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Case report

Resilient herders: A deeply stratified multiperiod habitation site in northwestern Mongolia

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ABSTRACT

Currently, the development of mobile pastoralism in Mongolia is known almost exclusively from burial and ritual contexts. Here we present the results of archaeological excavations and geoarchaeological work carried out at a deeply stratified multiperiod habitation site in northwestern Mongolia. Data include an unprecedented number of well-preserved artifacts, faunal and botanical remains, sedimentary information, and chronology that document the development of pastoralism in this region. Our findings index the local durability of pastoralist occupation over 4000 years, as well as the adaptive resilience of the herders here, indeed up to the present day, and this despite major changes in the sociopolitical, socioeconomic, and environmental conditions through time.

1. Introduction

Since the origins of domestication, pastoral societies have been an exceptional example of adaptation and resilience (Manzano et al., 2021; Stephens et al., 2019). For a long time, the knowledge about the development of pastoralism and the chronology and nature of early pastoralist societies in Mongolia was hampered by a monument focused research paradigm, which largely ignored habitation sites. However, in recent years this situation has started to change as more and more researchers have acknowledged the importance of habitation sites and settlement patterns on a landscape level, largely starting with Houle's (2010) work in northcentral Mongolia. Other recent habitation site-oriented studies have been carried out, for instance, by Gardner and Burentogtokh (2018); Taylor et al. (2020); Wright (2016). Despite this, most models for the introduction of domesticated herd animals and early forms of pastoralism in Mongolia still mostly rely on the more numerous data from burial sites (e.g., Erdenebaatar and Kovalev, 2007; Eregzen, 2016; Kovalev and Erdenebaatar, 2009; Volkov, 1980). Based mostly on this mortuary record, but also museum collections and surface materials from the Gobi Desert (Janz, 2006, 2012), and a few settlements in the Russian Altai and the Minusinsk region of Southern Siberia (Kosintsev and Stepanova, 2010; Vadetskaia et al., 2014), two main models have recently been proposed for the introduction and spread of pastoralism in Mongolia, both of them originating with the arrival of Afanasievo groups in the Altai around the 3rd millennium BCE and then spreading east along a southern route (Honeychurch et al., 2021; Janz et al., 2020). However, Janz et al. (2020:162) see little to no evidence of herding in the Gobi until the mid-second millennium BCE with what they call a 'second wave of advance in the spread of a pastoralist economy', a period when local hunter-gatherers might have been motivated to adopt herd animals (sheep/goat, cattle) as items of value following enhanced opportunities to engage in expanding trade networks in luxury goods (stone beads in particular). On the other hand, relying on Afanasievo burial data from the central Khangai mountains, which includes

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evidence of dairying (Wilkin et al., 2020), Honeychurch et al. (2021) recognize an early ca. 3000 BCE introduction of herd animals (sheep/goat, and maybe cattle) into central Mongolia, but suggest that an extended 'learning curve' period better explains the delayed transition to a more intensive herding economy. According to them, it is only once human-animal relationships grew stronger and vital social networks developed to support this new economy that pastoralism flourished in the mid-second millennium BCE. Noteworthy, widespread pastoralism according to both models intensified only once environmental and climatic conditions became increasingly arid in the Gobi and highly variable in central Mongolia around 2000 BCE, a theory not unlike the one put forth by Anatoly Khazanov in the early 1990s (Khazanov, 1994:95). In both cases, the rise and spread of pastoralism in Mongolia is seen as a long-term process embedded in unique human-animal, human-human, and human-environment relationships that likely vary regionally.

Here we present the initial results of our archaeological excavations and geoarchaeological work carried out at a deeply stratified, open-air multiperiod habitation site in northwestern Mongolia. The information derived from this unique context allows us to recognize similar patterns seen in southern and central Mongolia while providing important nuances that further support the non-unilinear processes seemingly involved in the introduction and spread of pastoralism in Mongolia.

Most of the prehistoric open-air occupation sites in Mongolia have shallow, mixed archaeological deposits, and appear ephemeral in character (Clark, 2014:92; Gardner and Burentogtokh, 2018; Houle, 2010). Many sites appear to represent relatively short-term habitation events, whereas some appear as palimpsests of seasonally recurring and partly overlapping sites (e.g., Houle, 2010: Chapter 3; Seitsonen et al., 2018). Only occasionally thicker deposits have been encountered at open-air localities (e.g., Fitzhugh, 2004:10–12; Gladyshev et al., 2012; Houle, 2016; Taylor et al., 2020; Vella, 2017; and just beyond the border in Tuva, see Semenov, 2018). In the summer of 2018, we located two such sites with over one-meter-thick archaeological deposits in Züünkhangai, Uvs province, northwestern Mongolia (sites ZK513 and ZK554) (Fig. 1). Of these, site ZK513 turned out to be the deepest and best-preserved, and we focus on it here.

Test excavations at ZK513 revealed 13 clear-cut stratigraphic layers originating from recurrent use of the locality for over 4000 years, with the lowermost archaeological deposits over 165 cm deep. These layers yielded, for the local context, an unprecedented number of well-preserved ceramics, lithics, botanical and faunal remains, as well as environmental data and organic material for various analyses. The first results of the ongoing Western Mongolia Archaeology Project are starting to provide new details about the chronology, nature, and

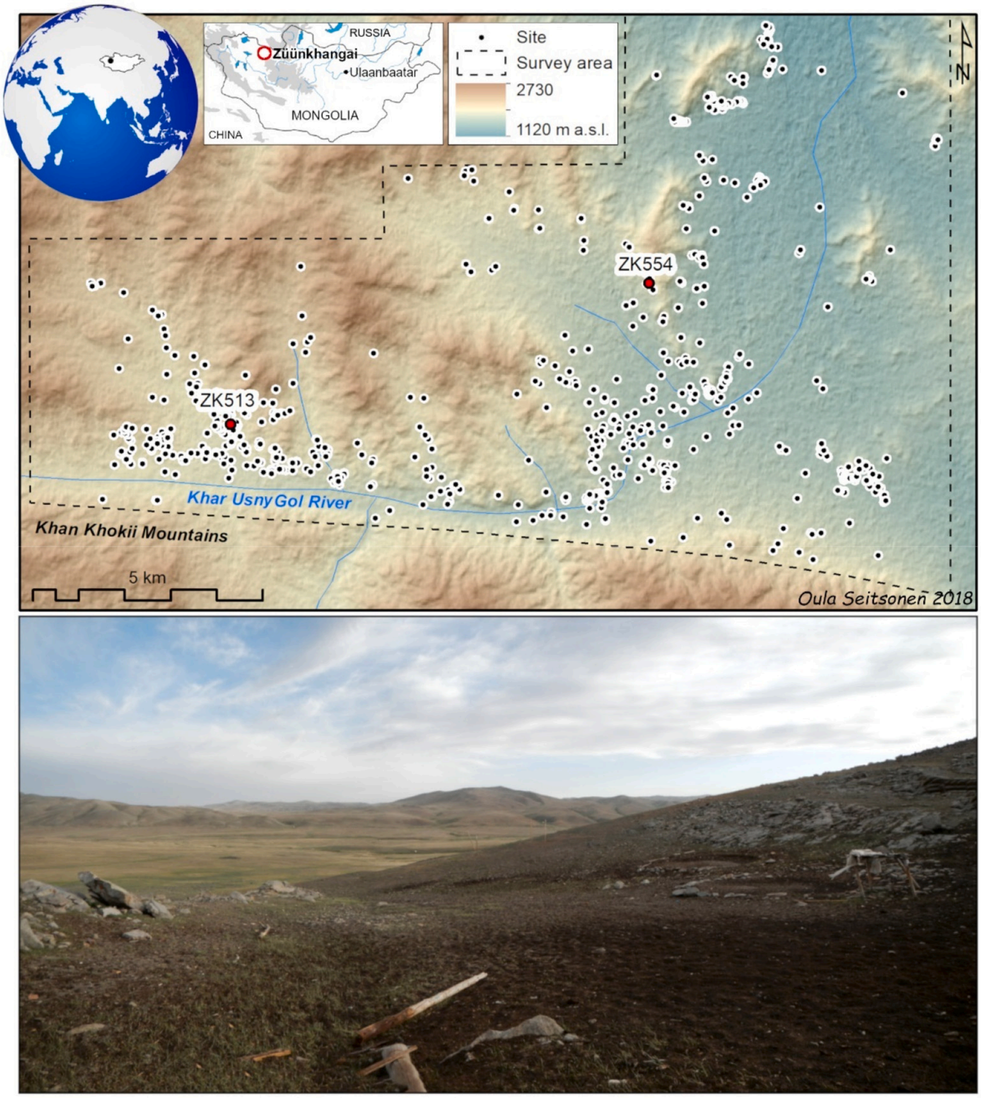

Fig. 1. Top: Southern part of the Züünkhangai pedestrian survey area with all the archaeological sites (all recorded by the WMAP project), and the deeply stratified sites ZK513 and ZK554. Bottom: View from ZK513 over the Khar Usny Gol River Valley (Illustration Oula Seitsonen).

environmental context of early pastoralism in northwestern Mongolia.

2. The Western Mongolia archaeology project in Züünkhangai 2015–2018

The Western Mongolia Archaeology Project (WMAP) is a joint research endeavor by the National Museum of Mongolia (Jamsranjav Bayarshaikhan) and Western Kentucky University, USA (Jean-Luc Houle), in collaboration with European researchers (Oula Seitsonen, Finland; Natalia Éguez, Spain; Lee G. Broderick, UK; Juan José García-Granero, Spain). The project has been studying the prehistory of the Züünkhangai region in Uvs province since 2015 (Fig. 1). The research area was a virtual archaeological *terra incognita* with few known archaeological sites when the fieldwork began. Our work to date has mostly concentrated on systematic, full-coverage pedestrian survey (following methods described in Honeychurch et al., 2007 and in Houle, 2010). So far, over 1000 new sites have been recorded in the survey area. These are mostly monumental sites dating to many periods, including Bronze Age khirigsuurs and deer stones (aka Deer Stone-Khirigsuur [DSK] Culture, ca. 1200-700 BCE, after Taylor et al., 2017), Iron Age Xiongnu ring burials (ca. 4th/3rd centuries BCE-100 CE, after Honeychurch, 2015), and Turk-Uyghur period mortuary and ritual structures (ca. 6th-9th centuries CE, after Rogers, 2012). Besides these, several prehistoric ceramic and lithic scatters, probable occupation sites or activity areas, have also been recorded. Many of the Bronze Age and later occupation sites have been located at modern day pastoralist settlement sites, especially at winter camps typically situated in the protected valley draws.

3. ZK513 habitation site: site characteristics and test excavation methods

ZK513 is one of the ceramic and lithic scatters we discovered through surface inspection in 2017. It is situated at a modern pastoralist winter camp in a well-protected valley draw. At the macro-scale, the site lies in the open steppe environment and is surrounded by numerous Bronze Age and later period monuments, such as khirigsuurs, deer stones, slope burials (aka Sagsai burials), Turkic balbals, and so on (see Jacobson-Tepfer and Meacham, 2009 and Jacobson-Tepfer et al., 2010 for an overview of monument types in English). The site is located on a gentle hillslope at the crossroads of the Khar Usny Gol (Хар усны гол) River Valley and a north running side valley. It lies about 1.5 km north of the river, and ca. 70 m above the bottom of the valley (Fig. 1).

The extent of the site is limited by the natural barriers formed by rocky outcrops on its east and west sides. The modern camp covers an area of ca. 70 × 40 m and has two ger (or yurt) placements, an animal shelter, and several middens and stone clearing piles. Slope burials are found on the hillslopes above the site. These mortuary structures are often found in the immediate vicinity of contemporary Late Bronze Age habitation sites, usually on the uphill side (Houle, 2010; Seitsonen et al., 2014). The site was chosen for shovel probe tests, geoarchaeological sampling, and test excavations in 2018 (Fig. 2).

Based on surface materials, ZK513 was expected to be a seasonal Bronze Age occupation site, presumably a winter camp, with shallow archaeological deposits and scarce finds, like many analogous sites have shown to be in Züünkhangai and elsewhere (e.g., Houle, 2010). Shovel test pits and soil geochemical sampling were carried out over the site in a 10 × 10 m (at places 5 × 10 m) grid, with 50 × 50 cm shovel probes excavated 40–50 cm deep. The probes revealed two distinct clusters of prehistoric finds and some observations of clear-cut archaeological features. The geochemical analyses of phosphate (P), electrical conductivity (EC) and pH values of soil extracted from the test pits (collected ca. 30 cm below the surface) also showed intrasite trends. Archaeological research has broadly used soil P, pH, and EC indicators in off-site and on-site studies to define the extension of otherwise invisible occupation areas, and to distinguish activity areas within the site, including mobile pastoralist sites (Seitsonen and Égüez, 2021). P enrichment results from prolonged human occupation and has been strongly correlated with cattle enclosures and food consumption activities in ethnoarchaeological hunter-gatherer and agropastoral contexts (Shahack-Gross et al., 2003). Additionally, the determination of pH has become almost a routine analysis in soil studies relating to archaeology. Knowledge of soil acidity is useful in evaluating soils because pH exerts a very strong effect on the solubility and availability of many nutrient elements and destructive processes that can affect artifacts like bones, wood, etc. EC measurements estimate the amount of total dissolved salts (TDS), or the total amount of dissolved ions in the water. In archaeology EC analysis is used to detect the extent of cultural layers and the presence of metals primarily. Interpretation of these elements should be done in tandem as one could influence another (e.g., acid sandy soils are usually less able to retain phosphate than neutral or alkaline soils). On the whole, intrasite patterns (waste areas, cooking areas, hearths, corralling areas, etc.) can be assessed by studying these three indicators. The results of both sampling methods (shovel probes and soil geochemistry) were used as a basis for selecting the locations of excavation units.

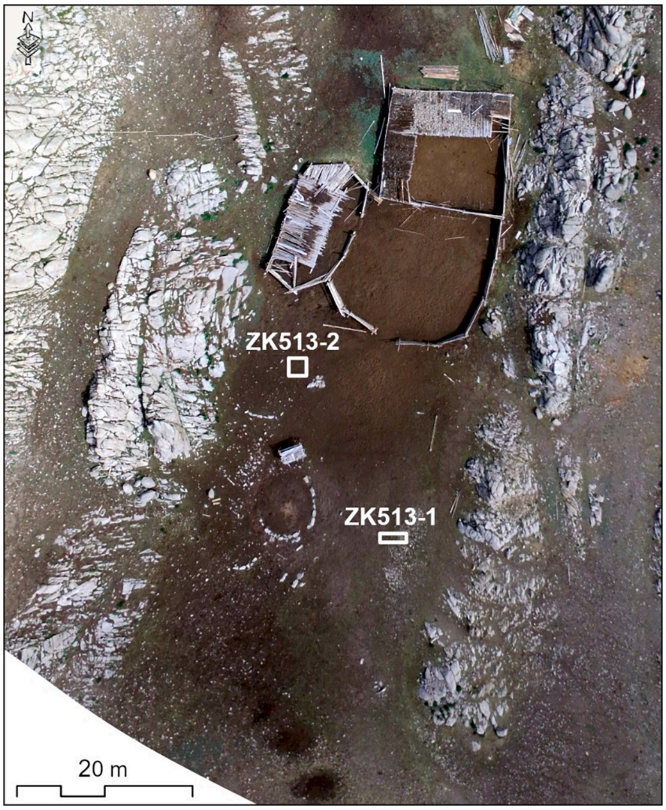

Fig. 2. Drone image of ZK513 showing the locations of the two excavated trenches at a modern pastoralist winter camp. Two partial stone rings on the left are modern pastoralist ger (yurt) places (Illustration Oula Seitsonen).

Two units were opened at the site: a 3 × 1 m trench (ZK513–1) placed in the middle of the site where high *P* values and most finds from the shovel test pits were unearthed, and a 2 × 2 m unit (ZK513–2) in the upper part of the site, where high EC values and surface finds were discovered. The aim of these test excavations was to recover in situ archaeological remains and datable material associated with this presumed Bronze Age habitation site. ZK513–2 proved to correspond to the initial assessment of the site, with ca. 35 cm deep archaeological deposits and only a few finds, apparently dating to the Bronze Age and/or Iron Age based on the recovered ceramics. A burnt soil feature was revealed in the southwestern part of this unit, possibly contributing to the elevated EC values. Early in the excavation, trench ZK513–1 appeared to exhibit analogous characteristics to those observed in unit ZK513–2, with ca. 30–40 cm deep deposits. Below this topmost find layer, however, we found out that the archaeological deposits continued significantly deeper. Our goal then became to recover in situ sediments, organic material, and stratigraphically associated diagnostic artifacts to begin exploring the economic characteristics and ecological conditions over time at this locality.

Because deposits are usually shallow and clear stratigraphic layers have not been encountered in previous excavations of similar habitation sites in central Mongolia (Houle, 2010), the first 30 cm were excavated by arbitrary levels of 5 cm using a trowel. All soil was screened through 6 mm wire mesh. Once we recognized that the deposits were clearly stratified and continued significantly deeper, and given time constraints, we switched to an expedient excavation strategy that combined troweling, shoveling, and systematic screening (using 6 mm wire mesh), following observed stratigraphic levels. Stratigraphic depths were recorded from a baseline datum.

4. Stratigraphy and dating of the trench ZK513-1

The excavation of ZK513-1 revealed 13 clear-cut strata, with the lowermost archaeological deposits over 165 cm deep (Fig. 3–4). Permafrost was encountered ca. 125 cm below the surface, which explains the good preservation of faunal remains in the lower strata, though remains were generally well-preserved throughout. Based on the finds and radiocarbon dates from the strata, they cover the past 4000 years (Fig. 3; Table 1). This illustrates the recurring use of this sheltered locality throughout the millennia.

The archaeological sedimentary layers illustrate how the inclination of the locality has changed through time, from the relatively level prehistoric layers to the modern-day, ca. 5-degree slope. The top of the sequence (layer 1) is characterized by a recent light brown haplic kastanozem-type soil (see Table 2) with large roots that extend from this superficial layer to layer 2. Fine roots characterize the rest of the profile with a very low degree of bioturbation, and almost no bioturbation at the bottom of the sequence. Parent materials of these soils consist of loess-type deposits with a succession of organically rich, finely laminated, and well-sorted dark orange to black sediments in most of the layers. Fine silt and sand predominate, with some non-oriented subangular pebble and cobble inclusions between laminations. Hardly any leached secondary carbonate layers were visible through the whole sedimentary profile.

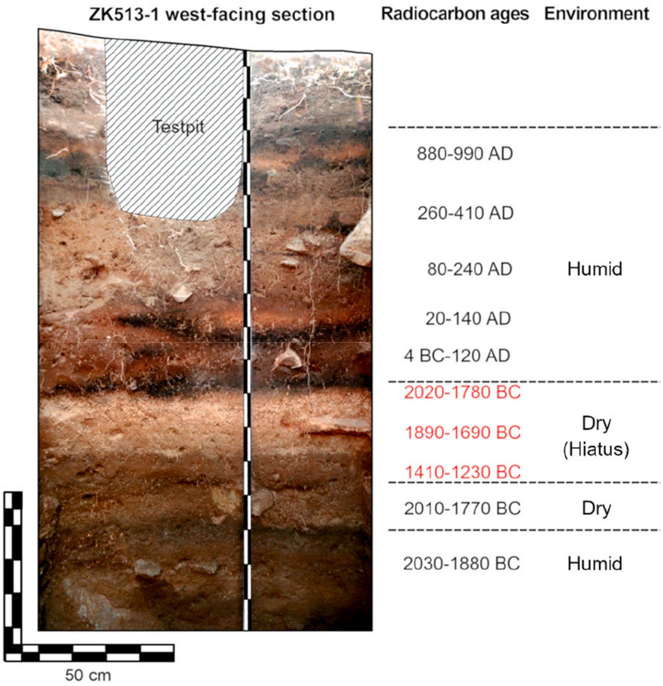

Fig. 3. West-facing section of the trench ZK513–1 with the associated radiocarbon ages (reversed dates in red; dates from each layer combined in Oxcal 4.3 [with R_combine function], using IntCal 13 calibration curve [Bronk Ramsey, 2009; Reimer et al., 2013], see Table 1), and environmental data based on the soil geochemical analyses (Illustration Oula Seitsonen). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Clear signs of human occupation occur in layers 1–8 (1116 ± 25 to 3570 ± 26 cal BP) and 11–12 (3559 ± 25 to 3582 ± 28 cal BP) with a relatively high density of artifacts present throughout the sedimentary sequence (Fig. 4). The exception to this is layers 9 and 10. These layers have a low artifact density and appear to present a partial hiatus in the occupation of the site. Notably, the radiocarbon dates from the base of layer 8 and layers 9–10 (Fig. 3) appear to be reversed, 3470 ± 26 and 3058 ± 29 cal BP, respectively. It is unclear right now why these dates are reversed, but the sharp contact with the layers above and below indicate a fundamental change in the nature of the depositional process at this stage. Both the layers above (layer 8) and below (layer 11) have clear signs of anthropogenic activity, as indicated by the artifactual evidence and the more compact, heterogeneous sediment content, with dark organic-rich layers and some charcoal-rich lenses and traces of what appears to be burnt soil.

The macro-characteristics of the sediments (rounded and pale-yellow well sorted sandy mineral particles, porous and low bulk density with almost no bioturbation and no iron oxidation) in layers 9–10 may indicate a phase of sustained windblown deposition, when prevailing winds transported soil materials from the arid and semi-arid regions of China, Inner Mongolia, and Mongolia itself. These layers could relate to a short episode during the dry and high-temperature Holocene Megathermal that has been dated for Inner Mongolia and Mongolia to the mid-Holocene (between ca. 8.0 and 4.3 kyr BP), with the duration of the dry intervals differing very locally (An et al., 2008; Chen et al., 2003; Fowell et al., 2003; Klinge and Sauer, 2019; Timireva et al., 2020; Struck et al., 2022). Thus, we believe that the fine and very organic sediments from layers 3 to 8, when the intensity of occupation was likely high, were deposited in a more humid environment when compared to layers 9–10. This is supported by the archaeobotanical remains (see Section 5.1 below). The sediment composition and texture observed in layer 11 shares characteristics with layers 10 and 9 but with presence of artifacts, which possibly indicates a gradual change between the wetter conditions of layer 12 and the drier ones found above. Finally, layer 13 corresponds to the beginning of the paleosol with few carbonate aggregates and permafrost. In order to confirm and further investigate the site formation and post-depositional processes in more detail, undisturbed blocks were extracted during fieldwork for micromorphological analysis. Additionally, loose sediment was collected every 10 cm for plant wax biomarkers analysis and compound-specific stable isotope analysis ($\delta^{13}C$, δD) as a proxy for detailed vegetation change and hydroclimate reconstruction (ongoing).

5. Assemblages

5.1. Botanical remains

Phytoliths (silicified microscopic plant remains) and seeds were analyzed to determine the environmental conditions prevailing throughout the occupation of ZK513 and, potentially, explore how its inhabitants exploited plant resources. Phytoliths were chemically extracted from sediment samples collected every 5–10 cm throughout the west-facing section of trench ZK513–1 following the protocol proposed by Lombardo et al. (2016), while macrobotanical remains were analyzed from flotation samples taken from each layer of the trench. The method used to process sediment samples was a simple manual bucket flotation technique using river water that was first filtered through

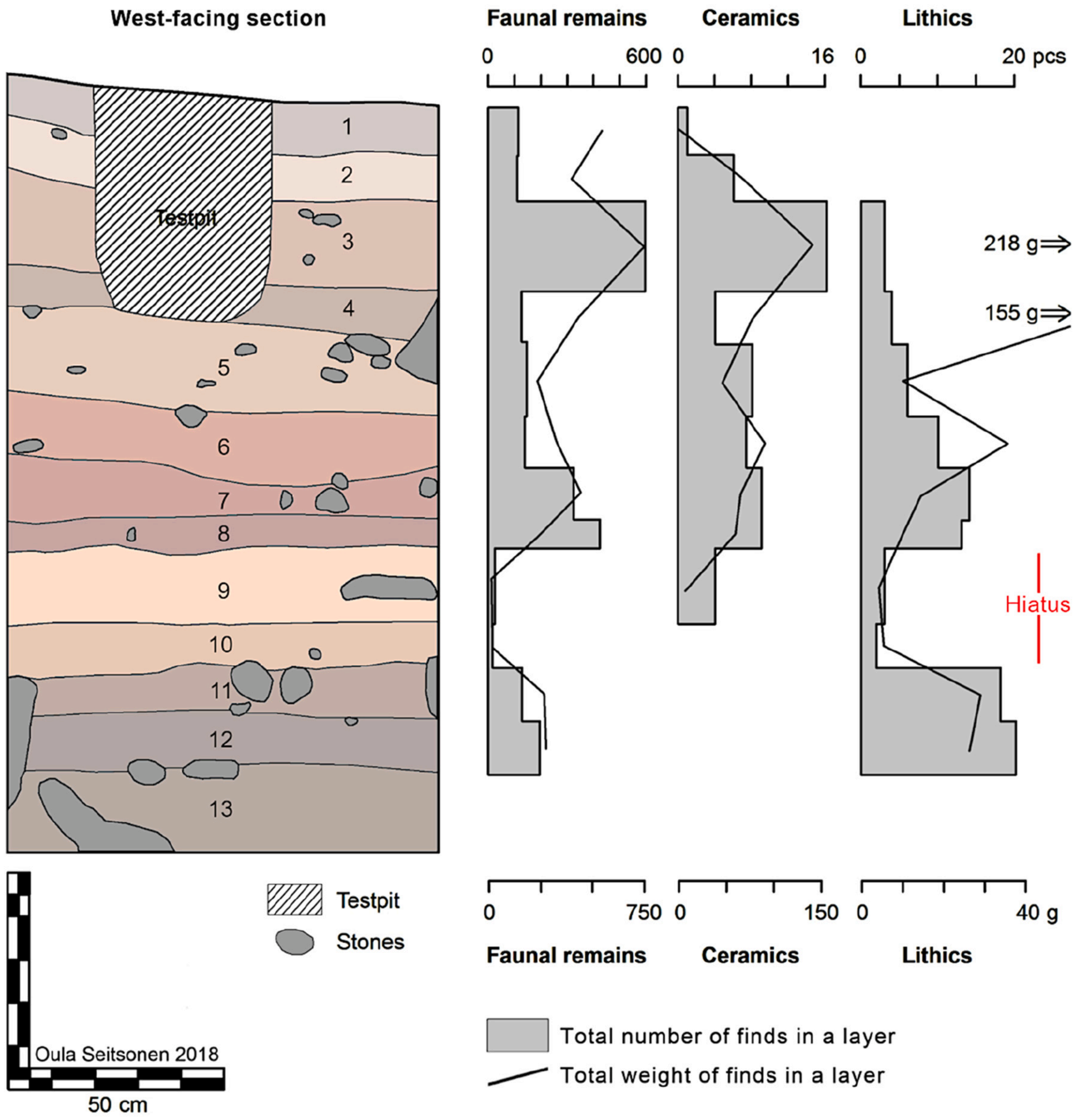

Fig. 4. West-facing section of the trench ZK513–1 and the vertical distribution of finds according to the number of pieces (histogram, scale at the top) and weight in grams (line, scale at the bottom) (Illustration Oula Seitsonen).

Table 1
Radiocarbon dates from ZK513-1 (reversed dates representing the hiatus in italic; calibrated in Oxcal 4.3, using IntCal 13 calibration curve [Bronk Ramsey, 2009; Reimer et al., 2013]).

Layer	Lab. code	Material	14C age BP	cal BC/AD (95,4%)				Environment
1–2								
3	D-AMS034375	Charcoal	1116 ± 25	880	–	990	AD	
4	AA112757	Bone	1701 ± 30	250	–	410	AD	
	D-AMS034376	Charcoal	1676 ± 24	260	–	420	AD	
5	AA112759	Tooth enamel	1778 ± 27	130	–	340	AD	
	D-AMS034377	Charcoal	1903 ± 23	20	–	210	AD	Humid
6	AA112760	Tooth enamel	1924 ± 27	20	–	140	AD	
7	AA112761	Tooth enamel	1852 ± 27	80	–	240	AD	
	D-AMS034378	Charcoal	2041 ± 27	170 BC	–	30	AD	
8	D-AMS034379	Charcoal	*3570 ± 26*	*2020*	–	*1780*	*BC*	
9	D-AMS034380	Charcoal	*3470 ± 26*	*1890*	–	*1690*	*BC*	Dry (Hiatus)
10	D-AMS034381	Charcoal	*3058 ± 29*	*1410*	–	*1230*	*BC*	
11	AA112763	Tooth enamel	3559 ± 25	2010	–	1770	BC	Dry
12	AA112764	Tooth enamel	3582 ± 28	2030	–	1880	BC	Humid

Table 2
ZK513-1 profile description showing macro characteristics of sediments.

Soil horizon	Depth (cm)	Description
Ah	0–20	Light brown (5 YR 6/3, moist) silt loam. Moderate coarse subangular blocky; gravel inclusions; many very fine to coarse roots; many fine, medium and coarse pores; gradual inferior boundary
Bw	20–95	Light brown (5 YR 4/3, moist) well-sorted silty clay loam. Medium subrounded; many very fine to fine roots; darker sediment possible of anthropogenic component; sharp inferior boundary
1A	95–100	Black (10 YR 2/1, moist) loamy sand; black sediment possible of anthropogenic component; sharp inferior boundary
1Bw	100–120	Yellowish brown (10 YR 5/6, moist) well-sorted coarse loamy sand. Medium pores; sharp inferior boundary
2BCwk	120–150	Light brown (5 YR 4/3, moist) well-sorted silty clay loam. Medium subrounded; some fine roots; few pedotubules; darker sediment possible of anthropogenic component; subangular platy stone inclusions; few scattered carbonates; gradual smooth inferior boundary
C	> 150	Dark reddish grey (5 YR 4/2, moist) well-sorted clay loam. Subangular platy stone inclusions

locally purchased fine-mesh stockings to avoid contamination from modern plant remains. After gently disaggregating the sediment and then creating a vortex by swirling the water by hand, light fractions were collected from the float with a handheld 1 mm sieve, while heavy fractions were recovered in a 3 mm mesh screen. Samples removed from the float were then placed in stockings, labeled, and hung for drying indoors. The heavy fractions did not contain any plant remains, so only light fractions were examined.

Phytoliths are very abundant in all samples (Table 3). Poaceae (grass) phytoliths predominate in all the samples (84–98% of the total identified phytoliths). Anatomically, most grass phytoliths identified at ZK513–1 come from leaves and stems (elongate psilates, elongate sinuates and bulliform cuneiforms), whereas phytoliths originating in grass inflorescences (elongate echinates and papillae) are comparatively scarce (<20% of the anatomically informative grass phytoliths in most samples). On the other hand, short cell phytoliths (which can be broadly ascribed to different grass subfamilies) mostly come from the Pooideae subfamily (rondels and most trapeziforms), characteristic of temperate climates, whereas the Chloridoideae (saddles) and Panicoideae (bilobates) subfamilies, often found in drier and hotter climates, are marginally represented. Other phytolith morphotypes include six cones characteristic of the Cyperaceae family (sedges), two irregular phytoliths often found in woody plants (Dicotyledons) and a few morphotypes that occur among multiple plant families and thus cannot be taxonomically ascribed (Table 3; Fig. 5).

The seed assemblage is composed entirely of wild taxa, mostly within the Amaranthaceae family, including *Chenopodium* sp. and *Atriplex* sp., and the Cyperaceae family (sedges)—all common taxa in the steppe environment and still prevalent in the research area (Table 4; Fig. 6). Numerous uncharred (i.e. modern) *Chenopodium* sp. seeds (not included in Table 4) were also found within the assemblage, including some seeds trapped in modern animal dung, likely due to bioturbation (e.g., rodent activity).

All the samples from ZK513–1 have very similar phytolith assemblages, which suggests that environmental settings did not drastically change during the occupation of the site. The predominance of pooid grasses and the virtual absence of phytoliths from woody taxa further indicate that the Züünkhangai region has consistently been a temperate grassland for the last 4000 years. Similarly, the composition of the seed assemblage is consistently dominated by *Chenopodium* sp. and *Atriplex* sp., with a minor presence of sedges, thus also showing a certain degree of continuity. In spite of this, two environmental phases can be distinguished based on the phytolith and, to a lesser degree, macrobotanical assemblages. In layers 1–8 phytolith water availability indexes, calculated as a ratio of sensitive to fixed phytolith forms within the Poaceae family (Jenkins et al., 2016; Madella et al., 2009), suggest a wetter environment than in layers 9–12, which correlates with the palaeoenvironmental conditions observed in the macro-characteristics of the sediments. Interestingly, the seed assemblage from the more humid layers (3–8) includes sedges, many of which are associated with wetlands. Although scarce, sedge phytoliths are almost exclusively found in the most humid deposits, specifically layers 3–7. Taken together, the phytolith and seed evidence support the hypothesis that the later phases of occupation at ZK513 occurred during a period when local conditions were wetter. Noteworthy, these layers correspond to periods of great socioeconomic change in Mongolia with the appearance of mounted pastoralism and growing social inequality during the Late Bronze Age and Early Iron Age (ca. 1200–500 BCE) and the first nomadic empires (Xiongnu [ca. 200 BCE-100 CE], Xianbei [1st-3rd centuries CE], 'Turkic' polities [ca. 550–800 CE]).

Pooid grasses typically flower in spring-summer. The scarcity of grass inflorescence phytoliths in all the samples from ZK513–1, therefore, suggests that ZK513 was consistently occupied during the fall and, especially, the winter months. Considering that the site lies in a modern pastoralist winter camp, the phytolith evidence suggests that the modern-day season of site occupation can be traced back to the last 4000 years.

The predominance of Amaranthaceae seeds in the macrobotanical assemblage from ZK513–1 suggests that it derives mostly from dung (see Spengler in Taylor et al., 2020: Supplementary information S6), an interpretation reinforced by the presence of *Chenopodium* sp. seeds in modern dung pellets found at ZK513–1. Nonetheless, we must also consider the possibility that the archaeobotanical assemblage simply represents the vegetation prevalent in the research area. Most of the recovered wild plants are edible, and therefore their use for human consumption cannot be discarded, although we currently lack evidence (e.g., isotopic data or microbotanial evidence from human dental calculus) supporting this hypothesis. The phytolith assemblage seems to be solely representative of the general vegetation available at and around the site (possibly also derived from animal dung), and it is not currently possible to discern specific human activities related to the assemblage formation processes.

5.2. *Ceramics*

Altogether, 64 pottery sherds were collected from the different layers in trench ZK513–1 (Fig. 3). The earliest pottery sherds were located 120 cm below the surface (at the contact between layers 9–8) and are associated with two AMS/^{14}C samples dated to the Early/Middle Bronze Age (3470 ± 26 BP and 3570 ± 26 BP, together reflecting a calibrated age range of 2020–1690 cal BCE; Table 1). These are relatively thick (mean 15.5 mm) and coarse, undecorated red-brown sherds, i.e. within the Munsell color ranges of R and YR (Fig. 7a).

Layers 7 through 5 contain pottery sherds associated with contexts spanning the whole of the Iron Age/Xiongnu period and a bit beyond (with 5 radiocarbon dates from 170 cal BCE to 340 cal CE; Table 1). The thickness of these sherds varies between 9.6 and 12 mm, with a few as thick as the Bronze Age ones. All are relatively coarse paste wares that vary in color from red-brown to grey. Some of these are plain, while others are scrape-polished and decorated with punctuates, stamp impressions, incisions, and punctuated applique strips (Fig. 7b-g). None of these have the archetypical 'wavy line' decoration common to the Xiongnu period.

Ceramics from layer 4 exhibit the characteristic diamond stamp motif on one of the sherds (Fig. 7h), which we situate to the 'early Türks'. The Turkic period stands in, for our purposes, for a chronologically long and ill-defined period between the end of the Xiongnu and the beginning of the Khitan/Liao period (i.e. ca. 200–900 CE). Two AMS/^{14}C samples from layer 4 at about 50 cm below the surface date

Table 3
Phytolith morphotypes identified in the samples from ZK513–1, including water availability indexes.

	ZK513–1-1	ZK513–1-2	ZK513–1-3	ZK513–1-4	ZK513–1-5	ZK513–1-6	ZK513–1-7	ZK513–1-8	ZK513–1-9	ZK513–1-10	ZK513–1-11	ZK513–1-12	ZK513–1-13	ZK513–1-14	ZK513–1-15	ZK513–1-16
Poaceae																
El. psilate	50	42	31	18	35	39	70	65	89	62	86	58	62	92	85	86
El. sinuate	5	6	7	.	.	5	8	2	7	2	5	5	4	2	10	2
El. echinate	1	3	3	3	2	4	6	6	5	4	7	6	10	4	3	2
El. crenate	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
El. columellate	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
El. irregular	1	4	4	.	.	2	1	6	3	2	3	1	2	6	1	1
Saddle	6	2	1	3	5	.	1	1	2	1	.	.	2	.	.	.
Bilobate	11	5	1	5	3	6	2	7	3	3	3	4	1	2	5	1
Rondel	83	102	105	70	98	80	71	85	47	64	56	55	45	27	39	39
Trapeziform	17	32	9	55	28	20	14	5	9	4	2	10	7	3	11	5
Trap. bilobate	5	2	2	5	2	1	.	.	1	.	.	.	.	.	.	1
Trap. sinuate	21	28	11	19	25	38	22	25	22	41	32	17	23	22	28	15
Trap. polylobate	.	1	1	1	.	.	3	1	1	.	.	.	4	1	.	3
Trap. ovate	110	74	59	56	87	42	47	45	42	57	57	60	57	63	36	62
Trap. elongate	2	6	4	3	8	4	1	4	4	14	4	2	1	2	6	4
Bulliform cuneiform	1	9	.	1	.	1	.	.	.	.	1	.	.	.	.	2
Papilla	2	2	.	.	.	2	6	7	12	5	8	20	16	23	12	8
Cyperaceae	.	.	.	.	1	.	.	.	.	1	.	1	1	2	.	.
Dicotyledons	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Undetermined																
Parallelepipedal	2	3	1	2	.	.	.	1	1	1	.	.	.	.	.	.
Trichome	13	14	11	12	6	6	12	16	14	6	9	14	12	15	13	13
Trichome base	4	11	2	3	.	2	2	3	7	1	7	7	6	12	8	9
Elongate undet.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Tracheid	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Total phytoliths ID	334	346	253	257	300	252	266	279	270	269	280	261	253	277	257	253
Water availability index	0.70	0.79	0.88	0.56	0.48	0.66	0.38	0.79	0.46	0.53	0.26	0.14	0.10	0.23	0.22	0.22

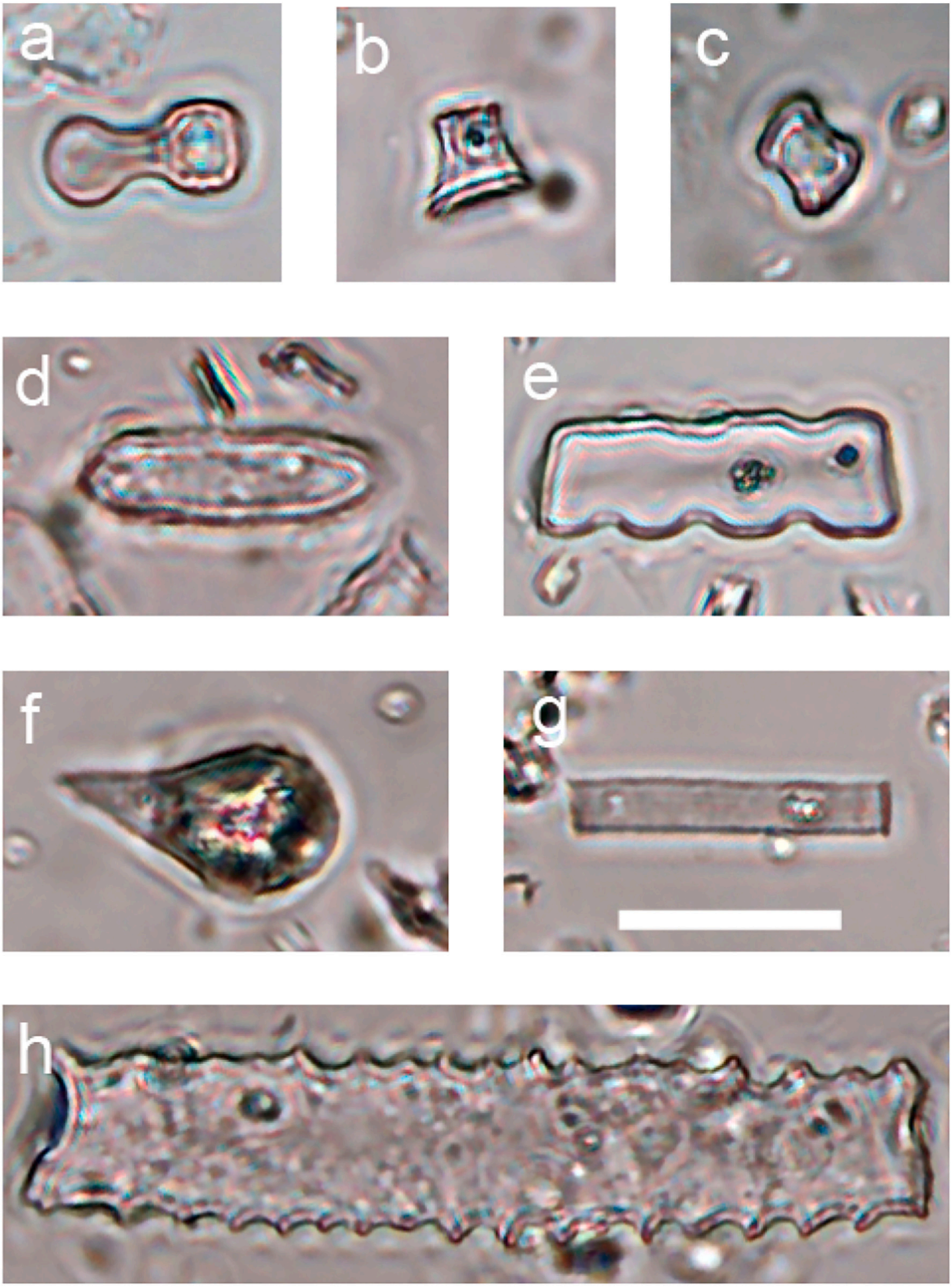

Fig. 5. Most common phytolith morphotypes identified in samples from ZK513–1: a) bilobate, b) rondel, c) saddle, d) trapeziform ovate, e) trapeziform sinuate, f) trichome, g) elongate psilate and h) elongate echinate. Scale bar in g) is 20 μm and applies to all phytoliths.

between 250 and 420 cal CE (Fig. 7h-j).

Layer 3 is dated to between 880 and 990 cal CE, conceivably to the Khitan/Liao period (ca. 900–1200 CE). Pottery sherds in this layer are finer paste, undecorated grey-brown wares with an average thickness of 9.7 mm (Fig. 7k). Though not dated, layers 1 and 2 contain mostly modern materials. However, one small, glazed sherd with green and orange hues found in layer 2 might date to the Khitan/Liao/Mongol period (Fig. 7l). All sherds below this layer are sand/grit tempered, and save for the glazed one in layer 2, all the rim sherds appear to represent local handmade 'jar-shaped' storage vessels with an average rim diameter of 30 cm.

As part of a pilot project, XRF data for 33 sherds from different levels at ZK513–1 were submitted to principal components analysis. Three readings were taken on each sherd and averaged, eliminating outliers in

Table 4
Seeds recovered from ZK513-1.

Layer	Volume floated (L)	% scanned	Amaranthaceae	Cyperaceae	Unknown	Modern dung
3	6.5	100	32	2	.	No
4	6.5	100	82	5	.	Yes
5	6.5	33	32	.	.	Yes (with *Chenopodium*)
6	5.3	33	80	6	.	Yes (with *Chenopodium*)
7	7	33	14	1	1	Yes (with *Chenopodium*)
8	7	100	109	11	8	Yes (little)
9	6.6	100	10	.	.	No
10	7.5	100	4	.	.	No
11	7	100	.	.	.	No
12	7	100	2	1		No

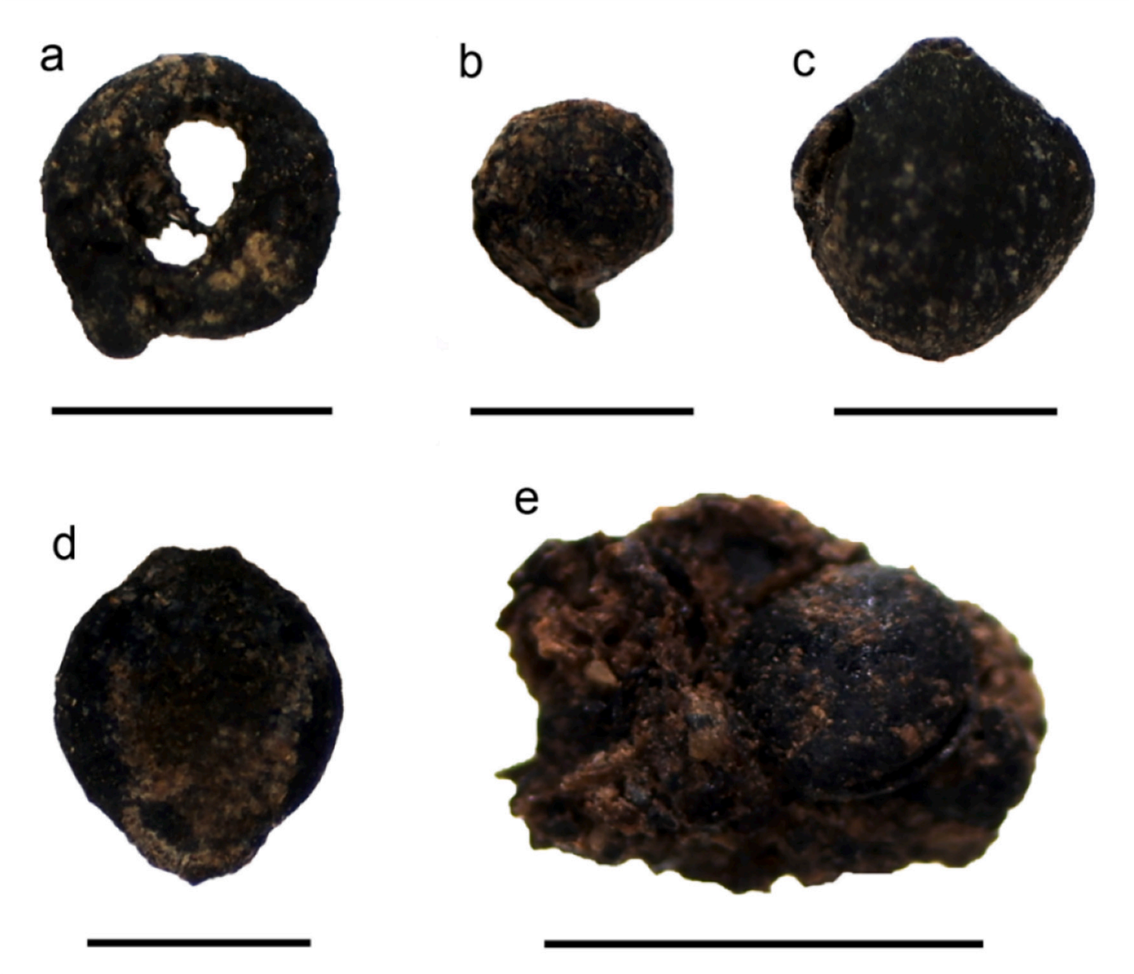

Fig. 6. Most common seeds identified in samples from ZK513–1: a) *Chenopodium* sp. from Layer 6, b) *Atriplex* sp. from Layer 3, c) Cyperaceae from Layer 6, d) Cyperaceae from Layer 3 and e) modern dung fragment from Layer 5 with an incrusted *Chenopodium* sp. seed. Scale bar: 1 mm in a-d) and 2 mm in e).

any particular elemental value that would be the product of random inclusions. This bulk elemental analysis approach was used to capture the clay paste 'recipe' as a whole—which includes clay, natural inclusions, and any added non-plastics—, not absolute mineralogy (or chemistry in this case). Elemental data revealed analogous chemical profiles throughout the sequence, indicating that the clay composition used by potters at the site remained remarkably stable through time, at least until the Turkic period (Camilla Sturm, personal communication). Accordingly, this ceramic assemblage not only provides a rare glimpse into the diachronic developments of some local domestic ceramic forms used by mobile pastoralists in this region (Fig. 8), but based on this preliminary analysis, elemental data also suggest incredible continuity in clay sourcing throughout the 4000 years of occupation of this site. That being said, we recognize that there is currently little information on how variable clay sources are in the region, which is something that needs to be studied in the future.

5.3. Lithics

The lithic assemblage from the site includes 101 artifacts, 8 from the surface and the rest from the different strata of ZK513-1 (Tables 5–6). Lithics were found throughout the sequence, including the layers with Iron Age ceramics; continuation of lithics use into Iron Age times has recently been suggested in Mongolia (Gardner and Burentogtokh, 2018).

Fig. 7. Ceramics from ZK513–1. a: layer 9; b-c: layer 7; d-e: layer 6; f-g: layer 5; h-j: layer 4; k: layer 3; l: layer 2 (Photographs Sophie Lafrance).

Even though the assemblage is small, it exhibits trends which appear to be in line with the general tendencies observed in the Mongolian Holocene lithic reduction sequence, admittedly sparsely known, with an emphasis on microblade production (e.g., Janz et al., 2017; Seitsonen et al., 2018; Zwyns et al., 2014). Fine-grained cryptocrystalline raw materials prevail throughout the sequence, but there are temporal differences in the characteristics of selected raw materials. In layers 11–12 the preferred raw material is white or white-grey translucent chalcedony (the place of origin is unknown), whereas in the layers above (layers 3–10) the ostensibly local, dark grey and black variants of chert and fine-grained quartzite are dominant.

In the topmost Iron Age layer (layer 3), a large bifacially-knapped axe-like quartzite implement (Fig. 9a) and a few angular fragments of debitage were uncovered, while a polishing stone, a flake, and a few blade fragments were found in layer 4. In layers 5–11, artifacts related to microblade production prevail (Fig. 9b–g), whereas nearly half of the recovered lithics in layer 12 are biface thinning flakes (Fig. 9h–j). This suggests some changes in site-use and/or lithic reduction techniques and tool types between layers 11 and 12. Two microblade cores were uncovered: a side fragment of a wedge-shaped microblade core in the Early Bronze Age stratum (layer 11; Fig. 9b), and a cylindrical (or barrel-shaped), relatively crude, microblade core in the Iron Age/Xiongnu layer (layer 6; Fig. 9c). The microblade core types might have chronological significance, as has been suggested elsewhere (Janz, 2012:201–202; Janz et al., 2017; Seitsonen et al., 2018). The width of blades and microblades (microblade width < 10 mm) might also bear chronological significance, although at the moment the assemblage is very small (Figs. 9d-g). The width of blades is more varied in the earliest layers (7–11), with both narrow and wider forms (up to 13 mm wide blades), whereas in the later layers (4–6) microblades are consistently narrower (width < 9 mm) (Fig. 10). In addition, in layer 12 we found one large, rounded-edged flake knapped from a polyhedral core with a prepared platform (Fig. 9k). Since its rounded condition differs clearly from the well-preserved state of the other lithic artifacts, it might originate from some older, possibly Paleolithic, assemblage in the vicinity and could have been mixed into the lowermost deposit either naturally or through human action.

The presence of bifacial thinning flakes only in layer 12 suggests temporal changes in the lithic technological organization and/or activity areas within the site. Perhaps hunting with bifacial points was more prevalent during the earlier phases of site use, and later, when pastoralism became more established in the area, different kinds of stone tools might have become important or, possibly, bronze implements could have taken the place of bifaces. In the future it is vital to collect a larger lithic assemblage from ZK513's well-preserved stratified contexts to gain a better temporal control over the Holocene lithic technology in the area.

5.4. Faunal remains

2735 bones and bone fragments were uncovered from ZK513–1 (Table 7). Full analysis of the faunal material is ongoing (including ZooMS and DNA), but already noteworthy is the generally well-preserved state of the remains in comparison with those from other

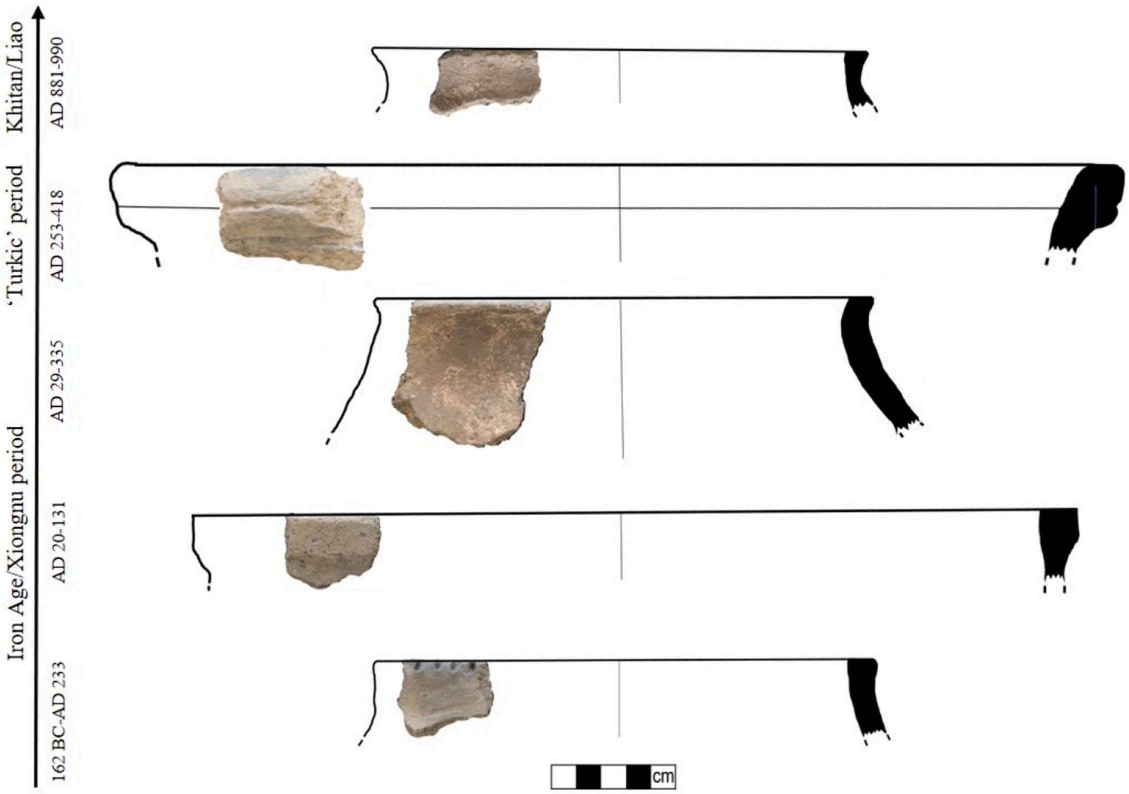

Fig. 8. Chronological sequence of ceramic forms from ZK513–1. Dates reflect the range of 2σ calibrated dates (Illustration Eric Sarfeld and Jean-Luc Houle).

Table 5
Lithic raw materials in different layers.

Layer	Chert	Chalcedony	Jaspis	Quartzite	Rock crystal	Metamorphic	Total
0	7		1				8
3	3						3
4	3					1	4
5	6						6
6	10						10
7	11	1			2		14
8	10	2			1		13
9	3						3
10	2						2
11	3	14				1	18
12	3	13		2		2	20
Total	61	30	1	2	3	4	101

Table 6
Types of lithic artifacts per layer.

Layer	Blade	Blade fragment	Flake	Bifacial thinning flake	Flake fragment	Core rejuvenation flake	Microblade core	Microblade core fragment	Scraper	Flaked axe	Polishing stone	Total
0	1	6			1							8
3					2					1		3
4		1	1		1						1	4
5	1	2	1		1	1						6
6		3			5	1	1					10
7	2	3	6		2				1			14
8		6	1		5				1			13
9		2	1									3
10			1		1							2
11		8	1		5			1	3			18
12			6	8	6							20
Total	4	31	18	8	29	2	1	1	5	1	1	101

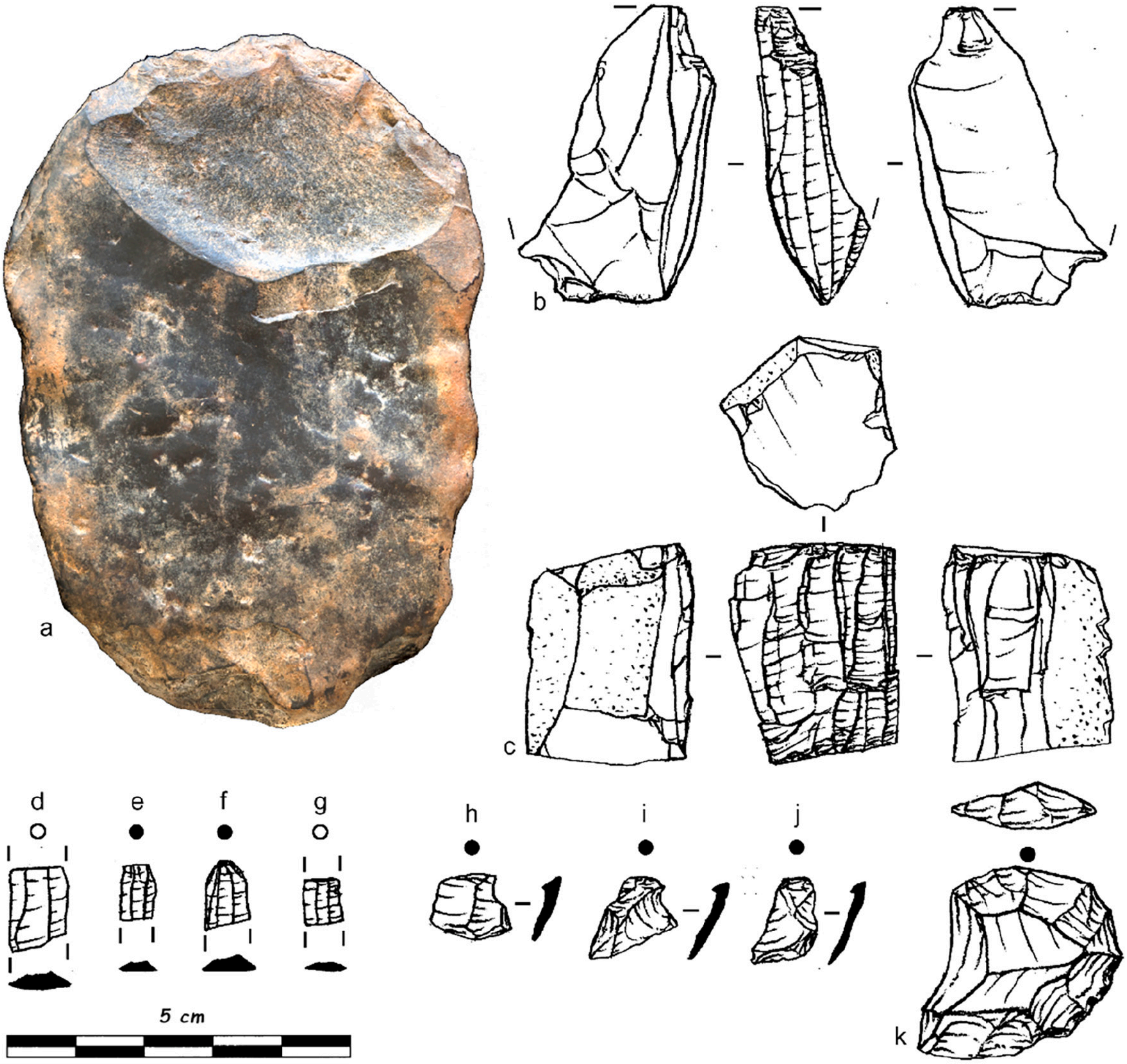

Fig. 9. Lithics from ZK513–1 (layer in parentheses). a: Flaked axe (3); b: Fragment of a wedge-shaped microblade core (11); c: Cylindrical microblade core (6); d–g: Microblade fragments (6, 8, 11, 11); h-j: Biface thinning flakes; k: Rounded flake with a prepared platform (12) (Photograph Sophie Lafrance, illustration Oula Seitsonen).

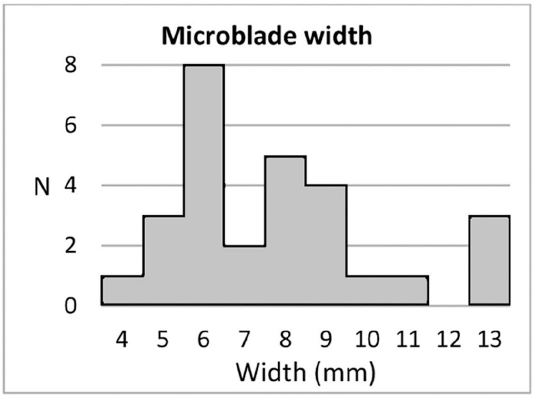

Fig. 10. Microblade widths from ZK513-1.

habitation sites in Mongolia. The bones from the Iron Age layer 7, in particular, are in excellent condition, including, for instance, perfectly preserved and articulated caprine (*Ovis aries/Capra hircus*) remains, such as intact scapulae, a skull, and an ABG (Associated Bone Group) consisting of parts of the right acetabulum and left and right femurs. This ABG featured knife cuts around the acetabulum and on the shaft of the right femur, suggesting disarticulation with the knife and filleting of the femur. In total, eleven specimens from the trench exhibited butchery marks associated with primary and secondary butchery practices, including one from the bottommost layer 12: a caprine astragalus chopped through obliquely, demonstrating much less careful disarticulation than was evident from the Iron Age pelvis.

Significantly, although wild animals are present on the site throughout the sequence, probable domestic animals, and therefore pastoralists, are present from the beginning. There is a danger in faunal analysis of introducing circular arguments around identification, particularly with some species, such as horses, where differentiation between wild and domestic forms is practically impossible in early periods. This is due to the similarities in size and morphology between early domestic and wild forms. Our current understanding is that domestic horses are present in central Kazakhstan and in Xinjiang by around 1500 BCE, based on DNA analysis (Librado et al., 2021; Wang et al., 2018). Often, then, 'wild' and 'domestic' labels are attached to specimens due to other archaeological data from the site. Some species can be considered more secure in this contextual argument than others, however – the wild ancestors of caprines are absent from Mongolia, for

Table 7
NISP (Number of Identified SPecimens) and NSP (Number of SPecimens) from each layer of ZK513-1.

Layer	*Bos taurus Taurus/ Bos grunniens*	cf. *Bos taurus Taurus/ B. grunniens*	*Ovis aries/ Capra hircus*	cf. *O. aries/ C. hircus*	*O. aries*	*C. hircus*	*O. aries/ C. hircus/ Ovis ammon*	cf. *O. ammon*	cf. *Capreolus capreolus*	*Equus caballus*	*Felis* sp.	*Marmotta* sp.	Vole/ hamster	Micro mammal	Small mammal	Medium mammal	Large mammal	Total NISP	Total NSP
1	1	1	12		1	1				1	1					15	16	49	110
2	1		5							1							1	8	110
3	2		4		1		1		1	2				1	1		1	14	605
4	1		5	3			1					1					10	21	476
5			1							2						1		4	153
6	3		1	1						1						4		10	143
7			26		3			2		1			1			75		108	310
8	1		4													12	3	20	453
9	1		1															2	22
10																		0	16
11		1	1	1						1		1						5	131
12					1		5	2		1		1			1		15	26	206
Total	10	2	60	5	6	1	7	4	1	10	1	3	1	1	2	107	46	267	2735

example, and their nearest relative, the morphologically similar Argali, is so much larger as to present little risk of confusion. Thus, we may, with some confidence, assign domestic/wild labels to taxa within an assemblage with recourse to the size of specimens found (even when they are not complete enough to take measurements), the wider archaeological record from the site, comparison with the assemblage from the site in other phases, and through comparison with archaeological sites from the broader region. For example, early domesticated sheep and cattle have possibly been identified at the stratified Toora Dash settlement in Tuva [ca. late 3rd to early 2nd millennium BCE] (Semenov, 2018) and at a likely habitation site dated to ca. 2136–1907 BCE at Biluut in the Mongolian Altai (Taylor et al., 2020:6). It is also worth noting that domestic sheep dating to ca. 3000 BCE have been confirmed without any doubt through mtDNA at the Afanasievo settlement site Nizhnyaya Sooru in the northern Altai (Hermes et al., 2020). Evidence of dairying corroborated by specific milk proteins (Bovinae or *Ovis* genus) has also been found through the analysis of human dental calculus of a ca. 3000 BCE Afanesievo individual in central Mongolia (Wilkin et al., 2020).

Both the sheep (*Ovis aries*) and horse (*Equus caballus* [includes *Equus caballus caballus* and *Equus caballus przewalskii*]) specimens from layer 12 at ZK513–1 would be to our knowledge some of the earliest yet dated from Mongolia (2026 to 1881 cal BCE). Also, probable domestic cattle or yaks (*Bos taurus taurus/Bos grunniens*) are present from at least 1883–1696 cal BCE. Note that, as suggested above, we can be more confident of horses being domestic from more recent layers, and that DNA analysis, in addition to direct dating, would be necessary for us to be absolutely certain, but little doubt should be cast on the caprine specimens. Given that it is only recently that we were able to confirm the presence of Bronze Age pastoralists in Mongolia from zooarchaeological material at habitation sites toward the end of the second millennium BCE (Broderick and Houle, 2012; Houle, 2010) and that cattle have only recently been documented from khirigsuur ritual sites of Late Bronze Age date (Broderick et al., 2014; Broderick et al., 2016), this set of dates is highly important for our understanding of the development of pastoralism and related ritual practices in Mongolia and in the wider region. The presence of pastoralists and domestic animals on this site at this time would also fit with current models for the spread of pastoralism into Mongolia by Afanasievo-related groups, from the Altai and Minusinsk regions to the Khangai in central Mongolia, between 3000 and 1500 BCE (Honeychurch et al., 2021), adding to evidence in support of that theory. Though in this case, it may have been through a northern route (cf. Honeychurch et al., 2021:13).

6. Discussion

The results of our work at ZK513 and the surrounding region are starting to contribute much-needed details about the chronology of early pastoralism in Mongolia. This is important as it seems increasingly likely that this region of north/northwestern Mongolia also played a major role in the adoption and spread of equestrian pastoralism. Thus far, outside the southeastern Gobi (Honeychurch et al., 2021:15), it is in Züünkhangai (Uvs) and in the adjacent northern provinces of Khovsgol and Arkhangai that we have the earliest radiocarbon dates for domesticated horses (Taylor et al., 2017). These come from ritual contexts (khirigsuurs) and date to between ca. 1300 and 1000 BCE (Fitzhugh, 2009a, 2009b; Fitzhugh and Bayarsaikhan, 2011; Taylor et al., 2017). In addition, probably domesticated sheep/goat and cattle bones have also been found together in a Bronze Age burial (1925–1691 cal BCE) in the Darkhad Depression of northern Mongolia (Clark, 2014:103), while horse bones may have been found in a nearby burial that dates to the same period (Fitzhugh and Bayarsaikhan, 2008:33). However, it is important not to conflate ritual practices and subsistence systems. The presence of these species in ritual contexts does not reveal the degree to which the people utilized and relied upon these domesticated animals for their subsistence and other needs. As the evidence for dairying from an Afanesievo individual in a burial that lacks faunal remains in central Mongolia suggests (Honeychurch et al., 2021:11), it is likely that there was some lag between the adoption of domesticated animals and their integration into large-scale communal ritual activities. The probable presence of domesticated sheep and possibly horse (though DNA work has to be done before confirming this) in a domestic context (ZK513) dated to between 2026 and 1881 cal BCE offers the possibility of this, as this precedes by several hundred years the construction of ritual monuments belonging to the Deer Stone-Khirigsuur (DSK) culture (Fitzhugh, 2009a). During the DSK period (ca. 1200–700 BCE) calcined sheep/goat bones and horse crania and vertebrae were intentionally deposited around khirigsuurs and deer stones.

The timing for the introduction of various domesticated species in Mongolia is also important. For example, contrary to what some researchers working in the Eurasian steppe have suggested (Anthony, 2007:160–161; Christian, 1998:99), domesticated animals do not always arrive together in comprehensive packages, and they certainly do not always occur in tandem with ritual activities that include these animals. It is clear from the sequence at ZK513 that this is not the case. The pattern and timing for the introduction of different domestic animal species in Züünkhangai is also quite different from what has been found in the Khanuy Valley region of central Mongolia (Houle, 2010), the Altai region (Houle, 2016; Kovalev and Erdenebaatar, 2010), and the Gobi Desert (Janz et al., 2017; Janz et al., 2020). Accordingly, it is becoming increasingly clear that the answer to these questions will not come from a single region of Mongolia and certainly not from monuments alone. Sites like ZK513 may thus play a crucial role in understanding non-unilinear trajectories for the development of pastoralism in Mongolia and the surrounding region.

Some influential models also see climate deterioration or resource scarcity as being the impetus for the emergence and the development of mobile pastoralism. For example, one widespread archaeological theory put forth by Anatoly Khazanov (1994:95) argues that more sedentary herders developed horseback riding and seasonal migration patterns as a response to prolonged drought during the late second millennium BCE. While not seeing climate change as the impetus, both Janz et al. (2020) and Honeychurch et al. (2021) indicate that the shift toward more intensive pastoralism correlates respectively with aridification in the Gobi and variable sub-regional climate regimes in central Mongolia after ca. 2000 BCE. Others have gone further and have suggested that drought led to the collapse of Bronze Age societies in Mongolia and to vast westward migrations around 1000–700 BCE (Koryakova and Epimakhov, 2007:211). However, the sequence at ZK513 seems to refute these ideas. In fact, domesticated animals probably appear during a period when local conditions were likely humid, then disappear from the sequence during a prolonged period of drought that precedes by centuries the 1000–700 BCE period, and reappear at the site when conditions became wetter and more stable – a period also associated with horse and sheep/goat rituals at monumental DSK sites in Mongolia (Taylor et al., 2017). Indeed, although it is commonly assumed that the Holocene Megathermal for Mongolia is a dry moment, it is currently not possible to assume a general trend because environmental data varies locally. In fact, there are many localities where a wet phase is recorded during the Holocene Megathermal (An et al., 2008). For example, while the paleoecological record showing arid conditions during the late Holocene for the province of Uvs generally hinges on Uvs Lake, which is ca. 200 km northwest of our research area (Grunert et al., 2000; Walther, 2010), recently published data shows that palaeohydrological conditions at the closer Lake Telmen, situated ca. 150 km east of our research area, shifted toward humid conditions around 1200 BCE (Klinge and Sauer, 2019; Struck et al., 2022). Accordingly, it seems possible that things played out differently in different regions of Mongolia depending on specific local conditions, herd composition, mobility patterns, social arrangements, etc. That being said, we are also aware that the data presented here is coming from an anthropogenic site and it could be reflecting the local scale environment signals. Thus, the possibility of registering human modified environmental signatures should not be discarded. New biomarkers and compound-specific stable isotope analyses could help elucidate this issue better.

Regardless, despite the relatively small sample size, it is interesting to note that the ratio of animals at ZK513 fluctuates through time. This could relate to changes in socioeconomic or finer grain climatic and/or environmental conditions through time. In any case, these fluctuations together with the continuous occupation of the site over millennia index the adaptive resilience of the Mongolian herders here. When prolonged environmental downturns hit the region, however, the site was abandoned or less-intensively occupied for long periods of time, only to be reoccupied when favorable conditions returned. This, of course, has implications for current herding lifeways in the region due to climate change.

The WMAP project is also providing important information on the long-term patterns of settlement geography in this region of Mongolia. According to our survey results, there is significant continuity in the location of campsites. Although only part of the seasonal nomadic round is currently known for this region (cf. Houle, 2016; Houle and Broderick, 2011), the recurrent use of ZK513 during the winter over the past 4000 years suggests a time-tested and well-established settlement system that seems to be linked to seasonal changes. Modern and historic movement between winter and summer campsite locations in the Züünkhangai region is about 30–50 km (Bazargur, 2002). Survey work by our team in a region ca. 30 km northeast of ZK513 identified monuments and occupation sites in areas currently used by herders during the summer. Future work there might thus identify the missing part(s) of the past seasonal nomadic round.

7. Conclusion

To our knowledge, ZK513 represents the first such deeply stratified Holocene multiperiod pastoralist open-air habitation site known in Mongolia, with over 165 cm deep archaeological deposits with clear chronological control. This allows an unprecedented chance to follow the development of various technological and economic characteristics, as well as ecological conditions over time at the same locality. The likely presence of pastoralists throughout the sequence suggests that the needs of these individuals were probably governed in the past, as in the present, first and foremost by the requirements of domestic animals, and by the general need for shelter from the elements such as the prevailing northerly winter winds. Thus, the narrow valley draw at ZK513 with its protective cliffs on three sides and the readily accessible winter pastures have likely offered a good seasonal settlement site for herders through time (see Frachetti and Maksudov, 2014:209, for a similar observation in Uzbekistan). Most importantly, the finds from ZK513 highlight the adaptive resilience of the Mongolian herders throughout the past four millennia, indeed up to the present day, despite major changes in the sociopolitical, socioeconomic, and environmental conditions through time. Forthcoming work in the region, including more extensive excavations of habitation sites and more detailed analysis of the sediments, the botanical and faunal remains (including DNA analysis), as well as the material culture will enable us to elaborate on these initial findings.

Declaration of Competing Interest

The authors declare no conflicts of interest.

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References

An, C.B., Chen, F.H., Barton, L., 2008. Holocene environmental changes in Mongolia: a review. Glob. Planet. Chang. 63 (4), 283–289.

Anthony, D.W., 2007. The Horse, the Wheel and Language: How Bronze Age Riders from the Eurasian Steppes Shaped the Modern World. Princeton University Press, Princeton.

Bazargur, D., 2002. Territorial organization of Mongolian pastoral livestock husbandry in the transition to a market economy. Focus. Geogr. 47, 20–24.

Broderick, L.G., Houle, J.-L., 2012. More than just horse: dietary breadth and subsistence in bronze age Central Mongolia. Mongolian J. Archaeol. Anthropol. Ethnol. 7 (1), 149–157.

Broderick, L.G., Houle, J.-L., Seitsonen, O., Bayarsaikhan, J., 2014. The mystery of the missing caprines: stone circles at the Great Khirigsuur in the Khanuy Valley. Studia Archaeol. 34 (Археологийн Судлал).

Broderick, L.G., Seitsonen, O., Bayarsaikhan, J., Houle, J.-L., 2016. Lambs to the slaughter: a zooarchaeological investigation of stone circles in Mongolia. Int. J. Osteoarchaeol. 26, 537–543.

Bronk Ramsey, C., 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51, 337–360.

Chen, C., Hsin-Chi Lan, J. Lou, Chen, Yan-Cheng, 2003. The dry holocene megathermal in Inner Mongolia. Palaeogeogr. Palaeoclimatol. Palaeoecol. 193, 181–200.

Christian, D., 1998. A history of Russia, Central Asia and Mongolia. Volume 1: Inner Eurasia from prehistory to the Mongol Empire. In: The Blackwell History of the World 1. Blackwell Publishers, Malden, MA.

Clark, J., 2014. Modeling late prehistoric and early historic pastoral adaptations in Northern Mongolia's Darkhad Dedpression. PhD thesis. University of Pittsburgh, USA.

Erdenebaatar, D., Kovalev, A.A., 2007. Mongol Altain bus nutgiin arkheologiin soeluud. Mongolian J. Anthropol. Archaeol. Ethnol. 3 (287), 35–50.

Eregzen, G., 2016. Ancient Funeral Monuments of Mongolia. Mongolian Academy of Sciences.

Fitzhugh, W., 2004. Project goals and 2003 fieldwork. In: Fitzhugh, W. (Ed.), The Hovsgol Deer Stone Project. 2003 Field Report. Smithsonian Institution, Washington, pp. 1–24.

Fitzhugh, W., 2009a. The Mongolian deer stone-khirigsuur complex: dating and organization of a late Bronze Age menagerie. In: Bemmann, J., Parzinger, H., Pohl, E., Tseveendorj, D. (Eds.), Current Archaeological Research in Mongolia: Papers from the 1st International Conference on Archaeological Research in Mongolia Held in Ulaanbaatar, August 19the23rd, 2007. University of Bonn, Bonn, pp. 183–199.

Fitzhugh, W., 2009b. Pre-scythian Bronze Age ceremonialism and art in northern Mongolia. In: Hanks, B.K., Linduff, K.M. (Eds.), Social complexity in Prehistoric Eurasia: Monuments, metals and mobility. Cambridge University Press, Cambridge, pp. 378–411.

Fitzhugh, W., Bayarsaikhan, J. (Eds.), 2008. American-Mongolian Deer Stone Project: Field Report 2007. Arctic Studies Center, Washington, DC.

Fitzhugh, W., Bayarsaikhan, J., 2011. Mapping ritual landscapes in Bronze Age Mongolia and beyond: Unraveling the deer stone–khirigsuur enigma. In: Sabloff, P. (Ed.), Mapping Mongolia: Situating Mongolia in the World from Geological Time to Present. University of Pennsylvania Press, Philadelphia, pp. 166–192.

Fowell, S.J., Hansen, B.C.S., Peck, J.A., Khosbayar, P., Ganbold, E., 2003. Mid to late Holocene climate evolution of the Lake Telmen Basin, north central Mongolia, based on palynological data. Quat. Res. 59 (3), 353–363.

Frachetti, M.D., Maksudov, F., 2014. The landscape of ancient mobile pastoralism in the highlands of southeastern Uzbekistan, 2000 BCE–1400 CE. J. Field Archaeol. 39 (3), 195–212.

Gardner, W.R.M., Burentogtokh, J., 2018. Mobile domiciles of the Eurasian Steppe: archaeological evidence of possible dwelling space during the early iron age. J. Field Archaeol. 43 (5), 345–361.

Gladyshev, S.A., Olsen, J.W., Tabarev, A.V., Jull, J.T., 2012. The upper paleolithic of Mongolia: recent finds and new perspectives. Quat. Int. 281, 36–46.

Grunert, J., Lehmkuhl, F., Walther, M., 2000. Paleoclimatic evolution of the Uvs Nuur basin and adjacent areas (Western Mongolia). Quat. Int. 65 (66), 171–192.

Hermes, T., Tishkin, A., Kosintsev, P., Stepanova, N., Krause-Kyora, B., Makarewicz, C., 2020. Mitochondrial DNA of domesticated sheep confirms pastoralist component of Afanasievo subsistence economy in the Altai Mountains (3300–2900 cal BC). Archaeol. Res. Asia 24 (100), 232.

Honeychurch, W., 2015. Inner Asia and the Spatial Politics of Empire: Archaeology, Mobility, and Culture Contact. Springer, New York, Heidelberg, Dordrecht, London.

Honeychurch, W., Wright, J., Amartuvshin, Ch., 2007. A nested approach to survey in the Egiin Gol Valley, Mongolia. J. Field Archaeol. 32, 369–383.

Honeychurch, W., Rogers, L., Amartuvshin, Ch., Erdenebaatar, D., Nasan-Ochir Erdene-Ochir, M.E. Hall, Hrivnyak, M., 2021. The earliest herders of East Asia: examining afanasievo entry to Central Mongolia. Archaeol. Res. Asia 26 (100), 264.

Houle, J.-L., 2010. Emergent Complexity on the Mongolian Steppe: Mobility, Territoriality, and the Development of Early Nomadic Polities. PhD. thesis. University of Pittsburgh, USA.

Houle, J.-L., 2016. Long-term occupation and seasonal mobility in Mongolia: A comparative analysis of two mobile pastoralist communities. In: Weber, Kathryn, Hite, Emma, Smith, Adam T., Khatchadourian, Lori (Eds.), Fitful Histories and Unruly Publics: The Archaeology of Eurasia from Past to Present. Oxford University Press.

Houle, J.-L., Broderick, L.G., 2011. Settlement patterns and domestic economy of the Xiongnu in Khanuy Valley, Mongolia. In: Brosseder, Ursula, Miller, Bryan K. (Eds.), Xiongnu Archaeology: Multidisciplinary Perspectives of the First Steppe Empire of Inner Asia, Bonn Contributions to Asian Archaeology, 5. Bonn University Press, Bonn.

Jacobson-Tepfer, E., Meacham, J.E., 2009. Archaeology and Landscape in the Altai Mountains of Mongolia. https://mongolianaltai.uoregon.edu. Accessed March 2022.

Jacobson-Tepfer, E., Meacham, J.E., Tepfer, G., 2010. Archaeology and Landscape in the Mongolian Altai: An Atlas. Esri Press, Redlands, CA.

Janz, L., 2006. Shabarakh-usu and the Dune Dwellers of the Gobi: Explanations for Lithic Assemblage Variability in the Gobi Desert, Mongolia. MA thesis. Department of Anthropology, University of Arizona.

Janz, L., 2012. Chronology of Post-Glacial Settlement in the Gobi Desert and the Neolithization of Arid Mongolia and China. PhD. thesis. University of Arizona, Tucson, USA.

Janz, L., Odsuren, D., Bukhchuluun, D., 2017. Transitions in palaeoecology and technology: hunter - gatherers and early herders in the Gobi Desert. J. World Prehist. 30 (1), 1–80.

Janz, L., Cameron, A., Bukhchuluun, D., Odsuren, D., Dubreuil, L., 2020. Expanding frontier and building the sphere in arid East Asia. Quat. Int. 559, 150–164.

Jenkins, E., Jamjoum, K., Nuimat, S., Stafford, R., Nortcliff, S., Mithen, S., 2016. Identifying ancient water availability through phytolith analysis: an experimental approach. J. Archaeol. Sci. 73, 82–93.

Khazanov, A., 1994. Nomads and the Outside World. University of Wisconsin Press, Madison.

Klinge, M., Sauer, D., 2019. Spatial pattern of Late Glacial and Holocene climatic and environmental development in Western Mongolia - a critical review and synthesis. Quat. Sci. Rev. 210, 26–50.

Koryakova, L.N., Epimakhov, A.V., 2007. The Urals and Western Siberia in the Bronze and Iron Ages. Cambridge University Press, Cambridge.

Kosintsev, P.A., Stepanova, N.F., 2010. Fauna Afanas'evskogo poseleniia Malyi Dugan. In: Stepanova, N.F., Poliakov, A.V. (Eds.), Afanas'evskii sbornik. Azbuka, Barnaul, pp. 121–129.

Kovalev, A.A., Erdenebaatar, D., 2009. Discovery of new cultures of the Bronze Age in Mongolia according to data obtained by the International Central Asian Archaeological Expedition. In: Bemmann, J., Parzinger, H., Pohl, E., Tseveendorj, D. (Eds.), Current archaeological research in Mongolia. Rheinische Friedrich-Wilhelms-Universität, Bonn, pp. 149–170.

Kovalev, A.A., Erdenebaatar, D., 2010. Afanas'evsko-Chemurchekskaia kurgannaia gruppa Kurgak gobi (Khuurai gobi) i voprosy vneshnikh sviazei afanas'evskoi kul'tury. In: Stepanova, N.F., Poliakov, A.V. (Eds.), Afanas'evskii sbornik. Azbuka, Barnaul, pp. 91–108.

Librado, P., Khan, N., Fages, A., et al., 2021. The origins and spread of domestic horses from the Western Eurasian Steppes. Nature 598, 634–640.

Lombardo, U., Ruiz-Pérez, J., Madella, M., 2016. Sonication improves the efficiency, efficacy and safety of phytolith extraction. Rev. Palaeobot. Palynol. 235, 1–5.

Madella, M., Jones, M.K., Echlin, P., Powers-Jones, A., Moore, M., 2009. Plant water availability and analytical microscopy of phytoliths: implications for ancient irrigation in arid zones. Quat. Int. 193 (1–2), 32–40.

Manzano, P., Burgasa, D., Cadahíaa, L., Eronen, J.T., Fernández-Llamazares, A., Bencherif, S., Seitsonen, O., Fortelius, M., Fernández-Giménez, M.E., Galvin, K.A., Cabeza, M., Stenseth, N.C., 2021. Toward a holistic understanding of pastoralism. One Earth 4 (5), 651–665.

Reimer, P.J., et al., 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55, 1869–1887.

Rogers, J.D., 2012. Inner Asian States and empires: theories and synthesis. J. Archaeol. Res. 20 (3), 205–256.

Seitsonen, O., Égüez, N., 2021. Here be Reindeer: geoarchaeological approaches to the transspecies lifeworlds of the Sámi reindeer herder camps on the tundra. Iskos 24, 124–145.

Seitsonen, O., Houle, J.-L., Broderick, L.G., 2014. GIS approaches to past mobility and accessibility an example from the bronze age Khanuy Valley, Mongolia. In: Leary, J. (Ed.), Past Mobilities. Archaeological Approaches to Movement and Mobility. Ashgate Publishing, Farnham, pp. 79–112.

Seitsonen, O., Houle, J.-L., Broderick, L.G., Woodley, P., Bayarsaikhan, J., 2018. Lithics in the steppe landscape: an off-site spatial analysis of stone artifacts in the Khanuy Valley, Mongolia. Archaeol. Res. Asia 16, 1–13.

Semenov, V.A., 2018. Toora-Dash. Multi-Layered Parking on the Yenisei in Tuva. IIMK RAS, Nevskaya Book Typography, Saint Petersburg, p. 340 [СеМенов В. А. 2018. Тоора-Даш. Многослойная стоянка на Енисее в Туве. СПб.: ИИМК РАН, Невская КниЖная Типография, 340 с.].

Shahack-Gross, Ruth, Marshall, F., Weiner, S., 2003. Geo-ethnoarchaeology of pastoral sites: the identification of livestock enclosures in abandoned Maasai settlements. J. Archaeol. Sci. 30 (4), 439–459.

Stephens, L., et al., 2019. Archaeological assessment reveals Earth's early transformation through land use. Science 365 (6456), 897–902.

Struck, J., Bliedtner, M., Strobel, P., et al., 2022. Central Mongolian lake sediments reveal new insights on climate change and equestrian empires in the Eastern Steppes. Sci. Rep. 12, 2829.

Taylor, William T.T., Burentogtokh, J., Lowry, K.B., Clark, J., Tuvshinjargal, T., Bayarsaikhan, J., 2017. A Bayesian chronology for early domestic horse use in the Eastern Steppe. J. Archaeol. Sci. 81, 49–58.

Taylor, W.T.T., Clark, J., Bayarsaikhan, J., et al., 2020. Early pastoral economies and herding transitions in Eastern Eurasia. Sci. Rep. 10 (1001), 1–15.

Timireva, S.N., Batkhishig, O., Sycheva, S., Kononov, Y.M., Simakova, A.N., Byambaa, G., Telmen, T., Samdandorj, M., Filippova, K.G., Konsnantinov, E.A., 2020. Landscapes, paleosols and climate in the north of Mongolia during the Holocene. In: IOP Conference Series: Earth and Environmental Science, 438, 012027. https://doi.org/10.1088/1755-1315/438/1/012027.

Vadetskaia, E.B., Poliakov, A.V., Stepanova, N.F., 2014. Svod pamiatnikov afanas'evskoi kul'tury. Azbuka, Barnaul.

Vella, A., 2017. On the Mongolian Steppe: A Subsurface Investigation of Soyo, Northern Mongolia. MA thesis. Flinders University, USA.

Volkov, V.V., 1980. Kurgany afanas'evskogo tipa v Mongolii. Arkheol. sudlal 9, 13–16.

Walther, M., 2010. Paleo-environmental changes in the Uvs Nuur Basin (Northwest-Mongolia). In: Erforschung biologischer Ressourcen der Mongolei / Exploration into the Biological Resources of Mongolia. Paper 55. Martin-Luther-Universität, Halle-Wittenberg, pp. 267–279.

Wang, W., Wang, Y., An, C., Ruan, Q., Duan, Q.F., Li, W., Dong, W., 2018. Human diet and subsistence strategies from the Late Bronze Age to historic times at Goukou, Xinjiang, NW China. The Holocene 28 (4), 640–650.

Wilkin, S., Miller, A.V., Taylor, W., Miller, B., Hagan, R.W., Bleasdale, M., Scott, A., Gankhuyg, S., Ramsøe, A., Uliziibayar, S., Trachsel, C., Nanni, P., Grossmann, J., Orlando, L., Horton, M., Stockhammer, P.W., Myagmar, E., Boivin, N., Warinner, C., Hendy, J., 2020. Dairy pastoralism sustained eastern Eurasian steppe populations for 5000 years. Nat. Ecol. Evol. 4, 346–355.

Wright, J., 2016. Households without houses: mobility and moorings on the Eurasian steppe. J. Anthropol. Res. 72, 133–157.

Zwyns, N., Gladyshev, S.A., Tabarev, A.V., Gunchinsuren, B., 2014. Mongolia: paleolithic. In: Smith, C. (Ed.), Encyclopedia of Global Archaeology. Springer, New York, pp. 5025–5032.