doi:10.17746/1563-0110.2021.49.2.003-022

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Late Pleistocene Paleoenvironments and Episodic Human Occupations in the Orkhon Valley of Central Mongolia

Here, we present initial results of a new course of research being carried out at the Moiltyn-am, Orkhon-1, and Orkhon-7 Paleolithic sites in the Orkhon River Valley, central Mongolia. Our research focuses on the Moiltyn-am site, which preserves a cultural and chronological sequence from the Final Middle to the Late Upper Paleolithic. Results from analyses of rare earth elements, Strontium (Sr) isotopes, and faunal assemblages are correlated with data on

Archaeology, Ethnology & Anthropology of Eurasia 49/2 (2021) 3–22 E-mail: Eurasia@archaeology.nsc.ru

paleoenvironmental conditions in the region during MIS-3 and MIS-2. Our conclusions are based in part upon post-depositional changes detectable in archaeological material from cultural layers at the Moiltyn-am site revealed through convergent analyses of stratigraphy, sedimentology, planigraphy, and the comparison of Sr isotopes in sediments and osteological remains. XRF-derived geochemical data from the Moiltyn-am sedimentary sequence yields evidence of past climatic conditions. We correlated these data with human occupational episodes in the Orkhon Valley during the Middle and Upper Paleolithic, and the results are analyzed in the context of extant paleoenvironmental information from northern Mongolia. Our results indicate a relatively humid climate prevailed during MIS-3, followed by a period of aridification, and the redeposition of sediments at Moiltyn-am. Faunal analysis reveals that Bos sp. and equids were the principal prey species for humans in the Final Middle to Initial Upper Paleolithic, supplemented by members of the Caprinae during the Early Upper Paleolithic. A complex mammoth fauna inhabited forest-steppe and steppe landscapes in the Khangai Mountains during MIS-3 and MIS-2.

Keywords: *Mongolia, Pleistocene, geochemistry, paleoclimate, Paleolithic, fauna.*

Introduction

The large number of Paleolithic archaeological sites discovered thus far in Mongolia establishes it among other important regions preserving evidence of the behavior of Pleistocene people. Mongolia is situated at the nexus of the South Siberian, Central Asian, and North Chinese environmental provinces, and comprises complex biomes and transition zones among them. Despite this diversity of biotic zones, the boundaries of which repeatedly changed during the Pleistocene, thus potentially effecting human subsistence strategies, the range of variability of known Paleolithic archaeological complexes is rather limited. Mongolian sites represent either one technocomplex, most often the Upper Paleolithic (e.g., sites in the middle Selenga River Valley) (Derevianko et al., 2007, 2013; Zwyns et al., 2019; Rybin et al., 2020), or several traditions separated by long hiatuses (e.g., Tsagaan Agui Cave in the Gobi Altai region) (Derevianko et al., 2000). Paleolithic sites located on the upper reaches of the Orkhon River (Khangai Mountain Range, central Mongolia) stand apart. Here, we refer to three stratified archaeological sites (Moiltyn-am, Orkhon-1, and Orkhon-7) located along a 10 kilometer stretch of the river, which have yielded cultural materials representing an unprecedented variety of cultural traditions, technologies, and settlement systems. It is especially important to note that the continuous cultural and stratigraphic sequence recorded in these sites covers the period corresponding to Marine Isotope Stages (MIS) 2 and 3. Here, lithic industries have been attributed to the Middle and Terminal Middle Paleolithic, as well as the Initial, Early, Middle, and Late Upper Paleolithic. It is possible that multiple cultures are represented within these subdivisions.

The valley of the Orkhon, Mongolia's longest waterway and a southern tributary of the Selenga River, defines one of the most important natural pathways connecting arid southern Mongolia (the Gobi Altai region) through the Valley of the Lakes (Nuuruudyn khöndii) with China (Xinjiang and the Ordos Plateau) and, through the Selenga Basin, with southwestern Transbaikalia in Russia (Rybin, Khatsenovich, 2020). Obviously, the complex paleoclimatic conditions characteristic of the Late Pleistocene may have either stimulated or hindered the dissemination of human groups, as well as faunal communities, through these corridors.

Our research, including isotopic and geochemical analyses, chronometric dating, and paleontological investigations, has been aimed at reconstructing past climatic and environmental conditions in the eastern Khangai Mountains and the Orkhon Valley, and comparing those results with evidence for episodic human settlement in the region (Fig. 1). The studies were aimed at identifying factors relevant to the formation of patterns of Pleistocene human settlement in the region, determining the climatic and environmental parameters of the lifeways (and potential coexistence) of hominin ancestors, and correlating the timing of the peopling of this area with the chronology of human occupation in contiguous regions.

We focused on reconsidering earlier-derived stratigraphic data and determining the state of preservation of the layered sequence at Moiltyn-am, one of the most famous open-air Paleolithic sites in Central Asia, which has been regarded since the 1960s as a reference point for understanding the regional Pleistocene cultural sequence (Okladnikov, 1981). Our data provide reliable grounds for reconstructing the environmental and climatic contexts of Pleistocene human habitation and available resources in the Orkhon Valley, as well as for assessing the impact of post-depositional processes on the state of preservation of the cultural remains encountered.

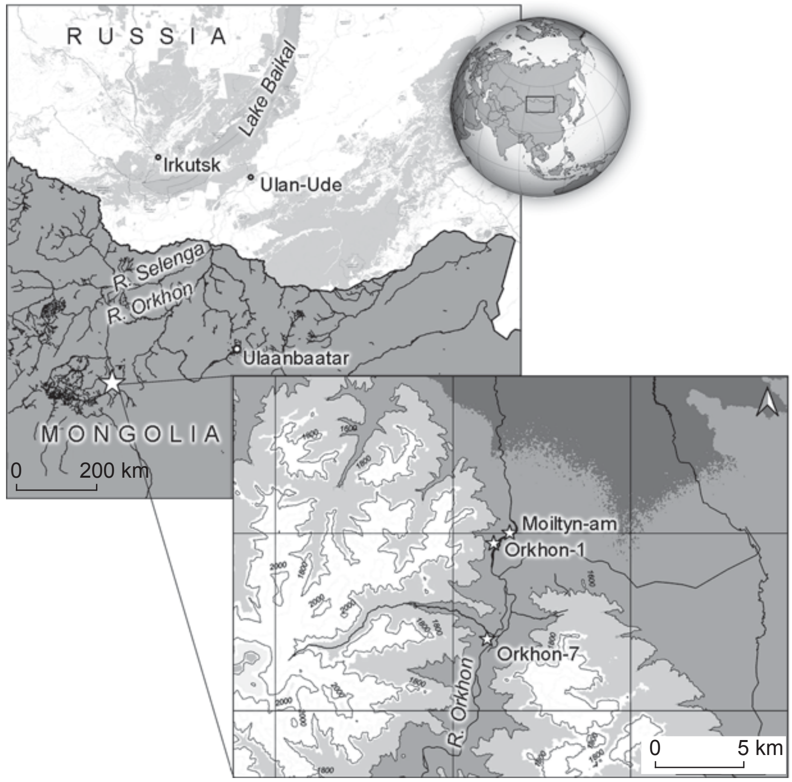

Fig. 1. Map of Paleolithic archaeological sites in the Orkhon Valley, Mongolia.

Research materials and methods

This study is based on materials recovered from three stratified open-air sites located on terrace 2 of the Orkhon River, near Kharkhorin in Övörkhangai Province, where the easternmost foothills of the Khangai Mountains meet the rolling steppe of central Mongolia, about 365 km west-southwest of Ulaanbaatar.

The Moiltyn-am site was discovered by Academician A.P. Okladnikov in 1949 and has been subsequently studied by several research teams: in 1960–1964, investigations there were directed by A.P. Okladnikov and V.E. Larichev, in 1985–1986 under the direction of Academician A.P. Derevianko and V.T. Petrin, and in 1996–1997 by a joint Mongolian-French expedition led by J. Jaubert (Ibid.; Derevianko, Kandyba, Petrin, 2010; Jaubert et al., 2004). All researchers assumed that some layers at Moiltyn-am were redeposited; however, investigations of the mechanics of redeposition and the search for the stratigraphic position of redeposited materials did not adequately clarify the situation, due in part to the lack of organic material suitable for radiocarbon dating. Okladnikov argued that the lower layer of the site contained Middle Paleolithic materials, while overlying strata yielded remains attributable to various subdivisions of the Upper Paleolithic (Okladnikov, 1981).

The Orkhon-1 and Orkhon-7 sites are located 1 and 7 km upstream, respectively, from Moiltyn-am (Fig. 1). These localities have revealed the longest stratified cultural sequences yet known in Mongolia. Two cultural complexes have been identified at Orkhon-1: a Middle Paleolithic horizon and an assemblage probably attributable to the Middle Upper Paleolithic. The Orkhon-7 site yielded a Terminal Middle Paleolithic horizon with a lithic industry documenting the Middle to Upper Paleolithic transition, and an Initial and Early Upper Paleolithic horizon. These sites, with the exception of the Orkhon-1 Middle Paleolithic horizon, yielded sufficient organic material (animal bones and carbonaceous lenses) to generate a large series of radiocarbon dates (Table 1). On the basis of the results of grain-size and palynological analyses and then-available radiocarbon dates, attempts were made in the late 1980s to partially reconstruct the climatic context of Pleistocene human occupation of the Orkhon Valley (Derevianko et al., 1989). Our new course of research initiated in 2018–2019 has clarified previous research data (Khatsenovich et al., 2018, 2019a, b).

A 4 m^2 trench was excavated at Orkhon-1, and an 8 m^2 unit was opened at Moiltyn-am in order to further investigate the stratigraphic relationships of the cultural layers at these sites (Fig. 2). The profiles at Orkhon-1 and Orkhon-7 were cleaned and samples for optically stimulated luminescence (OSL) dating and for a broad range of other analyses were collected from every layer at each these three sites, including Moiltyn-am.

The state of preservation of the deposits was determined based on the analysis of the original positions and orientations of linear artifacts (Bertran, Texier, 1995; McPherron, 2005). This study (Marchenko et al., 2020) yielded results useful for evaluating conclusions drawn by previous researchers (Lenoble, Bertran, 2004).

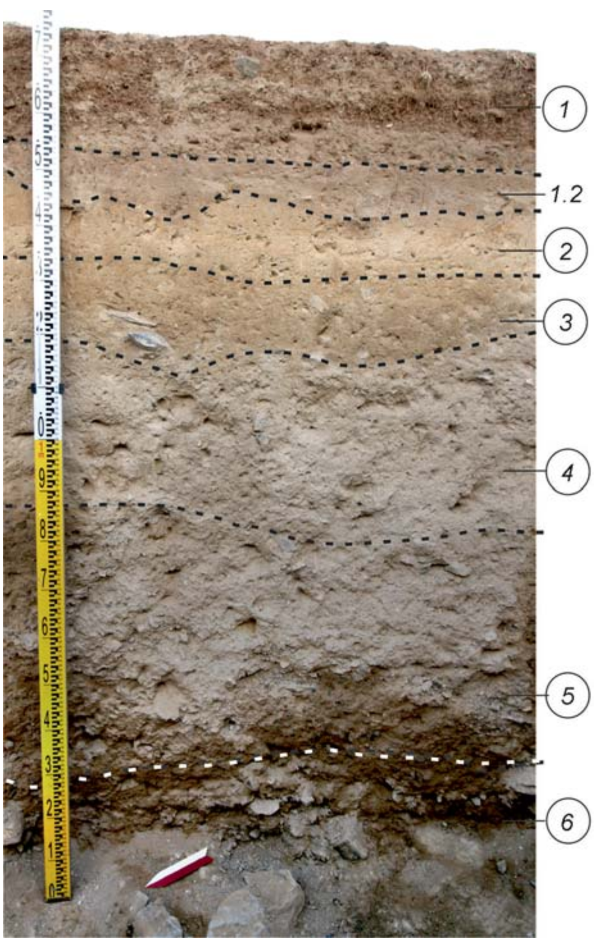

Fig. 2. Stratigraphic section of the southwestern wall of the 2018 excavation unit at Moiltyn-am.
1 – sod and sub-sod layer, bearing a mixed archaeological complex; *2* – layer of yellow-gray loess-like loam, with inclusions of fine gravel and grus, bearing a mixed archaeological complex; *3* – layer of light yellow-brown loam, with inclusions of small and large debris, enclosing an Upper Paleolithic archaeological complex; *4* – layer of convoluted laminar structure, with alternating cemented brown loamy and sandy layers permeated with fine gravel, bearing an Early Upper Paleolithic archaeological complex; *5* – dark brown loamy layer, with frequent shale inclusions, bearing an Early Upper Paleolithic complex; *6* – loose, light brown sandy loam, with significant inclusions of gravel and an Early Upper Paleolithic complex.

Standard archaeozoological analysis was conducted on the faunal collections (Gromova, 1950; Olsen, Shipman, 1988; Reitz, Wing, 2012; Baumann et al., 2020). Since the small-scale work carried out in 2018–2019 was of a preliminary nature, the amount of osteological remains recovered made it possible to identify only one individual of each species in the faunal complexes analyzed. Thus, the number of identified specimens (NISP) for each species was employed as the basis for interpretation. The derived data at least provide grounds for preliminary conclusions to be drawn concerning indicator species for reconstructing past environments.

Calibration and modeling of radiocarbon dates were carried out through OxCal v.4.4.2 software (Bronk Ramsey, 2020) using the IntCal20 calibration curve (Reimer et al., 2020). Although the number of dates was not sufficient for Bayesian analysis, date modeling allowed the identification and elimination of outliers—dates that stand out from the general sample and affect calibration accuracy and precision.

The main sediment-forming elements were determined through X-ray fluorescence (XRF) at the Center for Collective Use of Multielement and Isotope Studies (Sobolev Institute of Geology and Mineralogy, SB RAS, Novosibirsk). Paleogeographic conditions of sedimentation at Moiltyn-am were analyzed on the basis of the following principal geochemical indices:

$CIA = 100 \times Al_2O_3/(Al_2O_3 + Na_2O + CaO + K_2O)$, in which CaO – calcium oxide – a chemical index of alteration, indicates the ratio of primary and secondary minerals (Nesbitt, Young, 1982);

$CALMAG = 100 \times Al_2O_3/(Al_2O_3 + CaO + MgO)$ (Nordt, Driese, 2010) – one of the CIA index variations;

$CIW = 100 \times Al_2O_3/(Al_2O_3 + Na_2O + CaO)$ – chemical index of weathering (Harnois, 1988);

$CPA = 100 \times Al_2O_3/(Al_2O_3 + Na_2O)$ – chemical proxy of alteration (Cullers, 2000; Buggle et al., 2008);

$Al_2O_3/(CaO + Na_2O + K_2O + MgO)$ – a modification of the CIA index; a measure of the intensity of weathering (Gallet, Jahn, Torii, 1996; Retallack, 2001).

The increasing CIA, CALMAG, CIW, and CPA values indicate a warm, humid climate, while decreasing indices point to cold, arid conditions.

$ICV = (Fe_2O_3 + K_2O + Na_2O + CaO + MgO + TiO_2)/Al_2O_3$ – index of compositional variability is a reflection of sediment maturity (Cox, Lower, Cullers, 1995);

$(CaO + MgO)/Al_2O_3$ – an index assessing the accumulation of carbonates (Retallack, 2001);

TiO_2/Al_2O_3 (Schilman et al., 2001) or TM (Yudovich, Ketris, 2011) – this index tracks the degree of homogeneity of the material. It can be used as a paleoclimatic indicator provided that the source of the material remains unchanged.

The following petrochemical modules were also analyzed: Al-Si-M (aluminosilicate), HM (hydrolyzate), FM (femic), FM (ferrous), TM (titanium), NM (sodium), KM (potassium), AM (alkaline), TAM (total alkalinity), NAM (normalized alkalinity) (Ibid.).

Isotope studies were conducted in the Geoanalytic Center for Collective Use (Zavaritsky Institute of Geology and Geochemistry, Ural Branch of the Russian Academy of Sciences, Yekaterinburg). Sample preparation and measurements were executed through methods described in (Vishnevskaya et al., in press). Rare earth elements (REE) content was determined using a NexION 300S quadrupole mass spectrometer (PerkinElmer, USA). Determination of strontium isotopic ratios was carried out on a multicollector inductively coupled plasma mass spectrometer (ICP MS; Neptune Plus, Thermo Scientific, USA). The correctness of the measurement technique was assessed using the international strontium standard SRM-987 ($^{87}Sr/^{86}Sr$ isotopic ratio 0.71025). Mass fractionation was corrected by normalization according to exponential law with respect to a $^{88}Sr/^{86}Sr$ ratio of 8.3752.

Research results

Stratigraphy

Six lithological layers were identified at Moiltyn-am, each of which represents a cultural horizon (Fig. 2). The total thickness of the deposits is 170 cm. Layers 2–4 are deformed conformably; they sank down, probably under the influence of cryogenic processes. Layers 4–6 are combined into a single unit; they have the same sedimentary origin and probably the same age of deposition (distinct from the age of the enclosed archaeological complexes).

The analysis of the directions and orientations of linear artifacts indicates disturbances in all cultural horizons at Moiltyn-am. The layers comprising the middle unit (layers 2 and 3) are composed of scree deposited under dry conditions. The sediments of the lower unit (layers 4–6) exhibit traces of solifluction that occurred when the soil was saturated. Layers visible in the 1990s excavation trench at Moiltyn-am (Lenoble, Bertran, 2004) are better preserved than those of the 2018–2019 trench, located lower on the terrace slope.

The Orkhon-1 stratigraphic column in trench 1-2 comprised seven layers; archaeological horizons are associated with layers 4 and 7. The profile of Orkhon-7, trench 3 (2018–2019) includes 12 layers and generally corresponds with the descriptions by S.V. Nikolaev (Derevianko, Nikolaev, Petrin, 1992, 1994), except for our identification of an additional layer (Khatsenovich et al., 2019b).

Faunal analysis

Only 20 animal bones were recovered at Moiltyn-am. A well-preserved adult tarbagan (*Marmota sibirica*) radius from layer 6 is smaller than that of marmots as a whole (Gromova, 1950). *M. sibirica* is a common member of the Late Pleistocene fauna of the Selenga Basin (Khenzykhenova, 2010). Large ungulates are represented by the remains of a large bovid and a horse. A fragment of a *Bos* sp. indet. humerus from layer 2 exhibits a sharply protruding medial ridge, the edge of which is slightly shifted laterally in the direction of the distal trochlea of the humerus (by 31 % of the width of the entire distal trochlea), which is typical of the genus *Bos* (Bibikova, 1958; Balkwill, Cumbaa, 1992) (Fig. 3, *1*). A scapula fragment from layer 6 represents a medium-sized equid (Fig. 3, *2*). This scapula is somewhat larger than those of the kulan (*E. hemionus*) of southern Siberia; therefore, reliable identification of this specimen is difficult. Pending verification by alternative methods, this specimen is assigned to *Equus* sp. indet.

The fossil collection from the Orkhon-1 2018 excavations contains only seven specimens; insufficient to carry out a comprehensive analysis. Layer 4 yielded fragments of *Equus ferus* bones. Osseous remains from layer 5 were classified to the family Equidae (horse or wild ass). A mandible retaining a single tooth was recovered from layer 7. The adult mandible exhibits certain features of bovid morphology, but is smaller than that of the *Bison priscus* of southern Siberia. The molar (M_3) is 39.3 mm long and 16.8 mm wide; bison teeth from the Angara region are 42.0–54.7 mm long. Thus, the mandible can most likely be attributed to the Baikal yak (*Poephagus baikalensis*).

The Orkhon-7 faunal assemblage is significantly larger (92 spec.), but most of the fossils are unidentifiable fragments. Layer 8 yielded an equid vertebral body and an equid right scaphoid bone. The relative height

Fig. 3. Faunal remains from the Moiltyn-am site.
1 – fragment of *Bos* sp. indet. humerus, layer 2; *2* – fragment of *Equus* sp. indet. scapula, layer 6.

of the latter is noticeably greater than that of ancient European caballoid horses (Langlois, 2005), as well as those of Siberian Late Pleistocene horses*. A mountain sheep or argali (*Ovis ammon*) atlas vertebra recovered from layer 10 is associated with even older remains. The measurements performed according to the method of A. von den Driesh (1976) coincide with those of known *Ovis ammon* from Transbaikalia*.

Radiocarbon dating

Several radiocarbon dates were derived from bone remains recovered from deposits at Moiltyn-am and Orkhon-1. Together with previously published dates from Pleistocene sites in the Orkhon Valley (Derevianko, Kandyba, Petrin, 2010), they attest to the initial peopling of the valley beginning at least 50,000 cal BP (Orkhon-7, trench 3, layer 10b). The valley was subsequently visited sporadically until ca 34,000 BP, with occupation episodes occurring between 23,000–25,000 BP, immediately prior to the Last Glacial Maximum and immediately following the LGM, until nearly the beginning of the Holocene (Table 1).

Geochemical and isotopic characteristics of sediments at the Moiltyn-am site

The values of the chemical index of alteration (CIA) throughout the profile are low, falling within 49.6–50.4 (c/v – coefficient of variation = 0.6 %) (Fig. 4), which indicates the influx of young material from unweathered rocks (Buggle et al., 2008; Interpretatsiya…, 2001). CIA = 70 was taken as the boundary for separating sediments accumulated in cold versus warm climates (Nesbitt, Young, 1982). Thus, the accumulation of the deposits took place under cold, arid environmental conditions with underdeveloped leaching processes. The nearly constant CIA value throughout the profile indicates that no significant changes in climatic conditions occurred. The CIW and CPA indices do not change noticeably throughout the profile, the CIW values fall within the range of 56.2–57.3 (c/v = 0.7 %), CPA – 73.0–73.6 (c/v = 0.4 %), which indicates a low degree of chemical transformation of the sediments. When studying arid environments, the CALMAG index is also calculated, since this index is closely related to humidity, in particular with average annual precipitation (Yudovich, Ketris, 2011). The CALMAG values exhibit great variability, fluctuating throughout the profile within the range of 50.55–60.38 (c/v = 5.8 %). The highest values correspond with layer 6; they gradually decrease upward to layer 3, which is characterized by lowest values, attesting to a decrease in environmental humidity. Layer 2 exhibits increasing CALMAG values, which is an indicator of greater moisture content. Note that in this article, the humidity and aridity of the environment refer to the relative increase or decrease in the amount of precipitation in the course of sedimentation.

The sediment maturity index or the index of compositional variability (ICV) fluctuates from 1.53 to 1.85 (c/v = 6 %) throughout the profile; the values are higher in layers 2 and 3, indicating that aeolian processes played a greater role in the formation of these strata as compared to layers 4–6. Values of ICV >1 are typical of young deposits containing only a small amount of clayey minerals.

*Unpublished data of A.M. Klementiev.

Table 1. **Radiocarbon dates from Orkhon-1, Orkhon-7, and Moiltyn-am generated from 1990–2020**

Site	Layer	Method	Lab code	Date, yrs BP	Calibrated date, yrs BP (68.3; 95.4 %, IntCal 20)	Source
Moiltyn-am	2	AMS	SOAN-8156	18,830 ± 290	23,050–22,400 23,750–22,200	Rybin et al., 2016
"	4	AMS	GifA-10857	20,240 ± 300	24,700–23,900 25,200–23,750	Bertran et al., 2003
"	2	AMS	AA-112827	32,460 ± 620	37,750–36,100 39,100–35,700	Present study
Orkhon-1, trench 1-2	4	^{14}C	SOAN-2886	29,465 ± 445	34,450–33,500 35,100–32,850	Derevianko, Nikolaev, Petrin, 1992
"	4c	^{14}C	RIDDLE-717	34,400 ± 800	40,600–38,500 41,200–37,350	Derevianko, Kandyba, Petrin, 2010
"	5a	^{14}C	RIDDLE-716	38,600 ± 800	42,950–42,150 43,950–41,850	Ibid.
"	7	AMS	AA-112828	>40,400	–	Present study
"	7	AMS	AA-112829	>40,400	–	"
Orkhon-7, trench 3	3	^{14}C	SOAN-2878	9910 ± 85	11,650–11,200 11,750–11,150	Derevianko, Kandyba, Petrin, 2010
Orkhon-7, trench 1	4	^{14}C	USA	15,100 ± 900	19,550–17,250 20,850–16,150	Astashkin et al., 1993
"	4b	^{14}C	USA	15,600 ± 900	20,200–17,950 21,700–16,900	Ibid.
"	5	^{14}C	USA	23,595 ± 459	28,300–27,300 28,900–27,050	"
Orkhon-7, trench 3	2	^{14}C	SOAN-2883	23,595 ± 155	27,900–27,600 28,100–27,350	"
"	5	ESR	–	25,000	25,000	"
"	5	Pa-231	USA	25,400 ± 1100	–	"
"	5	Th-230	USA	25,500 ± 1400	–	"
"	6a	^{14}C	SOAN-2879	31,490 ± 310	36,150–35,500 36,450–35,250	Derevianko, Petrin, 1995
"	6b	^{14}C	SOAN-2880	33,295 ± 500	38,950–37,350 39,450–36,700	Astashkin et al., 1993
"	5c	^{14}C	SOAN-2885	33,785 ± 300	39,350–38,300 39,550–37,600	Derevianko, Petrin, 1995
"	6c	^{14}C	SOAN-2881	37,400 ± 580	42,350–41,650 42,550–41,250	Astashkin et al., 1993
"	7	ESR	–	38,200	38,200	Ibid.
"	7	^{14}C	SOAN-2884	39,970 ± 819	43,950–42,750 44,550–42,400	"
"	9	^{14}C	SOAN-2882	40,000 ± 700	43,900–42,800 44,450–42,500	Derevianko, Petrin, 1995
"	9	ESR	–	40,500	40,500	Astashkin et al., 1993
"	10b	^{14}C	USA	45,100 ± 1700	49,850–45,800 54,650–44,750	Ibid.
"	10b	ESR	–	59,500	–	"

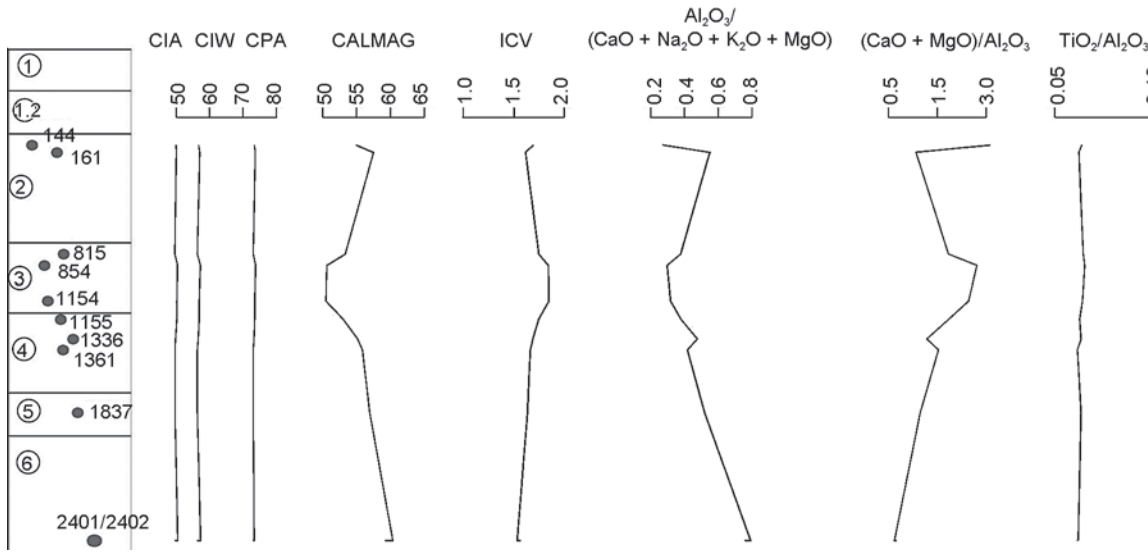

Fig. 4. Distribution of geochemical indices along the Moiltyn-am profile.

Another variation of CIA is the index Al_2O_3/(CaO + + Na_2O + K_2O + MgO); it shows a more dynamic distribution of values and generally corresponds to the distribution pattern seen in CALMAG, but exhibits greater sensitivity to changes in moisture content. Its values vary from 0.27 to 0.80 (c/v = 5.8 %); there is a clear tendency for the values to decrease upward from layer 6 to layer 3 and increase from the top of layer 3 to layer 2, with a sharp drop in the upper part of layer 2. Since the increase in this index's values is associated with active leaching processes, it can be assumed that the accumulation of deposits in layers 6–4 occurred under conditions of gradually decreasing the moisture content in the paleoenvironment and a decrease in the effect of chemical weathering. The lowest Al_2O_3/ (CaO + Na_2O + K_2O + MgO) values in layer 3 suggest accumulation in a relatively arid environment with the lowest degree of humidity, with increasing humidity during the formation of layer 2.

The derived values of the carbonate index (CaO + MgO) / Al_2O_3 are in agreement with the hypothesized dynamics of changes in the environment. The curve of the index values is inversely proportional to the curve of Al_2O_3 / (CaO + Na_2O + K_2O + MgO). It varies (c/v = 44.9 %) from 0.65 at the base of layer 6 to 3.08 in layer 2; increased values were recorded in layer 3 and the upper part of layer 2, which indicates the greatest carbonate content in the deposits and sedimentation under the most arid conditions.

Geochemical modules Al-Si-M, HydrolyzateM, FerrumM (Table 2) are similarly distributed through the profile, exhibiting extremely low variability (1.7–1.8 %); a slight increase was noted in layer 3. The variability of FerrumM values is 17.6 %; maximum values are also noted in layer 3. Variations of NatriumM, PotassiumM, AlcaliM, and Normal-alkali-M fall in the range of 1.0–2.0 %. A slightly higher coefficient of variation was observed for Total-Alkalinity-M –6.1 %. The TitaniumM value practically does not change throughout the layers analyzed (c/v = 2 %). Low Al-Si-M and HydrolyzateM values are indicators of young material at the source of sediment origin. NAM values >0.40 indicate the presence of a large amount of feldspar in the sediments; this is also evidenced by ALcalinity-M values >1.5 (Ibid.). Such a distribution of geochemical modules is apparently associated with young, weakly weathered material at the source of the sediments. Despite grain-size differences in the sediments, the primary material did not differ significantly in petrographic composition and degree of maturity; this can be explained by the fact that the material originated at a single location, but was transported by different means.

Low HydrolizateM values are characteristic of sediments poorly transformed by chemical weathering processes. A low SodiumM value indicates a very low degree of chemical differentiation.

Concentrations of rare earth elements and yttrium (REE+Y) normalized to chondrite (Sun, McDonough, 1989) are shown in Fig. 5 and in Table 3. The distribution of the chondrite-normalized REE indices is similar. The samples are enriched in light REEs, depleted in heavy REEs, without an anomaly in Ce

(Ce / Ce* ~1): they are characterized by a small negative Eu anomaly (Eu / Eu* ~0.78). Note that the spectrum of Sample 1837 (layer 5) is similar to the others, but the concentrations of all elements are almost two times higher. Fig. 5 also indicates the composition of REEs in the upper continental crust (UCC) (Taylor, McLennan, McCulloch, 1983). The samples under study, except for the magnitude of the Europium anomaly, show the same distribution pattern. Comparisons have been made with the mean composition of loess on the Chinese Loess Plateau (CLP in the graph) (Yokoo et al., 2004). The distribution of elements normalized to chondrite does not show any significant differences within the data. The diagram of distribution of samples normalized to PAAS (post-Archean Australian shale, which is the standard of Phanerozoic sedimentary rocks (Taylor, McLennan, 1985)) shows differences between the sediments at Moiltyn-am and the mean composition of the loess: the former have a positive Europium anomaly, and the latter have a negative one. This index suggests a different amount of plagioclase in the rocks and the degree of alteration. Despite the fact that the distribution patterns are similar, the sources of these sediments were probably different.

It has been established that the ratio of non-normalized LREE (La + Ce + Pr + + Nd + Sm + Eu) to HREE+Y (Gd + + Tb + Dy + Ho + Er + Tm + Yb + Lu + Y) can be considered as a climate indicator (Ronov, Balashov, Migdisov, 1967): less than 2.5 = arid, 2.5–4.0 = semi-arid-semi-humid, above 4 = humid. The ratio of LREE/HREE at Moiltyn-am varies within the range of 2.9 to 3.8 (mean 3.5), which is typical of sediments formed under semi-arid to semi-humid climatic conditions (Ibid.). This is also confirmed by the Th/U ratio (Siko, Goikovi, 1966), which varies from 2.6 to 3.8 (mean 3.1)

*The magnitude of anomalies was calculated from (Bau, Alexander, 2006).

Table 2. **Petrogenic oxides content of the Moiltyn-am deposits, wt%**

Oxide	MA 19 144 ISO	MA 19 161 ISO	MA 19 815 ISO	MA 19 854 ISO	MA 19 1154 ISO	MA 19 1155 ISO	MA 19 1336 ISO	MA 19 1361 ISO	MA 19 1837 ISO	MA 19 2401 ISO	MA 19 2402 ISO
SiO_2	44.49	57.95	53.60	48.28	49.17	52.87	56.53	53.81	58.19	63.77	63.01
TiO_2	0.53	0.65	0.62	0.59	0.59	0.61	0.66	0.62	0.67	0.71	0.70
Al_2O_3	10.81	13.62	12.46	11.66	11.89	12.69	13.45	13.13	13.68	14.93	14.77
Fe_2O_3	3.57	4.44	3.90	3.84	3.91	4.03	4.32	4.17	4.39	4.91	4.80
MnO	0.06	0.09	0.07	0.06	0.07	0.07	0.08	0.07	0.10	0.12	0.10
MgO	1.78	1.85	2.29	2.67	2.72	2.43	2.17	1.97	1.88	1.62	1.63
CaO	15.87	6.47	10.69	13.92	12.80	10.78	7.94	10.06	7.24	3.14	3.49
Na_2O	2.39	2.96	2.79	2.52	2.61	2.78	2.98	2.94	3.06	3.30	3.32
K_2O	2.38	3.11	2.77	2.55	2.58	2.75	3.01	2.91	3.04	3.29	3.23
P_2O_5	0.53	0.34	0.22	0.22	0.31	0.21	0.19	0.21	0.34	0.39	0.42
BaO	0.06	0.08	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09
SO_3	1.05	0.40	0.27	0.17	0.27	0.15	0.28	0.32	0.31	0.18	0.20
V_2O_5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cr_2O_3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NiO	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Loss on ignition	16.71	8.10	10.02	13.29	12.57	10.47	7.80	9.54	6.84	3.32	3.66
Total	100.23	100.08	99.79	99.84	99.58	99.92	99.51	99.86	99.83	99.77	99.45

Table 3. **The content of rare earth elements and yttrium (μg/g) and the isotopic composition of strontium in the Moiltyn-am deposits**

Chemical element	MA 19 144 ISO	MA 19 161 ISO	MA 19 815 ISO	MA 19 854 ISO	MA 19 1154 ISO	MA 19 1155 ISO	MA 19 1336 ISO	MA 19 1361 ISO	MA 19 1837 ISO	MA 19 2401 ISO	MA 19 2402 ISO
La	18	20	29	22	15	23	19	19	27	17	18
Ce	40	40	60	50	33	48	43	38	60	35	39
Pr	5	5.1	7	6.1	4	5.5	5.6	5.2	8	4	5
Nd	20	20	29	24	17	21	22	20	32	17	20
Sm	3.8	4.2	6	4.4	3.5	4	4.7	3.9	6	3.4	3.9
Eu	0.9	1.1	1.1	1.1	0.9	1.1	1.1	0.9	1.6	0.7	0.8
Gd	3.5	4	5	4	3.1	4	4	3.5	6	3.1	3.3
Tb	0.5	0.6	0.6	0.6	0.5	0.5	0.6	0.5	0.9	0.4	0.5
Dy	2.8	3.4	4	3.2	2.8	3.1	3.8	3.1	5	2.8	2.9
Y	15	17	11	16	13	17	18	14	25	8	7
Ho	0.6	0.7	0.8	0.6	0.5	0.6	0.8	0.6	1	0.5	0.6
Er	1.6	2	2.2	1.8	1.6	1.8	2.3	1.8	3	1.6	1.7
Tm	0.23	0.29	0.32	0.26	0.23	0.26	0.33	0.26	0.4	0.23	0.24
Yb	1.5	1.9	2.1	1.7	1.5	1.7	2.1	1.7	2.8	1.5	1.5
Lu	0.24	0.3	0.3	0.26	0.22	0.25	0.3	0.25	0.4	0.2	0.22
Ce*	1.007	0.927	0.959	1.034	0.993	0.984	1.016	0.917	0.992	0.954	0.982
Eu*	0.741	0.808	0.597	0.787	0.818	0.832	0.756	0.730	0.806	0.647	0.664
REE+Y	376	411	542	448	327	431	433	384	604	328	367
(La-Gd)/ (Tb-Lu, Y)	3.61	3.15	4.26	3.94	3.21	3.90	3.03	3.46	3.21	3.62	3.77
La/Yb	8.61	7.55	9.91	9.28	7.17	9.70	6.49	8.02	6.92	8.13	8.61
La/Sm	3.06	3.07	3.12	3.23	2.77	3.71	2.61	3.15	2.91	3.23	2.98
LREE/HREE	3.11	2.72	3.45	3.38	2.77	3.35	2.65	2.98	2.75	2.98	3.10
$^{87}Sr/^{86}Sr$	0.709265	0.709595	–	0.709588	0.709543	0.709381	0.709255	0.709549	0.709101	–	–

Note: All the estimated values are given for the values normalized to chondrite. Measuring error for the strontium isotopic composition is 0.005 %.
*The magnitude of anomalies calculated after (Bau, Alexander, 2006).

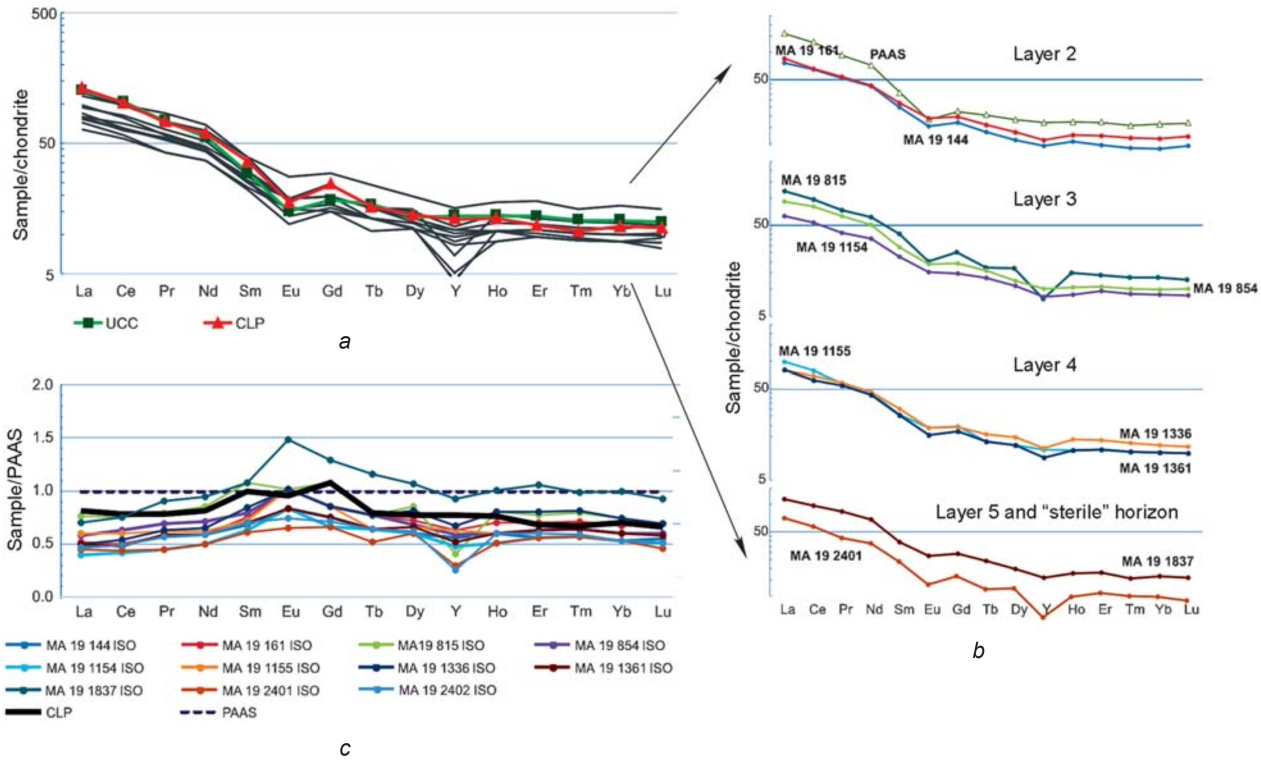

Fig. 5. Distribution of rare earth elements and yttrium.
a – normalized to chondrite (Sun, McDonough, 1989); *b* – the same, separately for each layer; *c* – normalized to PAAS (Taylor, McLennan, 1985). UCC – mean compositions of the upper continental crust (after (Taylor, McLennan, McCulloch, 1983)), CLP – mean compositions of central Chinese loess (after (Yokoo et al., 2004)).

and corresponds to the range between typically arid and typically humid environments.

The strontium isotopic composition of the study samples varies from 0.7091 to 0.7096 (Fig. 6, see Table 2). The ^{87}Sr / ^{86}Sr ratio increases up the profile, which indicates that there were no sharp climate fluctuations and changes in the locations of materials origin. In addition, two points (in layers 2 and 4) fall outside the trend line, which can be best explained by the redeposition of sediments.

Sediments in the Moiltyn-am area do not contain any anomalous trace elements, and their geochemical features are comparable with PAAS clayey rocks; the $^{87}Sr/^{86}Sr$ ratio of these rocks is typical of the upper continental crust, which implies that the sediments were subjected to vigorous mixing (Jahn et al., 2001).

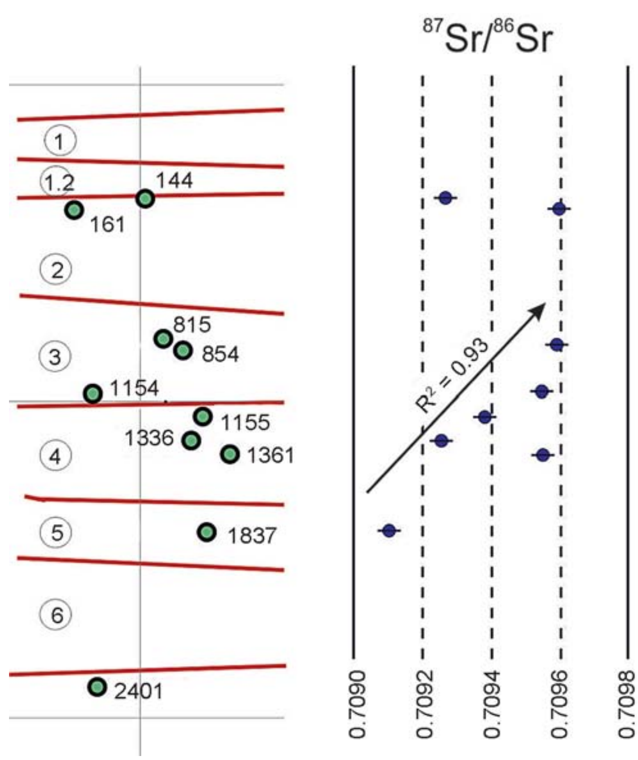

Fig. 6. Strontium isotopic composition of sediments at Moiltyn-am.
R^2 is the value of the reliability of the approximation for all values, except for samples MA 19 144 ISO and MA 19 1361 ISO.

Discussion

The data presented here provide additional information about the sedimentation features and depositional integrality of the Moiltyn-am layered sequence. On the basis of the reconstructed geomorphological situation, derived geochemical data, and the results of the analysis of the positions and orientations of linear artifacts, we conclude that all the deposits at the site were formed owing to the redeposition of nearby lithic material: the lowermost layers owing to down-slope migration processes in the valley, layers 3 and 2 evincing significant aeolian transport of dust from the valley (Fig. 7). The destruction of the uppermost deposits was so significant that some of the archaeological materials were exposed on the surface.

Distinctions between the middle and lowermost sedimentary units can also be traced in the state of preservation of the surface of uncovered remains: faunal material from layers 2 and 3 exhibits an unconsolidated structure and highly damaged surfaces, while bones recovered from layers 5 and 6 are dense and well-preserved (Klementiev et al., 2019). Patina covering both sides of stone artifacts from layer 2 testifies to the repeated transport of those objects until the moment of their interment.

Sedimentation at sites in the Orkhon Valley took place under various environmental conditions. Today, the Kharkhorin region is characterized by a semi-arid and cold steppe climate (Köppen climate classification Bsk), with an average annual temperature of –0.2 °C and an average rainfall of 254 mm per year. During MIS-3 (ca 57,000–29,000 cal BP), the climate differed

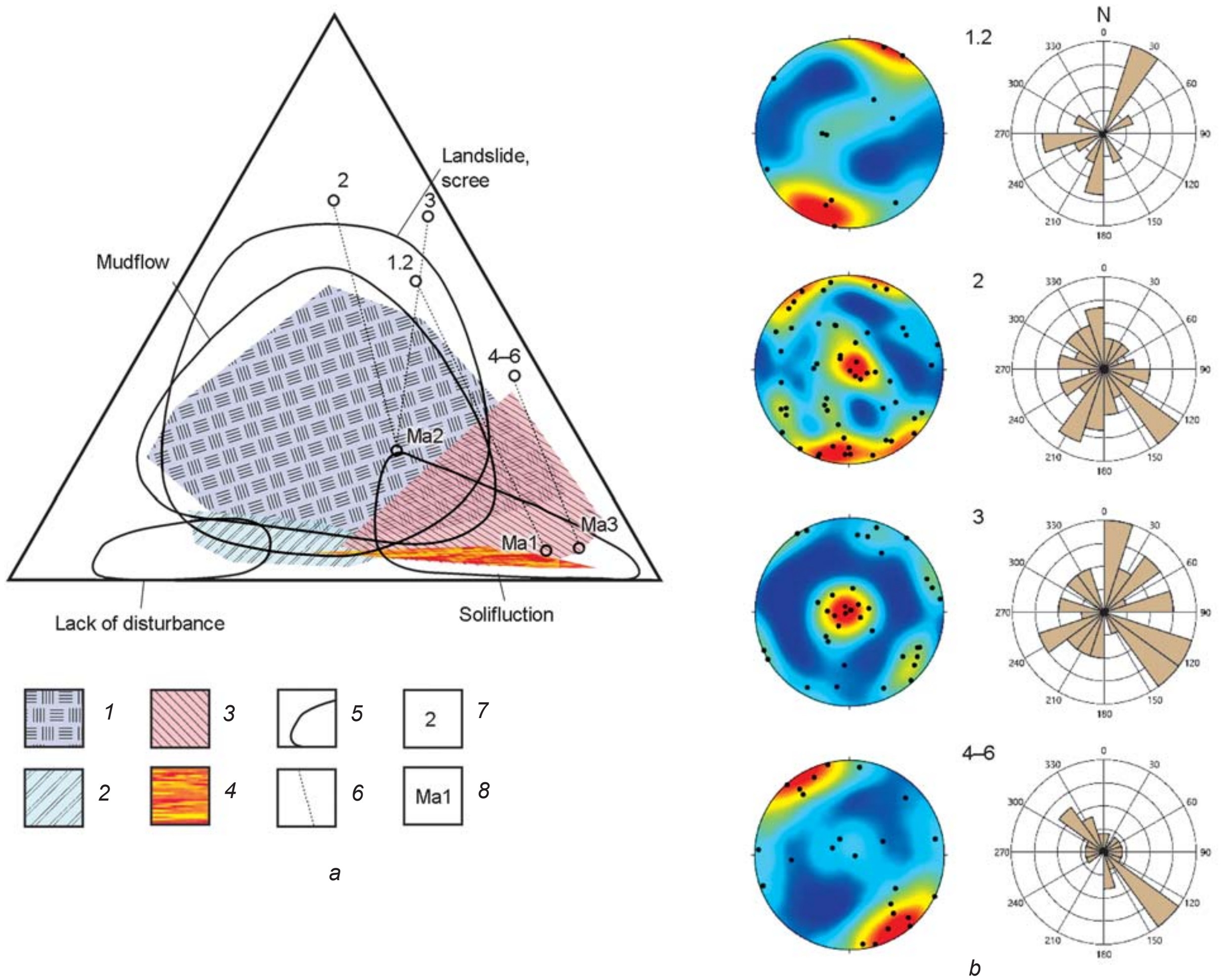

Fig. 7. Diagrams after Benn (after (McPherron, 2005)) (*a*), Schmidt and rose diagrams (*b*) for the Moiltyn-am deposits.
1 – mudflow; *2* – shallow outflow; *3* – solifluction; *4* – steep outflow; *5* – boundaries of post-depositional processes (after (Lenoble, Bertran, 2004)); *6* – correlation of units corresponding to one another; *7* – number of the layer identified in 2018–2019; *8* – number of the layer identified in 1997.

from current conditions throughout the entire Khangai Plateau and, in particular, in the Orkhon Valley (Fig. 8).

Data generated by lithological, sedimentological, and paleocryological analyses suggest that the early stage of the formation of terrace 2, containing Orkhon-7, dates back to ca 40,000 BP (Derevianko, Nikolaev, Petrin, 1992), during a cold climatic interval evidenced by powerful cryogenic deformations. Hence, cold snaps were sharp but short-lived under arid conditions between 40,000–37,000 BP. Significant climate fluctuations lasting for several centuries are also recorded. In general, noticeable cryo-deformations

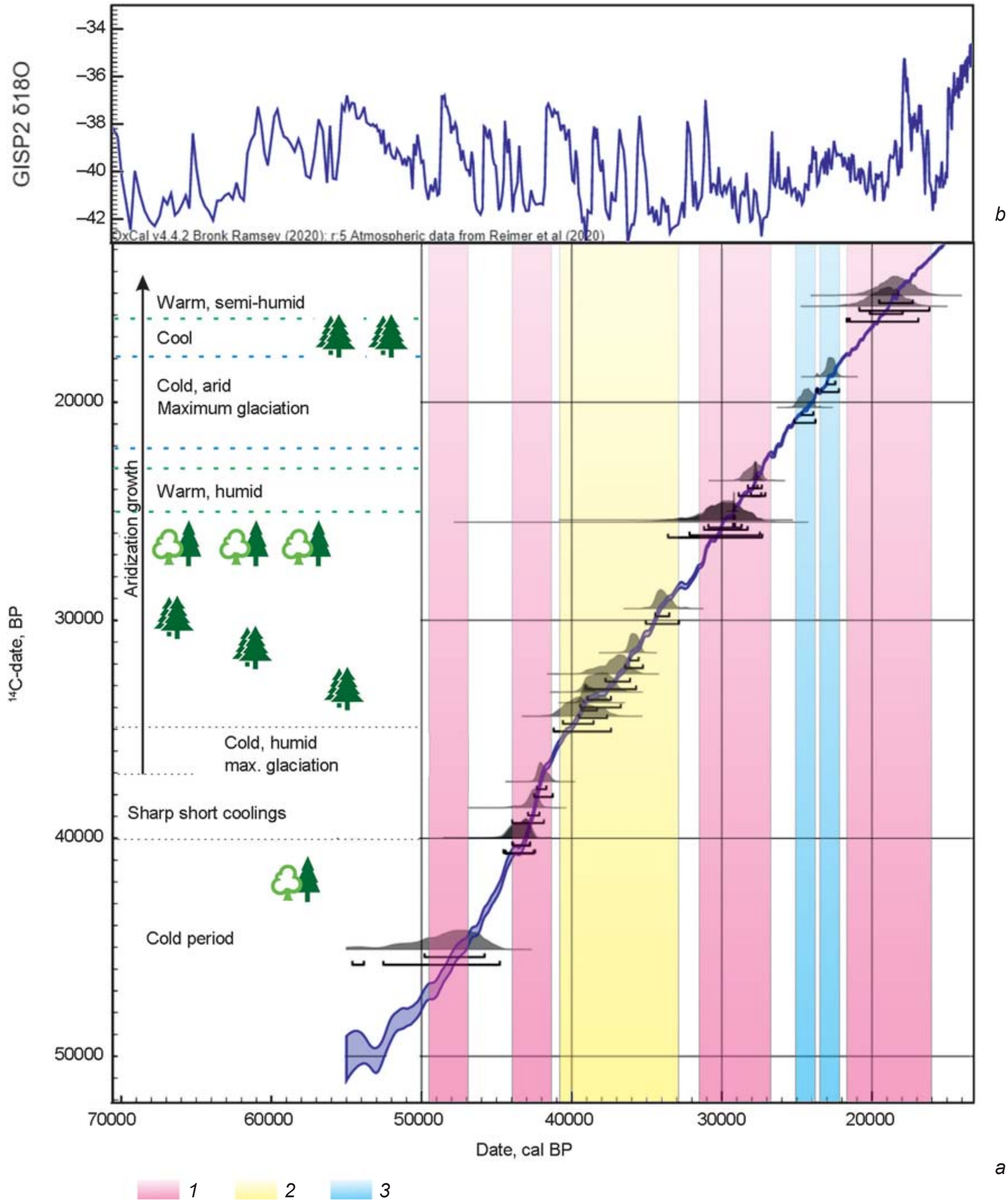

Fig. 8. Paleoclimatic changes and distribution of calibrated radiocarbon dates from sites in the Orkhon Valley (*a*), reconstruction of temperature fluctuations based on data from annual core layers of the Greenland Ice Sheet Project 2 (*b*).
1 – human occupation episodes; *2* – a series of occupation episodes; *3* – probable occupation episodes during the Last Glacial Maximum.

decreased up the profile owing to increasing climate aridification. The results of palynological studies at Orkhon-1 and -7, supported by radiocarbon assays, indicate that afforestation processes were vigorous during the first half of MIS-3, and areas lightly vegetated by coniferous species and mixed forests expanded (Ibid.).

According to the new chrono-climatic scale based on analytical data on sedimentation processes in the Gobi Altai and Khangai Plateau regions and on OSL dates from deposits in Orkhon excavation units (Lehmkuhl, Nottebaum, Hülle, 2018), MIS-3 represented a period of relatively high humidity in the Khangai. Studies of moraine sequences in this highland area have shown that glaciated tracts were most extensive ca 40,000–35,000 cal BP; the climatic conditions of MIS-3 were cold and humid, with more precipitation than today in winter. In the drier Gobi Altai district (Batbaatar, 2018), maximum glaciation during MIS-3 occurred between ca 40,000–30,000 BP.

Lithological, sedimentological, and paleocryological data from the Orkhon Valley indicate favorable humid conditions at the end of MIS-3 (ca 25,000–28,000 cal BP). According to the results of palynological analysis, this was a period of forest expansion in the region; but while moisture conditions remained unchanged, it was cooler than during the previous phase (Derevianko, Nikolaev, Petrin, 1992).

The boundary of Orkhon terrace 1 was formed at lower temperatures during a cold phase; the accumulation process began with the humidification of the climate and the development of dense vegetation cover, which promoted the accumulation of loess. This coincides with data on dated eolian deposits of the LGM (23,000–18,000 BP) (Grunert, Lehmkuhl, 2004; Schwanghart, Schütt, Walther, 2008). In the Late Pleistocene (14,400 ± 1400 BP for the lithological section at an altitude of 2439 m asl and 13,300 ± ± 1300 BP at an altitude of 2047 m asl), periglacial processes prevailed in the highest montane areas (i.e., those exceeding 2800–3000 m asl) of the Khangai. In the alpine zone (1800–2800 m asl), aeolian deposits accumulated. Limited accumulation of sediments was noted at lower elevations on alluvial fans and, based upon the study of paleolakes and the results of OSL dating (Lehmkuhl, Nottebaum, Hülle, 2018), lacustrine water levels were low and the climate was very dry.

In the Orkhon Valley, cold and dry conditions have been reconstructed for the period of MIS-2 (ca 29,000–14,000 cal BP); average annual temperatures could have dropped to –6 °C (Derevianko, Nikolaev, Petrin, 1992). The area was characterized by an arid, extreme continental climate for a long period, contributing to the formation of specific stable landscapes during the Pleistocene. At the same time, minor fluctuations in temperature and humidity contributed to sharp local differentiation. Palynological data for MIS-2 in the Orkhon Valley are characterized by a low content of arboreal pollen (7 %), dominated by birch (*Betula* sp. indet.) and pine (*Pinus* sp. indet.) (Ibid.). Xerophytic taxa (e.g., *Artemisia*, *Cichorium*, members of the Amaranthaceae) dominated the herbaceous composition.

Analyses of periglacial zones reconstructed on the basis of dated moraines in the Khangai and Gobi Altai mountain ranges (Batbaatar, 2018) suggest three models of glacier development depending upon the local climate: 1) glaciers were larger in moderately humid regions during MIS-3 than during MIS-2; 2) in semi-arid regions, maximum glacier extensions were recorded during MIS-2; 3) in arid regions, Early Holocene glaciers were comparable in size to those of the LGM. In the Khangai, where the climate was more humid than in the Gobi Altai region, maximum glaciation is dated to ca 22,000 BP. ^{10}Be isotope studies of moraines in the Khangai region (Rother et al., 2014) and in the Gobi Altai (Vassallo et al., 2005) have shown that in the Khangai Mountains during MIS-2 (ca 23,000 to 17,000–16,000 BP), large-scale glaciation took place, reaching the maximum extent of MIS-3 glaciers.

Results of the analysis of geochemical models and rare earth elements also indicate that the climate of the Orkhon Valley remained semi-arid and, periodically, semi-arid to semi-humid during the Late Pleistocene. According to geochemical indicators of weathering at Moiltyn-am, the source of raw materials did not change significantly during the formation of all the layers at the site. Sedimentation occurred in an arid environment; layers 6–4 were accumulated under relatively humid conditions as compared to overlying strata. The driest conditions were observed during the formation of layer 3 (ca 25,000–30,000 cal BP). Our conclusions are at variance with earlier data that regarded this period as representing the wettest phase at the site (Derevianko, Nikolaev, Petrin, 1992). Moiltyn-am layer 2 was formed under conditions of increasing relative humidity and intensification of weathering processes.

During MIS-3, environmental conditions in the Khangai Mountains in general and in the Orkhon Valley in particular, were favorable for human habitation and the presence of faunal communities adapted to fluctuations in relative aridity and humidity, despite periods of climatic instability. Currently, the Khangai region is a key area for the development of ungulate breeding: cattle, ovicaprids, and horses graze here. In the arid regions of the Gobi Altai district, south of the Khangai Plateau, camels have replaced cattle in the livestock repertoire. Currently available radiocarbon data suggest attribution of isolated finds and remains of groups of species from archaeological deposits in Mongolia to the Late Upper Pleistocene and Holocene. The most numerous remains of bones and associations of species have been recorded during MIS-3 and early MIS-2 (Table 4).

Table 4. **Fauna of Mongolian regions during MIS-3 and -2***

Period, ka BP	Selenga Valley	Orkhon Valley	Eastern Mongolia, Gobi Desert	Western Mongolia, Gobi Altai
12–14	Kharganyn-Gol-5: *Ovis ammon*, *Struthio asiaticus*	–	–	–
15–17	Tolbor-4, -15: *Struthio asiaticus*	–	–	–
18–20	–	–	–	Sudjiin Khunduk Agui Cave: *Capra sibirica*
21–23	Dörölj-1: *Struthio asiaticus*	–	–	Tsagaan Agui Cave: Equidae
24–26	Tolbor-4: *Struthio asiaticus*	–	–	Tsagaan Agui Cave: Equidae Yarool Dzykhtyn Agui Cave: *Capra sibirica*
27–29	Dörölj-1: horse Tolbor-15: *Struthio asiaticus*	Moiltyn-am: *Bos* sp.	–	Sudjiin Khunduk Agui Cave: *Capra sibirica*
30–32	Tolbor-21: *Marmota sibirica* Kharganyn-Gol-5: *Ovis ammon* Dörölj-1, Tolbor-4: *Struthio asiaticus* Tolbor-15: Equidae	–	Salkhit: *Coelodonta antiquitatis*	Yarool Dzykhtyn Agui Cave: *Capra sibirica*
33–35	Kharganyn-Gol-5: *Ovis ammon, Cervid/Saiga* Tolbor-16: *Bos* sp., Felinae, Caprinae, Equidae Tolbor-4: Equidae, *Struthio asiaticus* Tolbor-15: Equidae	–	Rashaan Khad: *Bos* sp., *Equus*	Tsagaan Agui Cave: *Allactaga*, *Lepus tolai*, *Pantholops hodgsoni*, *Equus ferus, Equus hemionus* Yarool Dzykhtyn Agui Cave: *Capra sibirica*
36–39	Tolbor-21: *Coelodonta antiquitatis*, *Equus ferus*, *Equus hemionus*, *Poephagus baikalensis* Tolbor-16: *Bos* sp., *Mammuthus* sp.	Orkhon-7: Equidae Moiltyn-am: *Equus ferus*, *Bos* sp., *Marmota sibirica*, *Struthio asiaticus*	–	Tsagaan Agui Cave: Equidae Yarool Dzykhtyn Agui Cave: *Capra sibirica*
40–42	Tolbor-16: *Bos* sp.	Orkhon-1: *Poephagus baikalensis* Orkhon-7: *Equus ferus*	–	–
43–45	Kharganyn-Gol-5: *Ovis ammon*	–	–	Chusutuin-Gol: *Equus ferus, Camelus* sp., *Panthera* sp., *Crocuta* sp., *Mammuthus primigenius*
46–49	Kharganyn-Gol-5: *Equus hemionus, Poephagus baikalensis,* Equidae	Orkhon-7: *Ovis ammon,* Rhinoceratidae	–	Tsagaan Agui Cave: Equidae
50–52	Tolbor-21: *Cervid/Saiga*	–	–	Tsagaan Agui Cave: *Allactaga*, *Lepus tolai*, *Citellus*, *Canis lupus*, *Equus hemionus*, *Procapra gutturosa*, *Pantholops hodgsoni*, *Ovis ammon*, *Capra sibirica*

*Based on data published in (Dinesman, Kiseleva, Knyazev, 1989; Derevianko, Nikolaev, Petrin, 1992; Ovodov, 2001; Derevianko et al., 2013; Zwyns et al., 2019) and drawn from the present study.

Various assemblages of Karginian interstadial (MIS-3) mammals have been identified through paleontological analysis and confirmed by ZooMS. Fossils of proboscideans, bovids (*Bos* or *Bison* and yaks), equids (horse and kulan), ovicaprids, rhinoceros, deer/saiga, and felids have been recorded from archaeological sites in northern and central Mongolia and the Khangai region. The predominance of bones of *Bos* sp. indet. in these sites indicates a specialization of the local populations on hunting large bovids. In Mongolia, the genus *Bos* may be represented by both the aurochs (*B. primigenius*) and Baikal yak (*Poephagus baikalensis*), but the bones recovered as part of this study have been defined as yak. ZooMS analysis of these remains identified two complementary genera: *Bos* sp. indet./*Bison* sp. indet. (Zwyns et al., 2019). It cannot be excluded that the zoogeographic distribution of the Pleistocene wild horse, kulan, and, probably, Przhevalsky's and Ovodov's horses (*Equus ferus*, *E. hemionus*, *E. przewalski*, and *E. ovodovi)* in the Khangai were the same. The latter species have been recorded northwest (Plasteeva et al., 2019; Plasteeva, Vasiliev, Kosintsev, 2015) and east (Yuan et al., 2019) of Mongolia. In the ungulate group, equids and large members of the Bovidae were the principal landscape-forming species in the arid ecosystems of Mongolia, and the predominance of bovids has been noted in Middle and Upper Paleolithic complexes; representatives of the Caprinae (mountain sheep, ibex, probably gazelle) were noted in addition to the usual bovid-horse pair in Early Upper Paleolithic collections.

The faunal complex of western and southern (Gobi) Mongolia differs from that of Khangai. The latter correlates with the mammoth faunal complex, which reflects environmental conditions yielding steppe landscapes typical of the Lake Baikal region and Yenisei regions of Siberia and the Altai Mountains. The composition of the Mongolian Altai and Gobi Altai faunal complexes correlates with montane arid habitats close to semi-deserts.

The diversity of large Pleistocene mammals in Mongolia during MIS-3 suggests a lack of large predators (Rautian, Sennikov, 2001) in this area. Humans partially compensated for this deficit through their occupation of the large predator ecological niche. The development of human hunting (predatory) strategies during the Initial and Early Upper Paleolithic in Mongolia was ensured by changes in technology. This is consistent with the conclusion that a distinct expansion of specialization and an increase in the ecological valence of a predator are possible under conditions of complex and, therefore, relatively energetically expensive adaptation (Ibid.). Thus, during the second half of the Mongolian Late Pleistocene, the trophic pyramid of the northern latitudes of Eurasia (Vereshchagin, Baryshnikov, 1992) was supplemented by the genus *Homo*. *Homo* must be regarded as an active predator in this trophic pyramid.

Available radiocarbon dates for Paleolithic sites in the Orkhon Valley suggest the coexistence of hominin groups who used various stone working technologies. Probably, by ca 45,000 cal BP, the Orkhon Valley was populated by humans employing a simple pebble industry (e.g., Orkhon-7, section 3, horizon 7; section 2, horizon 5) and a somewhat younger, but still ≥40,000 years old, lithic complex including Levallois technology (e.g., Orkhon-1, section 1-2, horizon 3). This period was characterized by a cold, humid climate, the spread of mixed forest cover, and repeated waterlogging.

Of the radiocarbon dates modeled for this period (Bronk Ramsey 2020 OxCal v.4.4.2, IntCal20), only three can be taken into account; all of them fall within the range of 42,000–44,000 cal BP, the onset and end of the period bracketed by 42,000–47,000 and 43,000–39,000 cal BP respectively, defining a duration of 1000–3000 years. First, the number of available radiocarbon dates is insufficient for Bayesian analysis, since some of the assays are accompanied by large error intervals, while others are infinite. Second, we envision short-term, single-episode occupations of the Orkhon Valley (Orkhon-7 and Orkhon-1) by groups of people exhibiting varying sets of cultural characteristics. The archaeological materials correlate with the bones of large ungulates—bovids and horses, as well as argali. Most of the Early Upper Paleolithic dates were derived from archaeologically sterile layers in trench 3 at Orkhon-7 and correlated with cultural layers of neighboring excavations. Modeling of only three dates directly associated with archaeological material indicates the probable onset of the Early Upper Paleolithic between 39,000–33,500 cal BP, terminating 34,000–31,000 cal BP. The main period of Early Upper Paleolithic complexes falls within the warming period in MIS-3, when sudden cold snaps ended, aridification was well underway, and coniferous forests (probably dominated by larch, *Larix* spp.) prevailed. In the Khangai area, remains of bovids, horses, and sheep are associated with archaeological material of that period. The middle stage of the Upper Paleolithic lasted between 1500 to 5000 years; its probable onset and termination occurred 36,000–24,000 and 28,000–21,000 cal BP. During this period, the central Mongolian climate changed from increasingly arid to warm and excessively humid, then to the cold and dry

Last Glacial Maximum, which is possibly associated with a hiatus in the cultural sequence and continuity of human habitation in the region; archaeologically-associated LGM faunal remains in Mongolia are scarce, including only Asian ostrich (*Struthio anderssoni* and/or *S. asiaticus*) eggshells.

Conclusions

Collectively, our data indicate gradual aridification of a semi-arid to semi-humid climate in the Orkhon Valley during MIS-3 and -2. This conclusion is supported by the faunal complex reconstructed for the Khangai Mountains, representing the complex mammoth fauna of the steppe and forest-steppe ecozones. The available chronometric determinations do not allow modeling calibrated dates to identify likely episodes of human occupation and reliably correlate them with specific climatic changes. Nevertheless, taking into account radiometric dates of archaeological culture-bearing layers, features of identified lithic industries and their deposition, it can be concluded that human occupation of the Orkhon Valley was episodic, sporadic, and of variable duration. Two discrete occurrences of human occupation have been established thus far at Moiltyn-am; one for the lithological unit including layers 4–6, in which layer 4 is redeposited, and one for layer 3. Layer 2 is rich in archaeological artifacts and includes a complex of materials from layers 4–6 and the later ones, probably younger than the Last Glacial Maximum or contemporaneous with it. Remains of the large bovid – horse – sheep triad are most often found at these sites; the occurrence of bovids, most likely represented by the Baikal yak, decreases with the period of aridification lasting from the Middle Paleolithic to the Early Upper Paleolithic. The diversity of human material culture documented in the study area is obviously associated with paleoecological and paleoclimatic parameters, the fluctuating availability of water resources supporting predictable presence of prey animals, and lithic raw materials suitable for stone tool production, as well as with a favorable geographical location on the pathways of migratory game. The available chronostratigraphic characteristics of sites in the Orkhon Valley are still insufficient for conclusions to be confidently drawn about the coexistence of different hominin groups exhibiting varying cultural characteristics. It is possible that ancestral human populations migrating through the valley did not often encounter one another owing to what we perceive as short-term habitation of the currently known archaeological sites.

Acknowledgements

This study was supported by the Russian Science Foundation (Project No. 19-78-10112). Analyses of the geochemical modules were conducted by A.O. Volvakh, supported by the Russian Foundation for Basic Research (Project No. 19-59-44010 монг_т). The authors are grateful to D.V. Kiseleva from the Geoanalytic Center for Collective Use, Ural Branch of the Russian Academy of Sciences, for assistance with isotopic analysis.

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Received January 19, 2021.
Received in revised form March 12, 2021.