13298:25, 2710–1310 BC [UW-2359]); F) pie-crust rim (73/1169); G) channelled (73/1195 and 73/1196); H) painted fine redware (K.13298:2). Dates reported in Janz et al., (2015).

desert region characterized by dune-fields, dissected badlands, and gravel plains. Dune-fields are more extensive here than in the East Gobi or Gobi-Altai regions.

The Gobi Desert is often thought of as a frontier zone due to the harsh environmental conditions and low population densities; however, archaeological work has shown that population densities in the region peaked during the middle Holocene – from about 6000–1000 BC – when more humid conditions prevailed (Maringer, 1950; Janz et al., 2015, 2017). Based on program of dating and a study of lithic assemblages from across the Gobi Desert, Janz (2012, 2015) suggested the post-glacial period should be divided as follows: Oasis 1 (11,500–6000 BC), traditionally referred to as the Mesolithic, wherein hunter-gatherers first a shift towards the regular use of rivers and low-elevation wetlands; Oasis 2 (6000–3000 BC), traditionally considered to be the Early Neolithic, in which microlithic-using hunter-gatherers focused on the use of wetlands and hunted a diverse range of wild animals; and Oasis 3 (3000–1000 BC), traditionally thought of as the late Neolithic or Eneolithic, in which microlithic-using hunter-gatherers first adopted herd animals and also continued to use wetlands and hunt wild animals. Despite a lack of knowledge about group sizes and length of occupation, the high density of archaeological sites associated with Oasis 2 and Oasis 3 clearly show that population densities exceeded those of preceding or following periods. Statistical analysis of the distribution of Oasis 3 sites across the Gobi Desert suggests that residential sites were smaller on average and slightly more dispersed than Oasis 2 residential sites, but largely similar in distribution and organizational variability (Janz, 2012). This conforms to suggestions among Mongolian and Russian researchers that the late Neolithic or Eneolithic was characterized by increased residential mobility (Derevianko and Dorj, 1992; Cybiktarov, 2002).

Oasis 3 (3000–1000 BC) sites largely correspond with the Bronze Age in East Asia, but it is not clear if these habitation sites were formed by Late Neolithic hunter-gatherers, Eneolithic hunter-gatherer-herders, Bronze Age pastoralists, or some combination of different groups over time (Janz et al., 2017). It is difficult to distinguish between Oasis 2 and Oasis 3 sites as they have similar land-use patterns and similar lithic and ceramic technology, but Oasis 3 sites do have a number of distinguishing characteristics. These include the increased use of bifacially flaked projectile points on expedient flakes, greater emphasis on chalcedony relative to jasper and other cherts, and the presence of slag or bronze scraps, fully polished stone axes, and the use of coarsely tempered, high-fired redware, as well as other types of pottery with incised geometric designs, string-paddling, and moulding below or on the rims (Fig. 2) (Maringer, 1950; Janz, 2012, Janz et al., 2015, 2017; Wright et al., 2019). Many Oasis 3 sites are found in proximity to Late Bronze and Early Iron Age burial groups. For example, records from the Sino-Swedish expeditions in Inner Mongolia indicate burial architecture at Bulung khuduk (Dzun gung) (Fig. 3), just east of the Yellow River, that is comparable to Chemurchek-type burials (2500–1800 BC) described by Kovalev and Erdenebaatar (2009). There is a high level of continuity between Oasis 2 and Oasis 3 habitation sites, but major cultural changes during the second millennium BC are evident in the emergence of distinct burial cultures. Remains of domesticated herd animals are common in Bronze Age burials and ritual sites and new evidence shows

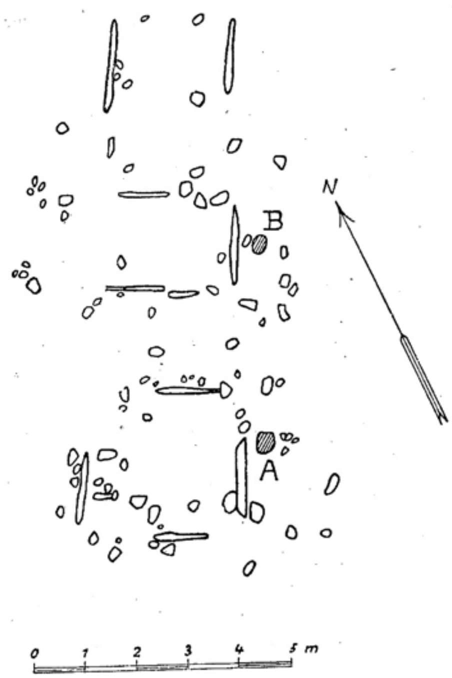

Fig. 3. Unexcavated burials at Bulung khuduk. A and B reported as "baba-stones." After Maringer 1950.

that dairying was interconnected with the spread of pastoralism (Jeong et al., 2018; Wilkin et al., 2020); however, there remains a paucity of dates for this transition in southernmost reaches of the Gobi Desert. As such, it is not currently known whether local groups were primarily hunter-gatherers or herders, or whether both groups were present during Oasis 3. We use organic residue analysis of pottery from Oasis 2 and Oasis 3 to determine when pastoralism was locally established.

Regardless of prevailing economic and cultural identities, there is some evidence that these groups were increasingly engaged in social interactions over long distances. These include both rare finds such as cowries and stone beads, and more common finds such as bronze slag and fine high-fired pottery. Janz (2012) has noted an increase in beadmaking during Oasis 3, though too few sites have been studied and/or solidly dated to quantify this trend. Bead-making involved a variety of raw materials such as ostrich eggshell, bone, and stone. Beads made of hard stone like carnelian and chert were an important trade item across East Asia during the Bronze and Iron ages, but required much more advanced techniques of manufacture than those made on shell and softer stone (Kenoyer et al., 1991; Domanski and Webb, 2007). Carnelian and other hard stone beads, as well as bone, shell and soft stone beads, are found in Bronze Age burials across the Gobi Desert, one of the best examples of which is the collection from Javkhlant, EX-08 (Fig. 4) (Amartuvshin et al., 2016).

Archaeologists working in China have primarily focused on the importance of carnelian beads during the Western Zhou Period (ca. 1045–771 BC), when the beads became an integral part of Zhou mortuary traditions (Rawson, 2013; Hommel and Sax, 2014). Based on the recovery of long concave biconical (see Hommel and Sax, 2014: 1215) carnelian beads from Western Zhou tombs, researchers (Rawson, 2010) have tied these later beads to the Indus Valley. Significantly less focus has been given to the appearance of carnelian beads at early Bronze Age sites in northwest China. Rawson (2013) suggested that the initial appearance of carnelian beads may be the product of local invention, but noted that the most plausible explanation centers on the exchange of carnelian beads from Central Asia or Siberia. However, this interpretation excludes data from Oasis 3 contexts in the Gobi Desert and leaves out the possibility that carnelian beads and/or raw material for

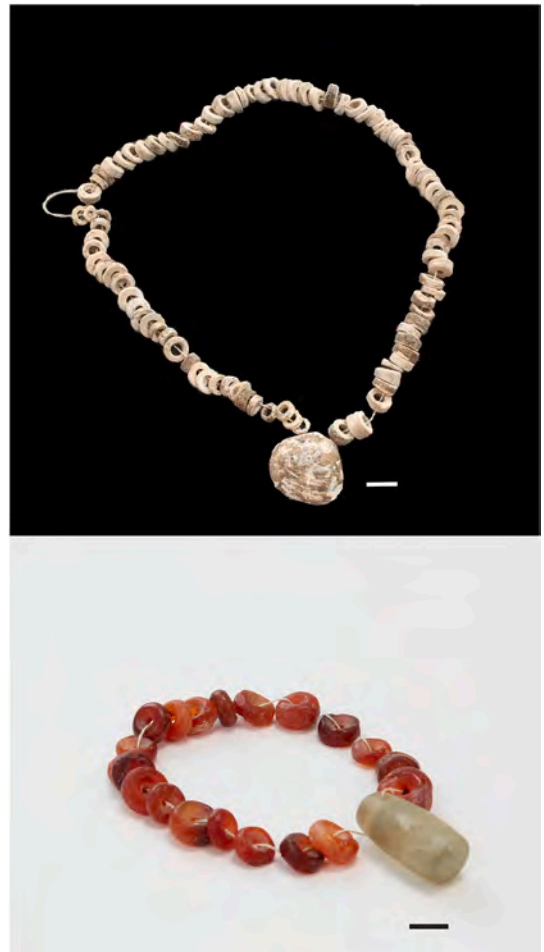

Fig. 4. Two necklaces from shaped burial, Javklant, EX-08: stone beads with shell pendant and carnelian beads with greenstone pendant. Photos by D. Bukhchuluun.

bead production entered into northwest China through interaction with groups in the Gobi Desert. Our study employs usewear analysis of grooved stone slabs to determine whether stone beads were made locally.

3. Materials and methods

The majority of materials considered in this study are derived from existing museum collections made during early 20th century scientific expeditions and housed at the American Museum of Natural History (AMNH) (New York, USA), and the Östasiatiska museet or Museum of Far Eastern Antiquities (MFEA) (Stockholm, Sweden). Janz worked with these collections on-site in 2004 (AMNH), 2008 (MFEA), 2009 (AMNH), and 2020 (MFEA). Analysis included extensive photography, categorization and itemization of diagnostic artifacts, recording of surface decoration, thickness and temper types for potsherds, and measurements of stone nuclei, scrapers, bifaces, and blade flakes. Details from over 100 sites were recorded between 2004 and 2009. Data are reported in Janz 2006, 2012. Observations of an additional 20 sites were made in February 2020 and artifact characteristics recorded through photography and qualitative notation. Study loans were made to Janz by the MFEA for analysis of pottery and ostrich eggshell in 2007 and by the AMNH for analysis of pottery and ostrich eggshell in 2010 (Janz et al., 2009, 2015) and use-wear analysis in 2017 (Evoy, 2019). Direct dates on artifacts are reported and discussed in Janz et al., 2015. These collections were selected for their expansive geographic range, covering the entire east to west range of the Gobi Desert, including both Inner Mongolia and Mongolia proper. High-fired redware from Zaraa uul, Tuvshinshiree *soum*, and Salaa bulag, Dariganga *soum* in Sükhbaatar aimag, eastern Mongolia, were recovered by the Gobi-Steppe Neolithic Project during 2017 excavations.

3.1. Use-wear analysis

Stone beads were an important imported trade good in China, but are also found in Gobi Desert habitation and burial contexts. Nelson (1925) first interpreted grooved stone slabs from Shabarakh-usu (*Bayanzak*) as arrowshaft straighteners. Specimens recovered from a Ukh-tokhoi cave site in the Alashan Desert by Bergman in 1930 were interpreted as grinding slabs for bead-making based on the presence of an undrilled bead preform and chalcedony debitage (Maringer, 1952). Evidence for the presence of specialized tools for making stone beads would show that stone beads were not simply imported, but were also being made locally.

Dubreuil and Janz selected 73/713 from Shabarakh-usu, Site 1A for use-wear analysis as part of an institutional loan from the AMNH to Trent University in 2017. The specimen was selected because it was the most complete specimen and recovered from a sealed depositional context: it was excavated from beneath about 13 cm of ash topped with 5 cm of clay. It was found lying face down among various other artifacts, including burnt and unburnt lithic tool manufacturing debris, cores, and microblade flakes. The artifact was made on a slab of petrified wood and measures 8.9 x 6.8 × 2.1 cm. There are three main parallel linear features on one of its flat surfaces: 1) a U-shaped groove with a straight longitudinal profile; 2) a straight striation; and 3) on one edge, a U-shaped groove similar to the first one but cut in its middle along the length (Fig. 5). Analysis followed well-established protocol (Dubreuil et al., 2015) encompassing low and high magnifications observations and comparison between various areas, here: the two flat surfaces, the grooves and striations as well as the edges of the slab. Comparison between areas has several goals, mainly: the analysis of broken surfaces is used to assess the presence and type of post-depositional wear; comparison between the edge, both faces, striation and groove allow investigating and describing use-wear related to the manufacturing process and isolating those associated to use.

Our method of analyzing use-wear features is based on the combination of various scales of observations from naked eyes to microscopic; this multiple-scale approach is regarded as essential in ground stone tool studies (Dubreuil et al., 2015). For the low and high magnification observations, we used a Nikon SMZ 1000 stereomicroscope with 8–80 × magnifications range and a Nikon eclipse LV- 150 compound metallographic microscope with long distance objectives offering magnification from 50 × to 500 × . The metallographic microscope is equipped with DIC. Photographic documentation was acquired with a DSLR Canon EOS T2i camera and we also used Helicon Focus staking program. Observations were made directly on the object.

The framework used for observation and analysis at low magnifications is presented by Adams et al., (2009); investigation at high magnifications follow the system established by Dubreuil et al., (2015). Comparative reference collections available for grooved stones have been recently expanding (see Savage, 2014), however no experiments have been done using petrified wood. The raw material of the tool is an important parameter impacting use-wear formation and morphology and we were not able to obtain comparable samples for experimental work. Nevertheless, research in tribology (the science and engineering of interacting surfaces in relative motion) allows establishing association between certain use-wear types and their mechanism of formation. This has been adapted to ground stone tool studies and specific use-wear features are used to distinguish between abrasive and additive process and for assessing some of the properties of the worked material (see Adams et al., 2009). Observations made on abraders and grooved stones of various raw materials as well as data from research on chert micro-polish (see for instance Keeley, 1980; Plisson, 1985; Astruc, 2002; Dubreuil, 2004; Dubreuil et al., 2015 and Savage, 2014) is used as a reference for interpreting use-wear characteristics and especially for distinguishing wood versus stone/shell type of contact.

3.2. Organic residue analysis

The goal was to examine changes in diet over time and space. Samples were included from both eastern and western sites and from all three post-glacial periods (Oasis 1, 2, and 3). Diagnostic and plain sherds were selected. Typologically unique specimens were avoided. Rim sherds (73/2232A, 73/2232B, 73/2476A) were selected when possible, and we prioritized body sherds with evidence of carbonized remains on the interior surface. All but three of the potsherds chosen had been previously dated (Janz et al., 2015).

Lipid analysis and interpretations were performed using established protocols described in detail in earlier publications (Correa-Ascencio and Evershed, 2014). For each sample, ~2 g of potsherd were sampled and surfaces cleaned with a modelling drill to remove exogenous lipids. The samples then underwent an acid/methanol (H_2SO_4/MeOH) extraction and were then dissolved in *n*-hexane for analysis by gas chromatography (GC) fitted with a high temperature non-polar column (DB1-HT; 100% dimethylpolysiloxane, 15 m x 0·32 mm i. d., 0.1 µm film thickness). The carrier gas was helium and the temperature

Fig. 5. Grooved stone from Shabarakh-usu 1A (AMNH, 73/713), Bayanzak, Mongolia. The three main linear features on one of the flat surfaces are indicated. Used with permission from the AMNH.

programme comprised a 50 °C isothermal followed by an increase to 350° at a rate of 10° min^{-1} followed by a 10 min isothermal. A procedural blank (no sample) was prepared and analysed alongside every batch of samples. Further compound identification was accomplished using gas chromatography-mass spectrometry (GC-MS). FAMEs were then introduced by autosampler onto a GC-MS fitted with a non-polar column (100% dimethyl polysiloxane stationary phase; 60 m × 0.25 mm i. d., 0·1 μm film thickness). The instrument was a ThermoFinnigan single quadrupole TraceMS run in EI mode (electron energy 70 eV, scan time of 0·6 s). Samples were run in full scan mode (m/z 50–650) and the temperature programme comprised an isothermal hold at 50° for 2 min, ramping to 300° at 10° min^{-1}, followed by an isothermal hold at 300° (15 min). Data acquisition and processing were carried out using the HP Chemstation software (Rev.C.01.07 (27), Agilent Technologies and Xcalibur software (version 3.0). Peaks were identified on the basis of their mass spectra and GC retention times, by comparison with the NIST mass spectral library (version 2.0).

Carbon isotope analysis by GC-C-IRMS were carried out using a GC Agilent Technologies 7890A coupled to an Isoprime 100 (EI, 70eV, 3 F cup collectors m/z 44, 45 and 46) via an IsoprimeGC5 combustion interface with a CuO and silver wool reactor maintained at 850 °C. Instrument accuracy was determined using an external FAME standard mixture (C11, C13, C16, C22 and C23) of known isotopic composition. Samples were run in duplicate and an average taken. The δ13C values are the ratios 13C/12C and expressed relative to the Vienna Pee Dee Belemnite, calibrated against a CO2 reference gas of known isotopic composition. Instrument error was ± 0.30/00. Data processing was carried out using Ion Vantage software (version 1.6.1.0, IsoPrime).

4. Location and accession of archaeological materials

All site collections and artifacts housed at the AMNH are identified by "73/ …" and those from the MFEA by "K.13 …". General collections analysis was carried out at the curating institutions in New York, USA and Stockholm, Sweden, respectively. Use-wear analysis was carried out in Dubreuil's laboratory during the course of a study loan from the AMNH to Trent University. Residue analysis was carried out at the University of Bristol under study loans to Janz from the AMNH. All artifacts described herein have been returned and are currently housed at their respective curating institutions. Collections made by the Gobi-Steppe Neolithic Project ("ZU …," "SB …") are housed in Ulaanbaatar and managed by D. Odsuren under the auspices of the Institute of Archaeology, Mongolian Academy of Sciences.

5. Results

5.1. Use-wear analysis

Overall, the variability and distribution of use-wear features, along with the fragmentation patterns, suggest a complex life history for 73/713. However, the use-wear within both grooves is noticeably dominated by a flat/striated type of micro-polish, diagnostic of a contact with a hard and abrasive matter according to a back-and-forth motion (Fig. 6). These observations provide support to the hypothesis that the grooves mainly functioned as an abrader for hard material such as stone or shell rather than for straightening arrowshafts as previously suggested (Fairservis, 1993; Nelson, 1925). The activity performed with this tool might have involved the processing of bead preforms arranged in a string or a wooden vise and moved back-forth along the groove to further shape them (for ethnographic observation of such process see for instance Kenoyer et al., 1991). Janz was given permission by Världskultur museerna to make casts of grooved slabs and beads from the MFEA collections during her visit in 2020 and future research will use these casts along with additional experiments to improve our understanding of bead manufacturing processes.

5.2. Organic residue analysis

Lipid analysis and interpretations were performed using established protocols described in detail in earlier publications (e.g. Dudd and Evershed, 1998; Correa-Ascencio and Evershed, 2014). To date, analysis of the total lipid extracts (TLEs, n = 11) from Mongolia, using GC and GC-MS, all contained sufficient concentrations (> 5 μg g-1) of lipids that can be reliably interpreted (Evershed, 2008). However, the majority of these lipid profiles contained distributions typical of petroleum contamination (Fig. 7, MON010), and these were not taken forward for further analysis. The remainder comprised lipid profiles which demonstrated that the free fatty acids, palmitic (C16) and stearic (C18), typical of a degraded animal fat (Fig. 8, MON006), are the most abundant components (e.g. Evershed et al., 1997a; Berstan et al. 2008). The mean lipid concentration from the sherds (Table 1) was 0.57 mg g-1, with a maximum lipid concentration of 3.0 mg g-1.

GC-C-IRMS analyses were carried out on four vessel samples (Table 1) to determine the δ13C values of the major fatty acids, C16:0 and C18:0, and ascertain the source of the lipids extracted, through the use of the Δ13C proxy. Ruminant dairy fats are differentiated from ruminant adipose fats when they display Δ13C values of less than −3.1‰, known as the universal proxy (Dunne et al., 2012; Salque, 2012). Sample MON006 (Shabarakh-usu Site 10, 73/1194A) plots in the ruminant dairy region (Fig. 9), confirming this vessel was used to process dairy products, such as milk, butter and/or cheese. Vessels MON001 (Chilian Hotoga Well [Site 35], 73/2797A), MON002 (Baron Shabaka Well [Site 19], 73/2231A) and MON004 (Shabarakh-usu Site 10, 73/1194A) (Fig. 2D) were used to process ruminant adipose products. Samples MON001 and MON002 date to Oasis 2, while samples MON004 and MON006 date to Oasis 3.

6. Discussion

6.1. The spread of domesticated herd animals in East Asia

The presence of domesticated herd animals, primarily caprines (sheep or goats) and cattle in the early stages, is an important as their presence in East Asia is closely tied to the emergence of bronze-using groups on the region's western frontier. One of the major challenges in identifying the spread of domesticates in Central and East Asia is distinguishing domestic species from wild caprines and bovines hunted during the preceding millennia by local hunter-gatherers. Body size is not a reliable determinate of domestication because there is currently very little understanding of the actual range of past variation in body size among either wild or domesticated species in eastern Eurasia. Brunson et al.'s (2016) DNA analysis of cattle scapula used in Late Neolithic oracle bone divination at Taosi and Zhoujiazhaung in central northern China moreover show that inhabitants were using bones of both East Asian wild (*Bos primigenius*) and western domesticated (*Bos taurus*) cattle, but that these individuals overlapped in body size. A very similar problem arises with the use of collagen-based molecular fingerprinting (ZooMS), which is not precise enough to distinguish to species, and studies relying on this method for identifying domesticates should be viewed with extreme caution.

What we do know about the spread of domesticated caprines and cattle is that both were domesticated first in SW Asia over the millennia spanning the terminal Pleistocene and early Holocene (Vigne et al., 2011; Zeder, 2011). The first evidence for milking comes from Anatolia at around 6000 BC in the form of lipid residues typical of cattle milk on potsherds (Evershed et al., 2008). Both caprines and cattle dispersed

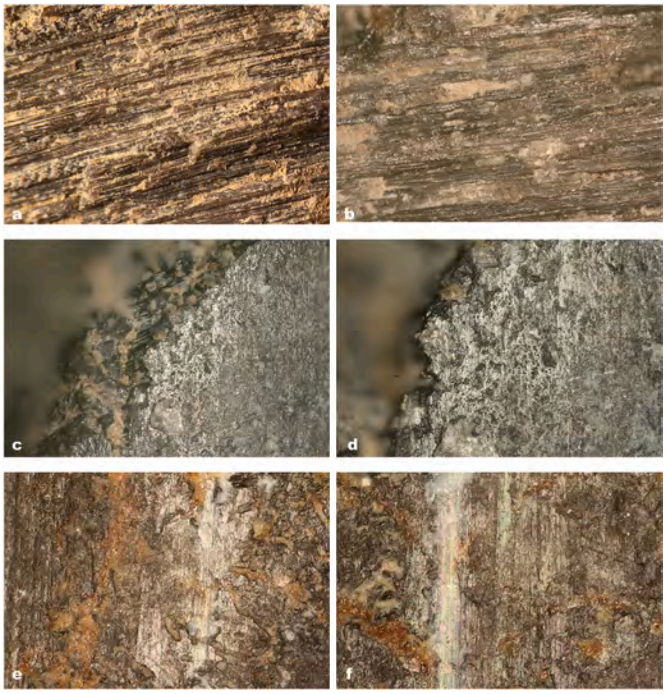

Fig. 6. High magnification observations on the grooved stone 73/713; a–b: on a fracture plan, showing linear arrangement of the petrified wood and no development of micro-polish a × 50 and b × 100; c–d: on the broken groove, leveling of the surface and flat micro-polish associated with fine parallel striations c × 50 and d × 100; e–f: on the most preserved U shaped groove, leveling of the surface and flat micro-polish associated with fine parallel striations e × 50 and f × 100.

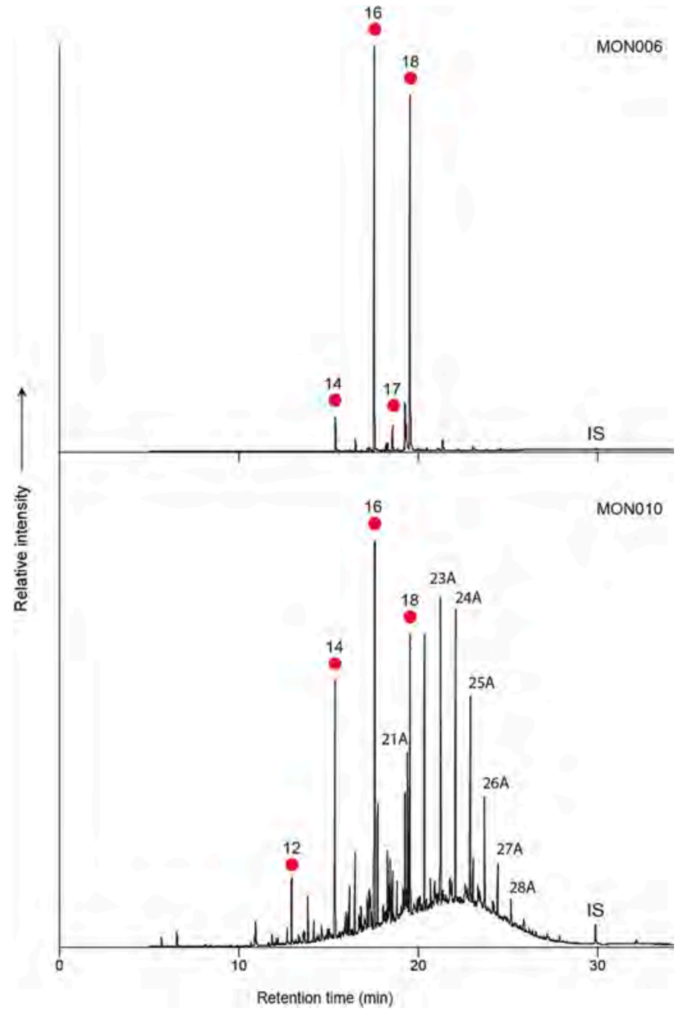

Fig. 7. Gas chromatograms of trimethylsilylated FAMEs from pottery extract MON006 and MON010, circles, *n*-alkanoic acids (fatty acids, FA); A denotes *n*-alkanes; IS, internal standard, C34 *n*-tetratriacontane.

across West Asia and then into Europe along with the migration of farming communities (Conolly et al., 2011; Özdoğan, 2011; Rowley-Conway, 2011; Manning et al., 2013; Ethier et al., 2017). The use of herd animals in farming and hunter-gatherer societies in eastern Europe continued through the fifth and fourth millennia BC, with the use of domesticated animals becoming increasingly specialized during the 4th and 3rd millennia BC (Dolukhanov 2002; Rassamakin, 2002; Koryakova and Epimakhov, 2007; Kotova, 2003; Frachetti, 2012). Domesticated herd animals were widely spread across Central Asia by the end of the fourth millennium BC including at sites across Pakistan, India, Tajikistan, and Kazakhstan (Meadow, 1996; Meadow and Patel, 2003; Young, 2003; Razzokov, 2008).

Highly mobile Yamnaya pastoralists were emerging around the same time in the steppes of Eastern Europe while Afanasievo groups were present throughout the mountains of Siberia, eastern Kazakhstan, and western Mongolia by the middle to late fourth millennium BC (Kislenko and Tatarintseva, 1999; Kovalev and Erdenebaatar, 2009; Polyakov and Svyatko, 2009; Svyatko et al., 2009; Honeychurch, 2015). Evidence for domesticated sheep and goat, foddered on cultivated millet, is present in southeastern Kazakhstan by 2700 BC (Hermes et al. 2019).

Despite the arrival of pastoralist groups in East Asia during the mid-fourth millennium BC, distribution in Mongolia appears to have been restricted to isolated groups in the Altai and Khangai mountains (Taylor et al., 2019; Wilkin et al., 2020). The spread of pastoralists into the Upper Yenisei of Siberia occurred around 2500–1700 BC with the Okunevo, while the early second millennium marks the southern and westward expansion of pastoralist cultural traditions associated with the Andronovo and Chermurchek (Qiemu'erqieke) (Jia and Betts, 2010; Taylor et al., 2019). The latter appears to correspond with demographic expansion of the Sintasha eastwards from the Urals (Allentoft et al., 2015; Jeong et al., 2018). It is not until the mid-second millennium BC that stone ritual and burial monuments associated with Eurasian pastoralist traditions are widespread across Mongolia in the form of burial types such as Ulaanzuukh, Tevsh, figure-shaped graves, and *khirigsuurs*, or large stone mounds with associated stone features (Wright, 2007; Tumen et al., 2014; Honeychurch, 2015; Wright et al., 2019; Taylor et al., 2019).

Continuity in pottery manufacturing styles, patterns of land-use, and lithic reduction strategies across the Gobi Desert during Oasis 2 and Oasis 3 suggest that when pastoralism did spread more widely the shift was related to cultural transformation among indigenous groups (Janz et al., 2017: 60–63). This hypothesis is supported by cranial and dental nonmetric, cranio-morphometric, and DNA analysis which all show the dominance of indigenous traits in later pastoralist populations and a relative lack of gene flow between groups prior to the Late Bronze Age (Erdene, 2013; Lee, 2013; Tumen, 2013; Allentoft et al., 2015; de Barros Damgaard et al., 2018; Jeong et al., 2018). Janz believes that the unique face-down burial posture of individuals from Late Bronze Age burials underscore the probability of cultural diffusion: that burial practice was being adopted by a group more familiar with exposure after death and that the prone position, and a stone over the head and

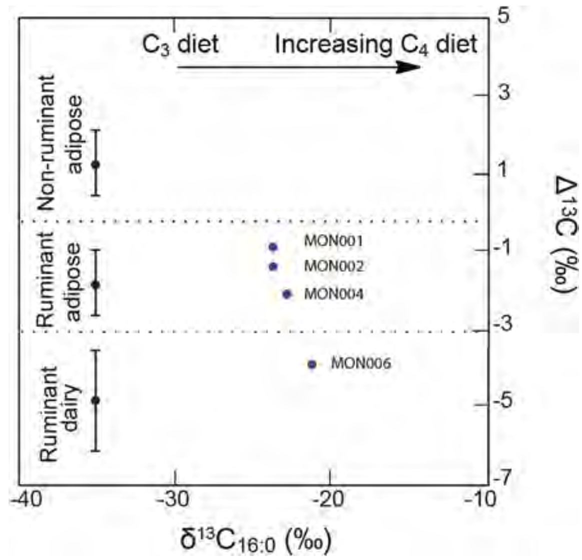

Fig. 8. Graph showing the Δ13C (δ13C18:0 – δ13C16:0) values from the Mongolian potsherds. The ranges shown here represent the mean ± 1 s.d. of the Δ13C values for a global database comprising modern reference animal fats from Africa (Dunne et al., 2012), UK (animals raised on a pure C3 diet) (Dudd and Evershed, 1998), Kazakhstan (Outram et al., 2009), Switzerland (Spangenberg et al., 2006) and the Near East (Gregg et al., 2009).

feet, was designed to stop the deceased rising from the grave in rigamortise. Regardless, eastward expansion appears to have been largely delayed until the mid-second millennium BC when Shaped, Ulaanzuukh, and Tevsh burials appear across the Gobi Desert and other parts of Mongolia (Tumen et al., 2014; Taylor et al., 2019; Wilkin et al., 2020).

These monuments frequently contain domesticated herd animals and the widespread presence of milk proteins in human dental calculus (Wilkin et al., 2020) from this period confirms extensive uptake of both primary and secondary products to be a component of this cultural transformation. Overlap between the spread of pastoralism across East Asia and the terminal phase of Neolithic-type archaeological sites, most notably Oasis 3 in the Gobi Desert, raises important questions about whether pastoralism was ubiquitous in arid steppe regions during this time. Evidence of dairying from organic residues on a potsherd from Shabarakh-usu 10 represents the earliest evidence (1614–1439 BC at 2 δ [3246 ± 39 BP]) of dairying in Mongolia beyond the mountain regions, proving that pastoralism was moving across the Gobi Desert by the mid-second millennium BC.

Genomic analysis of caprines and cattle from Chinese sites dating between 2500–1500 BC suggest that western domesticated species were adopted in China at some point between the end of the third millennium or the beginning of the second millennium BC (Cai et al., 2011, 2014). Recent research by Tricia Owlett (2016) shows that caprines and cattle were occasionally exploited in the Ordos region of China during the middle Neolithic, but that there was a dramatic shift towards the specialized use of sheep and goats during the late Neolithic (beginning of second millennium BC). Her data shows that the use of dogs and pigs remained stable, but caprines, and to some extent cattle, replaced wild species such as deer (Owlett, 2016: Table 1). Since it is unlikely that sedentary communities would shift from the exploitation of a resilient prey species like deer towards the intensive exploitation of naturally more reticent wild caprines, the pattern that Owlett sees in Late Neolithic China is convincing evidence for the adoption of domesticated caprines, even more so because it corresponds to other region-wide societal changes. We can say with some certainty that caprines became economically more important than wild game around 2000 BC in the Ordos region. Lu et al., 's 2017 summary of Chinese archaeological sites with cattle likewise indicate that the earliest irrefutable evidence of western domesticated cattle (*Bos taurus*) comes from sites dated at 2000–1600 BC. Extensive smaller-bodied cattle remains were found at many Chinese sites dating at 2500–2000 BC. Several sites dating at 3600–2500 BC, primarily in the western province of Gansu, also contained remains of smaller cattle, but as noted above a reliance on body size as a determinant must be considered with extreme caution. It seems likely that domesticated herd animals were adopted in parts of northwestern China between 2500–2000 BC, predating the wider spread of herding across East Asia several hundred years later. More dates for dairying in the Gobi Desert, alongside fine-grained genomic studies of early domesticated herd animals across East Asia, are required to gauge whether adoption of herd animals derived from interaction with agrarian and/or pastoralist groups.

6.2. *Origins of Bronze Age in China*

Jaang (2015) has argued that the epicenter of change during the Bronze Age in mainland China was a region covering the modern provinces of Gansu, Qinghai, Ningxia and western Inner Mongolia. She refers to this area as the Ejin River Transfer Zone (ERTZ), named for the Ejin Gol (also know as Etsin gol, Edsengol, Eznee gol, Ruoshui/Heihe). This river system has both north and south flowing branches that originate south of the modern city of Zhangye and end in Juyan nur (Juyanze Basin), once a large lake in the Alashan Gobi Desert of Inner Mongolia. Use of these two branches of the Ejin Gol could have

Table 1
Sample number, sherd number, lipid concentrations (μg g^{-1}), total lipid concentration in extract (μg), $\delta^{13}C$ and $\Delta^{13}C$ values and attributions of residues. All chronometric dates reported in Janz et al., (2015).

Laboratory number	Sherd Number	Calibrated BC	Lipid concentration (ugg-1)	Total lipid in extract (ug)	$\delta^{13}C_{16:0}$	$\delta^{13}C_{18:0}$	$\Delta^{13}C$	Attribution
MON001	73/2797A	5720–5561	404.1	990.1	−23.7	−24.5	−0.9	Ruminant adipose
MON002	73/2231A	4964–4716	137.1	203.1	−23.7	−25.1	−1.4	Ruminant adipose
MON004	73/1189B	2122–1780	2363.1	2646.7	−22.8	−25.0	−2.1	Ruminant adipose
MON005	73/2476A		213.8	269.4	–	–	–	–
MON006	73/1194A	1614–1439	3061.0	3428.3	−21.2	−25.1	−3.9	Dairy fat
MON007	73/466B	7733–7549	331.1	420.5	–	–	–	–
MON008	73/2232B		1434.1	1921.7	–	–	–	–
MON009	73/2232A		463.8	640.1	–	–	–	–
MON010	73/1609E	3986–3714	1958.9	2252.7	–	–	–	–

Fig. 9. Fine redware excavated from Level 1 of Salaa bulag 1B, Dariganga *soum*, Sükhbaatar *aimag*, Mongolia.

facilitated easy north-south transfer of goods between agricultural groups in the south and pastoralists in the north. There is some limited evidence of wheat, caprines, cattle, and copper and bronze artifacts by the beginning of the third millennium BC at sites like Shizhaocun (sheep/goats - 3000–2650 BC, cattle - 2200–1600 BC), Hetaozhuang (sheep/goats - 3200–2600 BC), Fujiamen (cattle - 3200–2600 BC), Xishanping (wheat - 2700–2400 BC, cattle - 3200–2000 BC), Donghuishan (wheat - 3368–1980 BC, sheep/goats - 2000–1500 BC), Linjia (bronze - 2900–2750 BC), Huangniangniangtai (bronze - 2200–1600 BC) and Buziping (wheat - 2900–2700 BC) (see Tables 1–3 in Jaang, 2015), but it is difficult to assess the reliability of many of these early dates, most of which have large error ranges or are derived from indirect dates assigned through site typologies. Domesticated animals, along with bronze artifacts, are much more common after 2000 BC, becoming widespread by 1500 BC. Jaang points out that these occurrences are earliest in Ejin Gol sites, predating both those from sites farther east, as well as sites in the western Hexi corridor and Xinjiang which are commonly thought of as the primary route from Central Asia into China.

The earliest metallurgical production sites are of primary importance according to Jaang's theory of interaction. Earliest production of bronze in China began around 2200 BC and was found on the western bank of Ejin gol at Huoshiliang and Ganggangwa. The nearby Baishantang copper mine was the source of ore for local production (Mei et al., 2012; Dodson et al., 2009). From 2150 BC evidence of mirror and mace-head moulds shows that bronze artifacts were being produced farther south along the Ejin River at Xichengyi (Heishuiguo) (Chen et al., 2015). Jaang (2015: 195–197) argues that the strong cultural continuity in habitation and burial structure, along with the highly advanced level of metallurgical production proves that the technology was adopted from knowledgeable specialists outside the community. Likewise, she hypothesizes that most of the bronze products were produced entirely for trade, as the only finished copper or bronze tools at the site were mundane artifacts such as awls and knives, and that metal objects were not recovered from burials. This hypothesis is supported by a contemporaneous increase in the number of high-value exotic goods at Xichengyi, including pearls, cowrie shells, graphite, turquoise, and carnelian beads (Wang and Chen, 2012), as well as wheat and domesticated herd animals (Jaang, 2015). Jaang suggests that these trade networks were first established with the long-distance exchange of high-fired painted pottery during the early stages of the Majiayao periods (3000–2000 BC). Evidence of this is scanty, but the presence of fine redware across the Gobi Desert (see below) lends support to Jaang's theory.

The location of production sites on the Ejin gol means that inhabitants had a direct route of access to Gobi Desert groups living around the Juyanze basin, around Sogho and Gashun nur. Archaeological collections made around the shores of these lakes are particularly dense and contain grooved slabs, polished axes, and fragments of bronze (Maringer, 1950: 139–148). The main question is: what were people in the Gobi Desert doing at this time and is there evidence that they played an important role in these early trade networks as Jaang (2015) suggests. Dates on the microlithic habitation sites characteristic of mobile hunter-gatherers show that these sites were occupied and used in similar ways from the beginning of the seventh millennium BC until at least the end of the second millennium BC (Janz et al., 2015, 2017), suggesting the persistence of hunting and gathering from 6000 to 1000 BC. Despite Jaang's hypothesis, that agricultural

Table 2
Gobi Desert sites dated 3000–1500 BC. Dates reported in Janz et al., (2015).

Site name	Id #	Method	Reported date (BP or a)	Calibrated BC (95.4%)	Location	Associated evidence
Jabochin-khure (K.13203)	K.13203:5	L	3590 + 310	2200–960	Alashan Gobi	
Gashun (K.13207)	K.13207:1	AMS	3385 + 40	1866–1545	Alashan Gobi	
Yingen-khuduk (K.13212)	K.13212:6	L	4030 + 310	2640–1400	Alashan Gobi	Pottery: fine redware, geometric incised
	K.13212:128		4030 + 230	2480–1560		
Mantissar 12 (K.13298)	K.13298:25	L	4020 + 350	2710–1310	Ejin gol	Pottery: fine painted redware, burnished
Bayanzak (Shabarakh-usu 1)	73/655A	AMS	4308 + 40	3023–2879	Ömnögovi	Grooved slab
Bayanzak (Shabarakh-usu 10)	73/1189A-1	AMS	3595 + 41	2122–1780	Ömnögovi	Dairy residue (1194A)
	73/1189A-2	L	3490 + 220	1920–1040		Pottery: geometric incised, raised moulded bands, channelled, string paddled, stamped
	73/1194A	AMS	3246 + 39	1614–1439		
Jira Galuntu (Site 18)	73/2476	AMS	3260 + 25	1634–1466	East Inner Mongolia	Polished axe Pottery: geometric incised

groups in China were engaged in long distance trade with pastoralists in the Gobi Desert as early as the middle of the third millennium BC, we have yet to distinguish clear evidence for pastoralism in the region until the middle of the second millennium BC when we have found the earliest evidence for dairying, largely contemporaneous with the emergence of Bronze Age mortuary patterns.

6.3. Evidence of long-distance trade in the Gobi Desert

The biggest challenge in identifying possible evidence for early long-distance trade has been the lack of dated sites in the Gobi Desert. Direct dating of pottery using radiocarbon and luminescence dating identified seven Gobi Desert sites with components directly dated to between 3000 and 1500 BC (Table 2) (Janz et al., 2015). Many of these sites were intermingled or adjacent to Neolithic-period assemblages. For example, both the Yingen-khuduk and Bayanzak/Shabarakh-usu sites were used throughout the end of Oasis 2 into Oasis 3 (see Janz et al., 2015). Gobi Desert sites studied and assigned to Oasis 3 are summarized in Table 3. Additional qualitative observations of site assemblages east of the Alashan Gobi, carried out by Janz in 2020 at the MFEA, suggest that Oasis 3 sites were densely concentrated from west to east across the southern Gobi Desert. Key diagnostic traits linking eastern sites to Oasis 3 include a high prevalence of coarsely tempered high-fired redware characteristic of Oasis 3 and frequently associated with Ulaanzuukh-type burials (Wright et al., 2019) (some of these sherds were coated with a red slip, and occasionally painted with black designs), bifacial points, polished axes, and the presence of bronze scraps. Sketches and photographs from the expedition likewise show the presence of Bronze Age stone monuments in the vicinity of many such sites (Maringer, 1950). Radiocarbon and luminescence dates on pottery from these sites (Table 2) mostly date to the first half of the second millennium BC, and therefore 1) appear to pre-date the more widespread expansion of pastoralist cultural traditions across East Asia, 2) be contemporaneous with the spread of pastoralism into Xinjiang.

One of the most notable characteristics of many Alashan Gobi sites is the presence of very high-fired red sherds with homogeneous paste, sometimes with designs painted in black on the exterior surface (Fig. 2H). Such redware is most abundant along the eastern edge of the Gurnai Depression (flanked in the west by Ejin gol) where painted pottery is common at sites such as Ukh-tokhoi-sume and Mantissar (Maringer, 1950: 151–163). This region is notable because it is about 100 km due east of early bronze production sites Huoshiliang and Ganggangwa. It is also notable because the microlithic assemblages contained evidence for the intensive manufacture of ostrich eggshell beads and the presence of copper or bronze slag, petrified wood and other fossils, and even a small scrap of turquoise. Although no painted pottery can be found in the Bayanzak/Shabarakh-usu collections today, it was reported by Soviet-period archaeologists from this and other Gobi Desert sites (Okladnikov, 1962; Cybiktarov, 2002). Similar high-fired red pottery was excavated in Test 2/3 of Zaraa uul, Tuvshinshiree *soum*, and from Level 1 at Salaa bulag 1B, Dariganga *soum*, in Sükhbaatar province (Fig. 9; Odsuren et al., 2018). Bone collagen from Level 2 of Salaa bulag 1B dates at 4547–4374 BC at 2 δ (5650 ± 30 BP). One sherd of fine redware from Yingen-khuduk was dated by luminescence to 4030 ± 310 ka or 2640–1400 BC (2 δ). Despite the large error range, the dates align well with the Majiayao period. The distribution of this pottery type far across the Gobi Desert supports Jaang's suggestion that Majiayao peoples were engaged in long-distance trade with northern neighbours.

Beads are one potential item produced in the Gobi Desert for trade. Stone beads (including steatite, limestone, pyrophyllite, turquoise, and carnelian) begin to appear in mortuary contexts associated with the Tevsh and Ulaanzuukh burial traditions (Kovalev and Erdenebaatar, 2009; Honeychurch, 2015), a variety of bead types (e.g., carnelian, jasper, ostrich eggshell, see Figs. 10 and 11) have been found in Oasis 3 surface assemblages, and similar beads to those recorded in China have been recovered from several Late Bronze Age mortuary contexts across the Gobi-steppe of Mongolia (Cameron et al. *forthcoming*). Use-wear analysis on specimen 73/713 from Shabarakh-usu 1A strongly suggests that grooved slabs were specialized tools designed for beadmaking by Gobi Desert groups. This specialized tool is not unique and other specimens were recovered from MFEA sites Djusumelin-gol (K. 13068), Lao-hu-ku (K.13143), Yingen-khuduk (K.13212), Ukh-tokhoi Cave (K.13230), Altat (K.13240), and Sogo-nor (K.13255), a large site at the eastern head of the Juyanze basin (Maringer, 1950). Artifacts from a relatively inaccessible high-elevation cave on the Ukh-tokhoi plateau, discovered during the Sino-Swedish expeditions in 1930, were interpreted as being connected to ritualized beadmaking site. Pottery was recovered alongside several quartz grooved slabs and a carnelian bead preform that fits roughly in the grooves (Fig. 11A; Maringer, 1950: 110, Figure 32, Maringer, 1952: Plate XXXVIII). Similar grooved slabs made on quartz were recovered at the nearby site of Altat (Maringer, 1950: 109, Plate XXXVIII).

Working with chalcedony or carnelian requires a different set of skills and knowledge than shell, bone or softer types of stone (Kenoyer et al., 1991; Domanski and Webb, 2007). Raw carnelian for bead making (usually yellow, orange or red chalcedony) is collected in three ways: it is mined from veins, taking from eroding cliffs with exposed carnelian, or often, suitable carnelian nodules are gathered from streams or ground surfaces (Kenoyer, 2003:15). In the Gobi Desert, at localities like Ukh-tokhoi, Bayanzak/Shabarakh-usu and Zaraa uul (Janz et al., 2017: 48–52), chalcedony geodes are a relatively common raw material to encounter on the ground surface. Once suitable material is gathered, the production of carnelian beads begins with air drying and then heating the carnelian in order to make the stone more malleable and to provide a red or deeper red color. The resulting material is then chipped into a blank or a "roughout," close to the desired shape and size for the bead. The carnelian bead preform (K.13230:7) from Ukh-tokhoi was chipped following a standard technique for making microblade cores: with a platform on each end, very narrow microblades were removed bi-directionally from around the perimeter until the core was cylindrical (Fig. 11B). The blanks are then ground down with a grooved grinding stone or pecked before the bead is finally perforated and polished (Kenoyer et al., 1991: 49–55; Francis, 2000). Studies concerning the production of carnelian beads associated with Oasis 3 mortuary contexts have yet to be published, however ongoing research into this topic shows that at least some of the carnelian beads from Bronze Age contexts in Mongolia were produced from local chalcedony geodes (Cameron et al. *forthcoming*).

Carnelian beads have been identified at Bronze Age sites in the ERTZ as well as farther east across Inner Mongolia and Xinjiang. Hommel and Sax (2014: 1218) note four early carnelian bead sites (2750–2150 BC) southeast of Qinghai Lake in Qinghai Province. These sites are referenced without any names or contexts, which makes them difficult to assess. Archaeologists discovered beads at several contexts in the ERTZ: Siba Culture (c. 1900–1500 BC) sites such as Huoshaogou (c. 1900–1700 BC), at Siwa Culture sites (c. 1500–1000 BC), and at Xichengyi (Rawson, 2013:62; Jaang, 2015:194; Han, 2007:105–106). Farther east into Inner Mongolia, excavations produced carnelian beads at the Lower Xiajiadian (c. 2000–1500 BC) site of Dadianzi (Rawson,

Table 3
Gobi Desert sites classified as Oasis 3 (see Janz, 2012 for more details). The first two sites are from the southern Gobi-Altai region (Ömnögov' *aimag*) and were first published in Fairservis (1993). All "K.13-" numbered sites are from the Alashan Gobi and were reported first in Maringer (1950). * denotes sites studied in February 2020 and tentatively assigned to Oasis 3 according to Janz (2012).

Region	Site	Environment	Period	Qualifications
Gobi-Altai	Shabarakh-usu/Bayanzak	Dunefield, basin, wetland/lake	Oasis 1, 2 and 3	Dates, pottery, bifaces, core/scraper types, polished axes, dairy residues, grooved slab
	Baruun davan	Dunefield, basin, wetland/lake	Oasis 2 and 3, Iron Age	Core/scraper types, pottery, polished tool
	Orok nur	Dunefield, plains, lake	Oasis 2 and 3, Iron Age	Pottery, core/scraper types
	Salt Creek	Plains, stream	Oasis 3	Core/scraper types
Alashan Gobi	Hoyar-nor (K.13176, −179, −180)	Dunes, lake	Oasis 3	Pottery, core/scraper types, polished axes, bronze (180): buckle, pendant, pin, plate (vessel or helmet), near Bronze Age burials
	Talin-ghashat (K.13183)	Plains, dunes	Oasis 3	Painted pottery, polished axe, cores
	Jabochin-khure (K.13203)	Plains	Oasis 3	Date, pottery
	Gashun (K.13207)	Basin, well, wetlands/ lake	Oasis 3	Date, pottery
	Yingen-khuduk (K.13212)	Dunefield, lake	Oasis 2 and 3	Date, pottery, grooved slab
	Hoyar-amatu (K.13208)	Dunes, basin, wetlands, well	Oasis 3	Bifaces, macrotools, core types
	Abderungtei (K.13209)	Basin, wetlands	Oasis 3	Biface/pottery types
	Mongol (K.13210)	Basin, wetlands	Oasis 3	Biface/pottery types
	Khara-makhtei (K.13216)	Foothills, spring	Oasis 3	Core/scraper types, bifaces –drills?
	Khara-dzag (K.13218, −222, −223)	Mountains, stream	Oasis 3	Core/scraper types, bifaces, pottery types
	Ukh-tokhoi (K.13230)	Mountains, cave	Oasis 3	Pottery, carnelian bead making
	Altat (K.13240)	Hill plains	Oasis 3	Spindlewhorls, pottery, polished axe, grooved slab
	Sogo-nor (K.13255)	Lakeshore	Oasis 3	Pottery, grooved slab, polished axe, grooved stone, bronze vessel or bowl fragment
	Ukh-tokhoi-sume (K.13277, −280)	Dunefield, wetland/lake	Oasis 3	Slag, pottery, painted pottery, scraper types
	Mantissar (K.13287, −290, −293, −294, −296, −298)	Dunefield, wetland/lake	Oasis 3?	Painted pottery, slag, pottery, core/scraper types, bifaces, drills, polished stone, turquoise
	Pan-t'an-ching (K.13303)	Dunefield, wetland/lake	Oasis 3	Scraper types
	Khorkhoit (K.13307, −311, −316)	Dunefield, wetland/lake	Oasis 3?	Slag, pottery, raw materials, core/scraper types
East Gobi	Ta Sur Heigh (7)	Hillside near river	Oasis 3	Cowrie shell, pottery types
	11/11A	Knoll, dunes, stream	Oasis 3	Bifaces
	Jira Galuntu (18)	Dunefield, wetland/lake	Oasis 2 and 3	Dates, pottery types, polished axes, bifaces
	Urtyn obo (23/23A)	Mesa near river	Oasis 3	Pottery types
	Tsagan nor (28/28A)	Hillside near lake	Oasis 3	Bifaces, stone beads, polished axe, raw materials, core types, near Bronze Age burial
	Paoling Miao (30/30A)	Valley bottom, river	Oasis 3?	Bifaces, core/scraper types
	Beli-miao (Aibaghin-gol) (K.13010, −014)*	Banks of river valley	Oasis 3	Spindlewhorls, pottery, polished axe, bronze arrowhead, bifaces, near Bronze Age burials
	Deldigen-obo (K.13076)*	Plains	Oasis 3?	Pottery, bifaces
	Khongkhor-obo (K.13096)*	Plains near hill	Oasis 2 and 3	Pottery, bifaces, near Bronze Age burials
	Tabun-tologoi (K.13129)*	River bank near mountains	Oasis 3	Pottery, bifaces, polished axes
	Lao-hu-ku (K.13143)*	River valley	Oasis 3	Pottery, bifaces, polished axe, grooved slab, near Bronze Age burials
	Bayanchingei-gol (K.13084)*	River valley	Oasis 3	Pottery, bifaces, drill
	Motto-obone-gol (K.13087)*	River valley	Oasis 2 and 3?	Pottery, raw materials, bifaces
	Ikhen-gung (K.13142)*	Undulating plains, well	Oasis 3	Polished axes, stone bead, bronze button

2010:9; Da Dian Zi 1998:168) and several Xicha Culture sites (c. 1500–1000 BC) sites (Neimenggu wenwu kaogu yanjiusuo and Qingshuihexian Wenwu Guanlisuo, 2008; Cao, 2001; Lu and Sun, 2015; Yang, 2007). Carnelian beads were found at Tianshanbeilu in Xinjiang (c. 1100–100 BC). Technical descriptions of these carnelian beads are not available, but based on images of the beads recovered from Dadianzi (Da Dian Zi, 1998: 168) as well as pictures and drawings of carnelian beads from the Late Shang capital of Yinxu (c. 1250–1046 BC) discovered in the tomb of Fuhao (Hommel and Sax, 2014: 1219; Institute of Archaeology, 1980: 204), many of the carnelian beads from Bronze Age sites in China appear to be pecked short barrel beads (see Hommel and Sax, 2014: 1215; Francis, 1988). We now know that stone beads were manufactured by Gobi Desert groups. Further research, particularly on stone beads from Chinese contexts, is required to determine whether beads made in the Gobi Desert were indeed traded south.

7. Conclusions

Based on the results of our analysis, we have established that Gobi Desert groups were involved in full-fledged dairy-based pastoralism by about 1600 BC. Secondly, we now know that Gobi Desert groups were producing one type of goods (i.e., beads) that were widely traded during the Bronze and Iron ages, and that they were in possession of fine redware of a similar quality to that produced in agricultural villages to the south. A lack of evidence for the spread of pastoralism across Mongolia until around 1600 BC means that we can not clearly connect Gobi Desert groups to pastoral societies until at least 1614–1439 BC when we now have the earliest evidence for dairying beyond the mountainous regions of western Mongolia. Regardless of their economic base, there is ample evidence of relatively high population densities in the southern Gobi Desert throughout the late third and early second millennium BC. Few studies have tried to integrate

Fig. 10. Gobi Desert beads: a) ground jasper beads from Tsagan nor (28/28A), 73/2670; b) ostrich eggshell beads from Mantissar, Gurnai Depression, K.13290:44 and K.13290:43; c) stone bead from Ikhen-gung, K. 13142:434; d) collection of bone beads sewn onto cape, from prone burial at Tairum nor (28B), 73/2671 (Fairservis, 1993); e) chipped chalcedony bead from Mantissar, Gurnai Depression, K.13293:27; f) chert drill from Mantissar, Gurnai Depression, K.13293:11. Scales equal 1 cm.

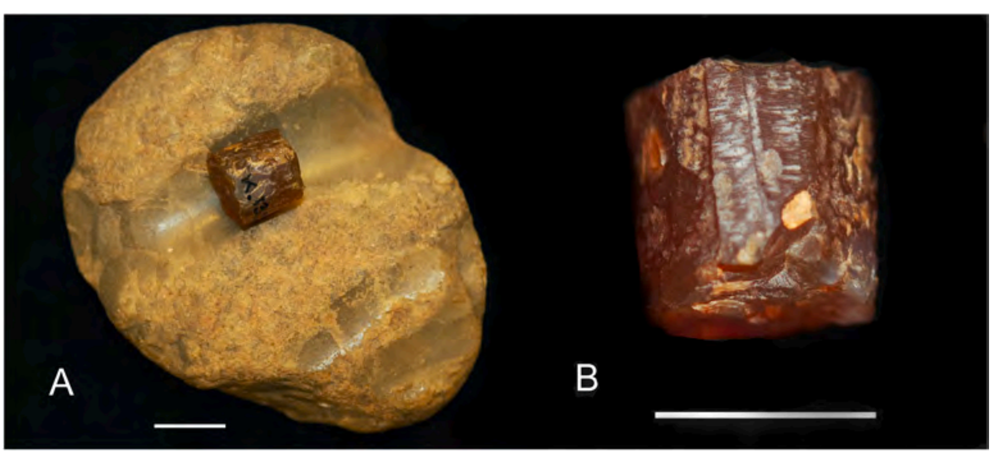

Fig. 11. A) Grooved slab (K.13230:5) from Ukh-tokhoi cave site with B) carnelian bead preform (K.13230:7). Scales equal 1 cm.

data from burial and habitation contexts in the region (but see Janz et al., 2017; Wright et al., 2019), but doing so can contribute a great deal to understanding the transition from Neolithic to Bronze Age. There is still much work to do in understanding this connection for Gobi regions. It is possible that Janz's Oasis 3 mirrors the spread of Bronze Age material culture, whether through trade, adoption of herding, or the spread of pastoralist peoples. If this is the case, dates for Oasis 3 should closely mirror the Neolithic to Bronze Age transition in the southern Gobi Desert if not in other parts of the country. Improving the resolution of such dates, particularly in the southernmost regions of the Gobi Desert, is critical.

It has been suggested is that Oasis 3 groups were early herders and the descendants of Neolithic hunter-gatherers (Janz et al., 2017) as the archaeological record from 3000–1000 BC consists primarily of microlithic and pottery surface assemblages that look very much like those of earlier hunter-gatherer sites. Most notably, the potsherd identified as have been used in dairying (AMNH 73/1194A) was recovered from a group of potsherds and lithics at Bayanzak (Shabarakh-usu 10), which was persistently used by Neolithic hunter-gatherers for many millennia prior with few changes in either material culture or land-use strategies (Janz, 2012: 293, 368–374, 404–407). There is currently insufficient evidence, however, to determine the economic base of Gobi Desert groups prior to c. 1600 BC. Regardless, the data presented here strongly suggest that Gobi Desert groups were engaged in burgeoning long-distance trade networks by the beginning of the second millennium BC, regardless of subsistence strategies.

The timing of such evidence is herein posited to underscore the influence of enhanced materialism across North China during the second millennium BC. These changes are not only evident in emerging commercial production of luxury goods in the ERTZ. Recent excavations of Shimao (Sun et al., 2018), a fortified urban centre on the Ordos Plateau, reveal large-scale movement and accumulation of exotic goods and a regional craft production capable of servicing an elite social class between 2300 and 1800 BC. These developments correspond with a second wave of advance in the spread of pastoralist economy and culture arid East Asia, represented in the southern Gobi Desert by what have been noted (Janz, 2012) as subtle shifts in material culture and land-use. Enhanced opportunities to engage in the accumulation and consumption of wealth during the second millennium BC may have been one key motivation for the adoption of pastoralism and the economic opportunities it provided. Based on the timing of this second wave of advance in the spread of pastoralism, and increasing evidence that cultural diffusion played a major role, it seems likely that pastoralism was at least in part an adaptive response to the mobilization of wealth on a massive regional scale.

Moreover, the persistence of a dominant hunter-gatherer culture lasting nearly 1500 years after the arrival of the Afanasievo on the western frontier presents a compelling study in the delayed spread of production economies and is comparable to the situation in the Lake Baikal region of Siberia where herding was likewise delayed. If pastoralist groups *were* present in the Gobi Desert during the fourth or third millennia BC, we still have much work to do in identifying them. Notable differences in the site density and distribution, variation in lithic assemblages, and better visibility of Bronze Age material culture (e.g., slag, burials) in the Alashan (Maringer, 1950; Janz, 2012: 285–286; Janz et al., 2017: 40–43) suggests that this region may be an important one for answering such questions.

Understanding the economic and cultural affiliations of Gobi Desert groups is critical to understanding the spread of pastoralism across East Asia, but requires a much better understanding of both the spread of domesticated herd animals and human demography. Sub-Saharan Africa offers a compelling comparative case study. Ethnographic and historical accounts in southern Africa indicate that domesticated animals were used very differently by different groups: some were dedicated pastoralists, some were hunter-gatherers who kept only a few herd animals, and some hunted the domesticated animals of other groups. There is much debate over whether herd animals were first introduced to the region through migration of herders or adoption of herds by hunter-gatherers whose diets were not significantly changed (Sadr, 2008; Smith, 2008; Stynder, 2009; Orton et al., 2013; McGranaghan, 2015; Badenhorst et al., 2016; Dusseldorp, 2016). Herd animals would have been appealing to both hunter-gatherers and agriculturalists as they allowed for entirely new approaches to the storage and movement of wealth. The ability to stockpile mobile wealth may have been a major contributor to the rise of interregional trade in East Asia.

Two primary types of analysis are required to determine when pastoralism arrived and whether its arrival involved the inward migration of pastoralists from the north, west, and/or south. The first is a comparative study of lithic technologies in the southern Gobi Desert with those of neighbouring regions. The second is a larger scale analysis of organic residues from pottery, which, considering the consistency with which dairying seems tied to pastoralism, will offer the best direct evidence of the spread of herding in the Gobi Desert.

Declaration of competing interest

The authors have no competing interests to disclose.

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