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RESEARCH ARTICLE

The earliest Holocene wanderers through the Gobi Desert evidenced by the radiocarbon chronology of the lakeshore settlement near the Tsakhiurtyn Hondi, Mongolia

P. Bobrowski[1], M. Jórdeczka[1], M. Masojć[2], B. Gunchinsuren[3], T. Goslar[4], R Sikora[5], P. Muntowski[6], D. Odsuren[3,7], M. Szmit[8], D. Bazargur[3], G. Michalec[2] and J. Szykulski[2]

[1]Institute of Archaeology and Ethnology, Polish Academy of Sciences, Branch Poznań, Poland, [2]Institute of Archaeology, University of Wrocław, Poland, [3]Institute of Archaeology, Mongolian Academy of Science, Ulaanbaatar, Mongolia, [4]Faculty of Geographical and Geological Sciences, Adam Mickiewicz University, Poznań, Poland, [5]Polish Geological Institute - National Research Institute, Kraków, Poland, [6]Scientia et Arte Foundation, Gdańsk, Poland, [7]Mongolian National University of Education, Ulaanbaatar, Mongolia and [8]Gdańsk Archaeological Museum, Poland
Corresponding authors: P. Bobrowski; Email: p.bobrowski@iaepan.edu.pl; M. Jórdeczka; Email: m.jordeczka@iaepan.edu.pl and M. Masojć; Email: miroslaw.masojc@uwr.edu.pl

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Abstract

We report a set of radiocarbon dating of prehistoric settlements located on the paleolake Baruun Khuree shores in the Gobi-Altai area, southern Mongolia. The obtained series of 11 AMS ^{14}C measurements on charcoal and other charred plant macro-remains can be associated with one of the earliest episodes of the Holocene highly mobile desert-adapted hunter-gatherers activities from the Gobi desert (ca. 11,250–10,500 cal BP). Exploiting a wide range of environments, including dune fields, they are characterized by pottery usage and microblade core technology with wedge-shaped cores as well as osteological materials. These preliminary results are part of a project analyzing the nature of long-lasting prehistoric occupation around Tsakhiurtyn Hundi (Eng. Flint Valley)—one of the most extensive early prehistoric sites of Central Asia owing its name to the presence of abundant flint outcrops, lithic workshops and their innumerable flint artifacts.

Introduction

Tsakhiurtyn Hundi (Eng. Flint Valley), located about 700 km south of Ulaanbaatar in the *Arts Bogdyn Nuruu* massif on the borderland area between the Altai mountains and the Gobi desert, is one of the most extensive prehistoric sites of Central Asia–Pleistocene and early Holocene flint workshops spread abundantly on dozen square kilometers on mesa-like plateau (Derevianko et al. 2002; Masojć et al. 2017) (Figure 1). Archaeological evidence—comprising more than 150 sites detected from vast areas around those flint outcrops—confirms the long-lasting presence of Pleistocene and early Holocene hunter-gatherer groups inhabiting the mountainous region as well as the paleo-lakeland area located in the present Gobi Desert, south from the Tsakhiurtyn Hundi (Masojć et al. 2024). Five paleolakes have been surveyed so far. According to a paleoenvironmental study, their chronology dates back to ca. 140 ky (Masojć et al. 2024). This paper presents the results of accelerator mass spectrometry (AMS) ^{14}C dating conducted on the group of hearths from early Holocene settlement sites located on one of the paleolake's shores—Lake Baruun Khuree (Lake V) (Masojć et al. 2025). While the recorded workshops from the Tsakhiurtyn Hundi belong mainly to the Pleistocene, the settlement from the lake shores is evidence of the post-LGM and the earliest Holocene human presence in this area.

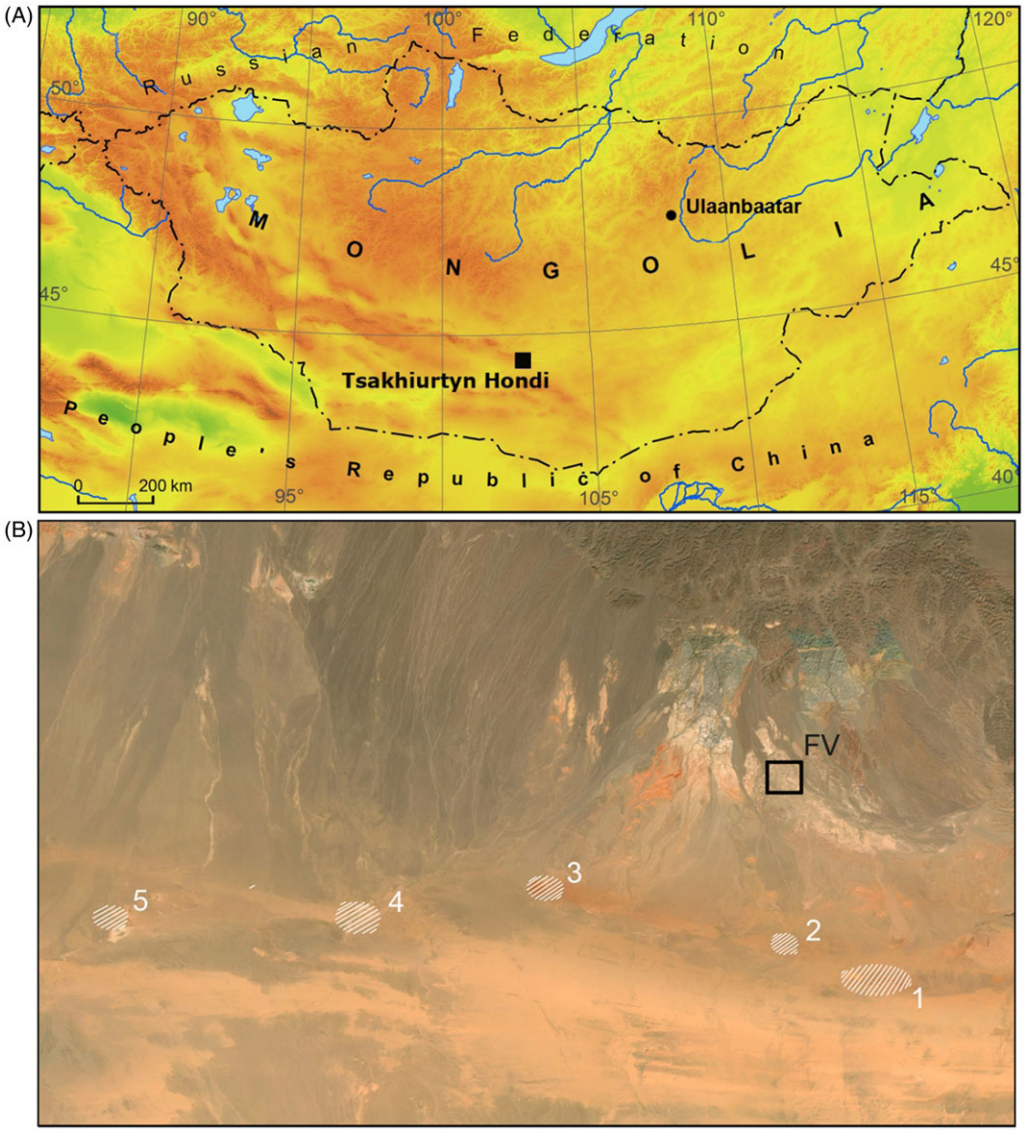

Figure 1. *(A) Location of Tsakhiurtyn Hundi (Flint Valley), Mongolia. (B) Area under investigations. FV—Tsakhiurtyn Hondi (Flint Valley), Paleolakes: 1—Talingaryn Shal; 2—Chavgantsyn Shal; 3—Zhun Khuree; 4—Luulityn Toirom; 5—Baruun Khuree.*

Materials

All samples presented in this report come from six hearths within three sites (FV 133; FV 134—artifact concentration A; FV 139—artifact concentrations A–C) located on the northern shore of the paleolake Baruun Khuree (Lake V) (Figure 2). It is one of several paleolakes registered south of the Tsakhiurtyn Hundi area, located in the SE part of the Arts Bogd Mountains, at the eastern margin of the Gobi Altai Mountains (Masojć et al. 2024, 2025). Archaeological and paleoenvironmental research was carried out around these paleolakes as part of the above-mentioned project. Archaeological evidence confirms the presence on the lake shores of both Pleistocene hunter-gatherers using advanced, predetermined core reduction techniques and early Holocene societies using microlith production of microblades

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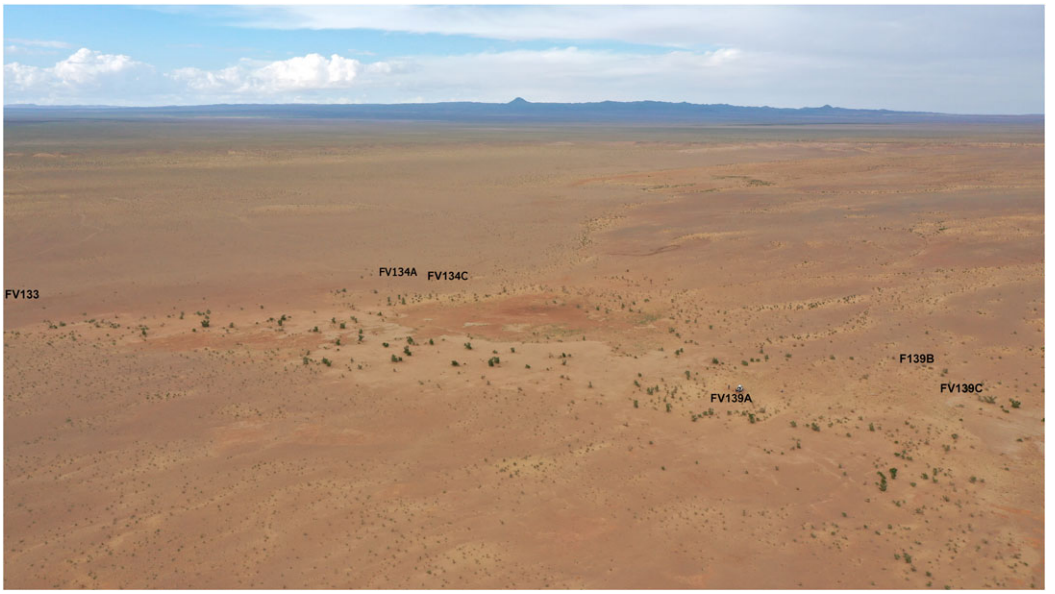

Figure 2. *Aerial picture of the Baruun Khuree paleolake, with the location of sites FV133, FV134 and FV139 marked (photo: M. Szmit).*

(Masojć et al. 2024, 2025). The northernmost and highest located site on Baruun Khuree Lake was FV 133, which was the isolated remains of a small camp. Site FV 134A, located slightly further to the SE, had a similar character, where several isolated concentrations of artifacts were recorded on the surface of a flat terrace, of which two were selected for research. At shallow depths, under concentration A, several small hearths were recorded lying close to each other. The southernmost site was FV 139, located on a flat terrace resulting from the retreat of the paleolake shoreline. Numerous isolated clusters of stone material were recorded here, concentrating around fires, taking the form of small mounds on the surface. Excavations examined three concentrations: A, B, and C. Artifacts were lying on the surface of all the mentioned sites and in the layer below the surface maximum to a depth of 10–15 cm below, and in the fills of the registered features. Samples were taken from the lower parts to the bottoms of the hearths.

The hearths discovered at sites FV 134 A and FV 139 A–C were accompanied by hundreds of artifacts made of chalcedony, quartz and red jasper. These assemblages are characterized by the presence of conical and cylindrical bladelet cores reduced with pressure technique and numerous debitage in the form of bladelets. In individual trenches at site FV 139, distinctive lithic tools, as well as decorated pottery (139 B, C), ostrich eggshell beads and archaeozoological remains were also found. Samples of charcoal were collected from all hearths and then selected in laboratory conditions for dating. Table 1 presents the characteristics of the samples and the dating results.

Methods

^{14}C dating was performed in Poznan Radiocarbon Laboratory (Goslar et al. 2004). Samples of charcoal were first treated chemically with the ABA method (Brock et al. 2010), combusted and graphitised in the automatic system "AGE 3" (Wacker et al. 2010) and analyzed for $^{14}C/^{12}C$ and $^{13}C/^{12}C$ in the spectrometer "Compact Carbon AMS". ^{14}C ages were calculated using formulas of Stuiver and Polach (1977) and then calibrated against curve INTCAL20 (Reimer et al. 2020) using Oxcal v4.2.3 software (Bronk Ramsey 2009, 2013).

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Table 1. *Radiocarbon chronology for Baruun Khuree paleolake settlement, Gobi Desert, Mongolia*

Site/sample name	Laboratory number	Age ^{14}C (uncal.)	^{14}C material/taxa name	C(%)/ $\delta^{13}C_{AMS}$ (‰)	Age cal BP (1σ)	Age cal BC (1σ)
FV133/Hearth1A (smp.4)	Poz-175819	9340 ± 50 BP	Charcoal Indet.	39.2/–17.4	10651 (10548) 10440	8702 (8599) 8491
FV133/Hearth1D (smp.5)	Poz-175820	9360 ± 50 BP	Charcoal Indet.	39.3/–22.2	10655 (10576) 10505	8706 (8627) 8556
FV134A/Hearth3 (smp.3)	Poz-170766	9330 ± 50 BP	Charcoal Indet.	n.a./–15.5	10649 (10536) 10435	8700 (8587) 8486
FV134A/Hearth6 (smp.6)	Poz-170510	9390 ± 50 BP	Charcoal Spiraea sp.	62.3/–26.2	10692 (10619) 10522	8743 (8670) 8573
FV139A/Hearth1 (smp.1)	Poz-170509	9810 ± 50 BP	Charcoal Sorbaria sp.	67.5/–19.9	11251 (11226) 11196	9302 (9277) 9247
FV139A/Hearth1_2 (smp.8)	Poz-170765	9650 ± 50 BP	Charcoal Spiraea sp.	60.0/–24.1	11180 (11013) 10820	9231 (9064) 8871
FV139B/Hearth1 (smp.2)	Poz-170511	9450 ± 50 BP	charcoal Ulmus sp.	68.2/–20.5	10748 (10686) 10584	8799 (8737) 8635
FV139B/Hearth1_ p.2 (smp.)	Poz-170507	9510 ± 50 BP	Charcoal Ulmus sp.	70.4/–25.7	11068 (10814) 10690	9119 (8865) 8741
FV139B/Hearth1_ p.12 (smp.)	Poz-170508	9680 ± 50 BP	Charcoal Indet.	54.3/–12.7	11195 (11101) 10883	9246 (9152) 8934
FV139B/Hearth2 (smp.1)	Poz-170764	9560 ± 50 BP	Charcoal Indet.	66.7/–16.4	11072 (10923) 10758	9123 (8974) 8809
FV139C/Hearth1 (smp.)	Poz-170506	9470 ± 50 BP	Charcoal Sorbaria sp.	70.0/–24.3	10994 (10718) 10589	9045 (8769) 8640

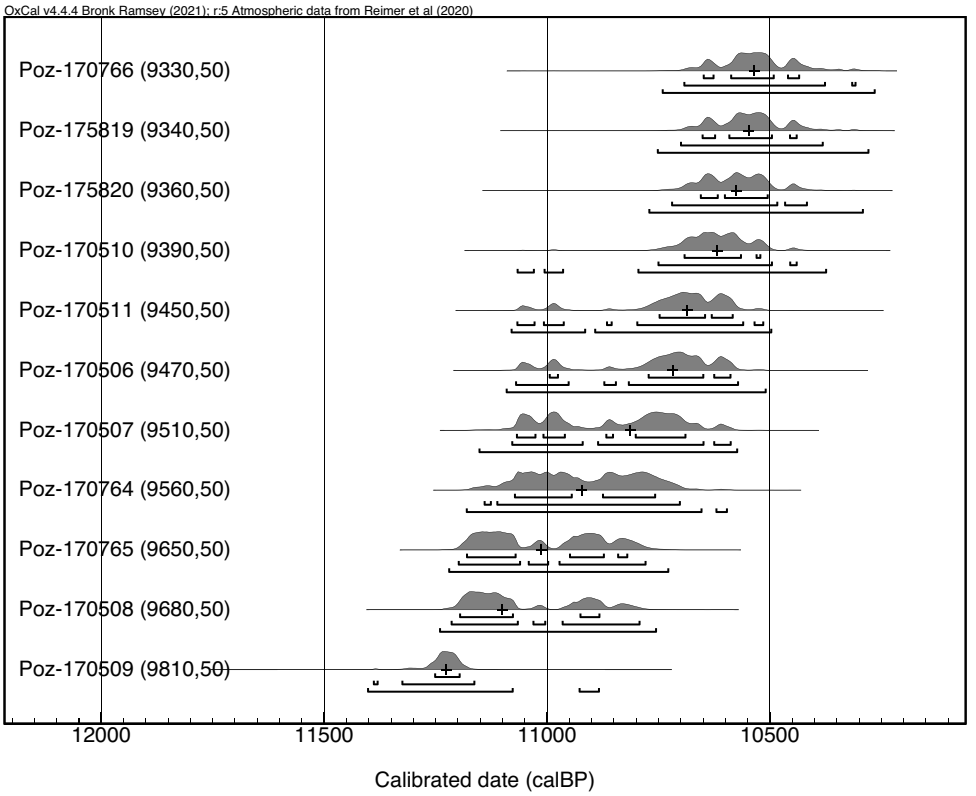

Figure 3. *Baruun Khuree. Calibration of radiocarbon dates on charcoal using the OxCal v.4.4.4 program (Bronk Ramsey 2021). Atmospheric data from Reimer et al. (2020).*

Determining of the reservoir effect

The studied lakes are arranged generally parallel to the axis of the Shereegeen Gashoon intermontane basin (in the E-W direction) and refer to the regional tectonic structures (Cunningham et al. 1996, 2010). For this reason, Lake Baruun Khuree was primarily supplied by the waters of ephemeral rivers from the N and NE directions, which drained the Arts Bogd massif. Remote sensing analyses of satellite images indicate that there was also supply from the S direction, which was of secondary importance.

In the presented dates, the so-called reservoir effect, really an old carbon effect from wood entrained in glacial meltwater, which could affect the age determination of the oldest pottery-yielding cultural layers (Izuho et al. 2022), can be excluded. Previously published studies indicate that mountain glaciers occurred sporadically in the Gobi Altai during the Late Pleistocene and Holocene, because the arid climate was then unfavorable for the development of ice caps (Lee et al. 2013; Lehmkhul et al. 2018; Yu et al. 2017, 2019).

So far, only 3 locations have been documented where glacial deposits have been found (Batbaatar et al. 2018; Khandursen et al. 2023). The closest one is located approx. 200 km to the WNW in the Ikh Bogd massif, where the Ikh Artsan glacier was situated in the valley directed towards the Shereegeen Gashoon basin. The range of its toe was extended not far from the glacial cirque and the waters flowing out of it did not reach the study area. In addition, this glacier nor stagnation for a long time and disappeared about 20.1 ka, soon after the peak of local glacial maximum (Khandursen et al. 2023). This event was much earlier than the dated materials were created.

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The study area is neotectonically active, but no Quaternary volcanoes that could supply thermal waters to the inscribed paleolake have been documented in its vicinity. According to the above information, it should be assumed that the obtained dates are not affected by the old carbon effect.

Results

The set of 11 radiocarbon estimations from the settlement located on the Baruun Khuree lake shores certifies several episodes of post-LGM, early Holocene hunter-gatherer's presence in the northern parts of the Gobi Desert (Table 1, Figure 3). They all fall into the years-scope of ca. 9300–9800 BP (median point ca. 11,225–10,535 cal yr BP), but could be grouped into two major chronological horizons, the younger one around 9300–9400 BP (ca. 10,620–10,535 cal yr BP) from sites FV 133 and FV 134A, and the older one from around 9500-9600 BP (11,100–10,685 cal yr BP) from site FV 139A, B, C with one exceptionally ancient hearth from FV 139A dated to ca. 9810 ± 50 BP (11,251–11,196 cal yr BP at 1σ). They all belong to the first of three distinct phases, Oasis 1–3, determined on the basis of the post-glacial technology and land use (Janz 2012; Janz et al. 2015, 2017).

The first phase—Oasis 1, also called Epipalaeolithic/Mesolithic, lasted from 13500 to 8000 cal BP and correlates well with significant ecological changes that began during the terminal Pleistocene and continued into the middle Holocene (Janz 2012, 2016; Janz et al. 2017, 2021). In monsoonal Central Asia, it began during a period of extremely low moisture availability corresponding to the Younger Dryas (Madsen et al. 1998). The continuing post-LGM trend towards warmer and more humid conditions, along with an increase in seasonality, continued until after 9600 cal BP (Herzschuh 2006). At the same time, increased effective moisture would have resulted in the infilling of lake basins and river channels as well as the stabilisation of alluvial and aeolian deposits formed during the LGM and terminal Pleistocene (Owen et al. 1997; Hülle et al. 2009).

The open-air, lowland settlement from the Baruun Khuree Lake belongs to the earliest post-LGM evidenced human presence from the Gobi Desert. This presence corresponds with the Chikhen Agui cave from the Gobi-Altai area, where post-LGM assemblages are dated to the period 13,400–8700 cal BP, where most dates (hearths) are between 10,000–9000 cal BP (Derevianko et al. 2003; Khatsenovich et al. 2023). Some other sites of similar chronology from the Gobi Desert could be listed, i.e. Shabarakh-usu, Orok Nor, Barogi Usu Valley, Bygat, etc., but their precise dating is doubtful (Janz 2012).

The first use of pottery in Northeast Asia may have occurred around 18,000–16,500 cal yr BP (Keally et al. 2003; Kuzmin 2017), although the oldest dates from southern China are somewhat controversial (Iizuka 2019). The oldest sites from Japan (Kaner and Taniguchi, [2017] 2018), and the Russian Far East (Kuzmin 2017) are dated to more than 15,000 cal yr BP. In northern China, most early pottery sites have an early Holocene chronology (e.g., Yujiagou—Xia et al. 2001; Li et al. 2017), with a few exceptions indicating the possibility of a slightly earlier adaptation of this innovation, from the turn of the Pleistocene and Holocene (the oldest dates reach 13,000 cal yr BP at Houtaomuga, or 11,500–10,700 at Nanzhuangtou—Iizuka 2019; Wu and Zhao 2003). In the Transbaikal region of Siberia, pottery was probably first used around 14,000–13,000 years ago (Kuzmin 2017), although here, too, there are doubts about the oldest datings (Konstantinov 2016; Iizuka 2019). To date, in the Gobi Desert and adjacent areas, the oldest confirmed use of pottery has so far been dated to approximately 9600 cal BP[1]—pottery vessels appear there in the late stage of the Oasis 1 phase (Janz 2012; Janz et al. 2021). From this perspective, the new sequence of radiocarbon estimations, dating precisely several camping episodes from the Baruun Khuree lake area, seems exceptional—besides a highly developed microblade core technology with rounded cores, ostrich eggshell beads including an ostrich eggshell pendant, additionally sites FV 139B and C bear pottery fragments

[1] The earliest date for pottery (11,600 cal year BP [AA89884, AMNH #73/1792A]) comes from Orok Nor, which is located in the Gobi-Altai region, but it is unreliable due to low carbon yields and the anomalously high-fired quality of the pottery sampled. Ostrich eggshells from Orok Nor were dated to 9400 and 9300 cal yr BP (Janz 2012, 122).

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Figure 4. *Baruun Khuree. Trench FV 139 B—bottom of layer 1 (0–10 cm). Pottery from feature 3 (pit within the hearth), recorded 10 cm deeper (photos: P. Muntowski, M. Jórdeczka).*

(Figure 4). In both cases, numerous pottery fragments were found on the surface of the sites and in the immediate contexts of the hearts, including their floor parts. Hence, their connection with the objects and their dating is solidly confirmed. All fragments were decorated with impressed ornaments (various motifs, also on the rim), most often covering all preserved external surfaces. Regarding site FV 139 B, we can talk about several different vessels. The thickness of the ceramics did not exceed 7–8 mm, most often around 5–6 mm. The color varied, from light gray through beige-gray to reddish and dark gray. The sparse source base for early Mongolian pottery makes it difficult to compare the data we collected with other sites[2], but it differs from previously published ceramic materials (see Gladyshev et al. 2013), especially from Neolithic sites (Iizuka et al. 2018). Based on available data, the pottery from Lake V is at least several or a dozen or so centuries older than previously known examples from Mongolia.

[2] Similar conclusions (Gladyshev et al. 2013)

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Conclusions

A set of radiocarbon dates has been reported from the Gobi Desert, where a settlement associated with the Lakeland area has been recently investigated. Although the archaeological analyses are still under development, based on our field observations and the radiocarbon dating, a group of five camp remains bears lithics, pottery, ostrich eggshells and osteological materials dated to the Holocene's beginning. Their chronology falls on the period between 11,250 cal BP and 10,500 cal BP. It is evidence of an early post-LGM population of the new area, which was possible due to the changing, favorable climatic conditions, allowing highly mobile desert-adapted hunter-gatherers to expand across the Gobi Desert. These results also bring new light on hunter-gatherer transformation within the Gobi Desert and the introduction of pottery, which was thought not to appear until about 9600 cal BP within the Mongolian Mesolithic (post-LGM aceramic horizon) (Derevianko and Dorj 1992; Janz 2021).

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