ГЕОМОРФОЛОГИЯ, 2022, том 53, № 5, с. 25–31

ПРОБЛЕМЫ ПАЛЕОПОЧВОВЕДЕНИЯ И ГЕОАРХЕОЛОГИИ

551.89:574→631.42:902/904 (470.333)

ДЕТАЛЬНАЯ ПАЛЕОЭКОЛОГИЧЕСКАЯ ЛЕТОПИСЬ ВАЛДАЙСКОГО КРИОХРОНА (МИС 4–2) ИЗ ПОЧВЕННО-ОСАДОЧНОЙ СЕРИИ СРЕДНЕПАЛЕОЛИТИЧЕСКОГО ПАМЯТНИКА ХОТЫЛЁВО I

© 2022 г. М. А. Коркка[1,2,*], Т. В. Романис[3,4], Л. А. Савельева[1], С. Н. Седов[5,6,7], А. К. Очередной[8]

[1]Санкт-Петербургский государственный университет, Институт наук о Земле, Санкт-Петербург, Россия
[2]Институт географии РАН, Москва, Россия
[3]Почвенный институт имени В.В. Докучаева, Москва, Россия
[4]Институт мерзлотоведения имени П.И. Мельникова СО РАН, Якутск, Россия
[5]Институт геологии, Национальный автономный университет Мексики, Дель. Койоакан, Мехико, Мексика
[6]Институт криосферы, ФИЦ "Тюменский Научный центр" СО РАН, Тюмень, Россия
[7]Тюменский государственный университет, Тюмень, Россия
[8]Институт истории материальной культуры РАН, Санкт-Петербург, Россия
**E-mail: maria.a.korkka@gmail.com*

Поступила в редакцию 14.06.2022 г.
После доработки 27.06.2022 г.
Принята к публикации 15.07.2022 г.

Группа разновременных среднепалеолитических памятников Хотылёво I расположена в Брянской области, в 400 км к юго-западу от Москвы в верхнем течении р. Десны. В 2021 г. в рамках работ на разрезе № 3 Хотылёво I была уточнена стратиграфия почвенно-осадочной серии последней ледниковой эпохи. В разрезах представлены почвы последнего макро-цикла МИС 5a–c – МИС 3 (датирование OSL, AMS). Почвы МИС 5 расположены в нижней части разреза, слабо дифференцированы и включают артефакты разного возраста, различающиеся по степени сохранности культурных отложений, их культурной принадлежности и интенсивности обитания человека. Почвы МИС 3 представлены в виде нескольких уровней почвообразования. Одна из почв (почва IV возраст 34.1–32.7 тыс. лет ^{14}C) имеет полный набор генетических горизонтов, не нарушенных криогенезом (похожие почвы описаны в Германии и Австрии), AO-E-Bw-Bk-BCk, современным аналогом которой являются палевые почвы (Cambic Cryosol) Якутии. Формироваться эта почва должна была в экстраконтинентальном семиаридном климате под таежными лесами. Тем не менее в разрезах Хотылёво I палеопочва IV отражает и последующий этап гумидизации климата, что выражено во вторичном оглеении горизонтов профиля и находит отражение в результатах спорпыльцевого анализа. В целом разрез 3 Хотылёво I сохраняет подробную палеопочвенную запись, отражающую даже кратковременные климатические колебания.

Ключевые слова: средний палеолит, Хотылёво I, Микок/KMG, палеопочвы, средний Валдай, палевая почва, МИС 3

DOI: 10.31857/S0435428122050066

1. INTRODUCTION

An important objective in the research of the paleoenvironment of the last cryochron on the territory of the East European Plain continues to be the detailed study of the paleosols of that period. The longest and most favorable interval for vegetation and soil formation during the last half-cycle correlates with marine isotope stage 3 (MIS 3). Undoubtedly, under the conditions of a cryochron, pedogenesis was restricted by rather harsh climate, but, nonetheless, various sections demonstrate soil-sedimentary sequences with several levels of MIS 3 soils, some of which have rhythmic structure. In general, such sections are described in gully deposits, where accumulating colluvium regularly interrupted pedogenesis. These soils are thin, poorly developed and their structure is disturbed by cryogenic processes (Sycheva, Khokhlova, 2015; Korkka et al., 2017a; Korkka et al., 2017b). Sometimes these multiple events of soil development can be correlated with the Greenland interstadials (Haesaerts et al., 2010).

Only one MIS 3 soil level is usually preserved in sections at flat upland landsurfaces. In Russian literature this soil is called the Bryansk paleosol. This pa-

Fig. 1. The scheme of Khotylevo I site locations.
Рис. 1. Схема расположения разрезов на памятнике Хотылёво I.

leosol has a well-formed soil profile disturbed by cryogenic deformations. It is described in detail in the works of A. Velichko and colleagues and included as a marker of the MIS 3 level in his East European loess stratigraphy (Velichko, 1990). A similar situation is observed in most European Late Pleistocene upland loessic sequences: MIS 3/Middle Pleniglacial is represented mostly by one or two well-developed paleosols (Stillfried B in Austria, PK1 in Czech Republic, Lohne in Germany, etc.) (Kadereit et al, 2013; Terhorst et al., 2015). The relation of these paleosols to the multiple contrasting climatic fluctuations during MIS 3 is still under discussion. In particular, the hypothesis of their polygenetic nature was formulated (Sedov et al., 2013). S.A. Sycheva and O.S. Khokhlova supposed that pedogenesis of the Bryansk paleosol occurred not only during MIS 3, but also extended into early MIS 2, during which cryogenic features were acquired (Sycheva, Khokhlova, 2015). We described a loess-soil sequence of the last cryochron in the sections of the Khotylevo I site in which a full-profile MIS 3 soil is diagnosed. The horizons of this soil have polypedogenetic features and are not deformed by pseudomorphs along ice wedges from the Vladimir cryogenic horizon (LGM). Soil profile preservation of the Khotylevo I site is comparable to the soils of Western Europe located on watersheds and is a distinguishing difference from the MIS 3 paleosols of the loess-soil sequences described on the territory of Russia.

2. OBJECTIVES AND METHODS

The Khotylevo I archaeological site is located at the northern boundary of the Khotylevo Village in Bryansk Oblast', approximately 20 km west of Bryansk city center and 400 km southwest of Moscow (fig. 1).

The site includes a complex of Middle Paleolithic cultural horizons and cultural layers of different ages varying in the extent of preservation of deposits, their cultural appurtenance, and human habitation intensity within each identified cultural horizon. According to preliminary data, most of the cultural horizons could have Micoquian/KMG (*Keilmessergruppe*) assemblages. The overall length of the site along the right bank of the Desna River is up to 1 km, making it one of the largest Middle Paleolithic sites in Eastern Europe (Otcherednoy, Voskresenskaya, 2009; Korkka et al., 2017a).

The objects of study are loess-soil sequences Section 3 and Section Kryuchka. They are located in the middle of the northern slope, at an elevation of about 150 m a.s.l. The pedogenetic levels of these sections are morphologically similar. These paleosols and sediments are described and sampled. We collected bulk samples for physical and chemical laboratory analyses, and undisturbed soil samples were taken from the genetic horizons for thin sections. However, in this article we describe morphology in detail as the most important basis for subsequent paleogeographic interpretation of the data. Most of the data presented herein are for Section 3. We used morphological data from Section Kryuchka to confirm the distribution of the described pedogenic levels over a significant area of Middle Paleolithic Khotylevo I sites. Soils and horizons were identified using the World Reference Base for Soil Resources 2014, update 2015.

The comparative geographic and soil stratigraphic methods were used in this work. For absolute dating the AMS dating method was applied (humified lenses from soils III and IV were dated).

Preliminary results of a pollen analysis were obtained from soil IV. Nine samples were collected from horizons AO-E-Bw and one from the thickness overlapping the soil. Samples were taken with 1.5–4.0 cm intervals and prepared applying standard chemical treatment with 10% HCl and NaOH and heavy liquid separation (Grichuk, Zaklinskaya, 1948). To estimate pollen concentrations, two tablets containing a known concentration of *Lycopodium* spores were added to each sample prior to preparation (Stockmarr, 1971). Non-pollen palynomorphs were identified, when possible, on the pollen slides. The mass of each sample ranged from 10 to 20 g.

3. RESULTS

Stratigraphy. In 2021, within the scope of the work at one of the areas of the Khotylevo I site (Section 3), the stratigraphy of a soil-sedimentary sequence of the last ice age was clarified, including MIS5a-5c and MIS3 soils (fig. 2, (a, b)). The section is positioned in the middle of the northern slope of a promontory which points at the Desna (fig. 2, (c)). The high bedrock coast of the river is composed of Late Cretaceous rock: Cenomanian quartz-glauconite sands with phosphorite inclusions overlapped by Turonian marly chalky rock with concretions of grayish black flint. The thickness of the profile is approximately 20 meters.

The section can be nominally divided into three blocks (from top to bottom).

1. Late Valday loams (fig. 2, (a), depth 0.0–5.2 m) slightly more than 5 m thick. Poorly layered, homogenous, light greenish gray. A modern Holocene Luvisol is formed within, and a cultural layer of a settlement dating to the XIII – XVII centuries is documented.

2. A Middle Valday soil-sedimentary sequence (fig. 2, (a), soil I–IV), 4.5 m thick, consisting of four unrelated soil levels. A detailed description of this unit is provided below:

– 5.2 m. Poorly developed soil I, with horizons AB-Bk-BG, well-pronounced in all section walls. The soil inherits the properties of underlying loess-like loams, is gleyed (light olive horizon, ferruginization in root channels). All horizons are pierced by worm burrows, the maximum of which is seen in horizon AB. Horizon Bk is lightened with powder carbonates. Horizon BG is dense, extensively gleyed. The soil is underlaid by poorly gleyed loess-like loams.

– 5.5 (5.8) m. Another poorly developed soil (soil II) consisting of two soil formation rhythms divided by Middle Valday loess-like loams. Soils with horizons AB-Bk which are similar in color and density inherit a hummock relief (the diameter of a "mound" is about 20 cm). The thickness of each rhythm is approximately 30 cm. The transition from the below soil layer to underlying loams is gradual, the boundary is very wavy. The soils are underlaid by loess-like loams with weak signs of gleiing.

– 6.1 (6.6) m. Soil III (AMS date 27.8–26.7 ^{14}C kyr BP) as a dark gray, humified thickness 40–60 cm thick. Disturbed in the upper part by several generations of small wedges (up to 20 cm) from overlying loess-like loams. In the central part abundant humified, very dark gray lenses untouched by cryogenesis are preserved. Overwetting is noted in Fe-Mn concretions, ferruginous and olive brown spots. In the bottom part the soil level includes lenses of yellow underlying sand. No genetic relation between the organic and underlying horizons has been determined. Supposedly, the humified horizon slid from higher hypsometric levels in more humid periods.

– 6.6 (7.7) m. A redeposited loamy sand material from the underlying soil presenting as humified, peated lenses integrated into the remains of horizon Bw.

– 7.7 (8.2) m. Soil IV – Middle Valday polygenetic paleosol AO-E-Bw-Bk-BCk (fig. 2, (b)). Horizons AO-E present as thin redeposited lenses 20–30 cm thick. Horizon AO is black, peated, with inclusions of charcoal.

Horizon E is light gray, sandified. Dessication cracks tinted by humified material protrude from AO-E lenses into lower horizons Bw and Bk.

Horizon Bw (25–30 cm thick) is dark yellowish brown, slightly loamy.

Horizon Bk (50–60 cm thick) is moderately loamy, dense, with powder carbonates. Insignificantly disturbed by a network of cracks. Uniformly present in all section walls. Gleyed. Bioturbated (krotovinas). Heterogeneous in color (from light brownish gray to light yellowish brown). The transition to the horizon below presents as lenses and krotovinas, the boundary is straight.

Horizon BCk (20–30 cm thick) is a thin-layered, yellowish brown loamy sand. Gleyed zones and carbonate coating are seen in root channels. The thickness of soil IV is 120 cm.

– 8.9 m. Very pale brown sandy layered unit 2.5 m thick.

3. Early Valday deposits corresponding to OSL dating results (Hein et al., 2020) and interstadial soils formed within them. In the upper part the unit of loess-like loams (approximately 2.5 m thick) is a light olive gray color. Underneath them is a unit of layered (interlayers of loam and loamy sand) crumpled loamy sands (approximately 2.5 m thick) overlapping paleohorizons. The unit is underlaid by marly chalky colluvium with inclusions of sandy lenses and layers (the thickness is approximately 1.5 m). Further down, Cenomanian sand begins.

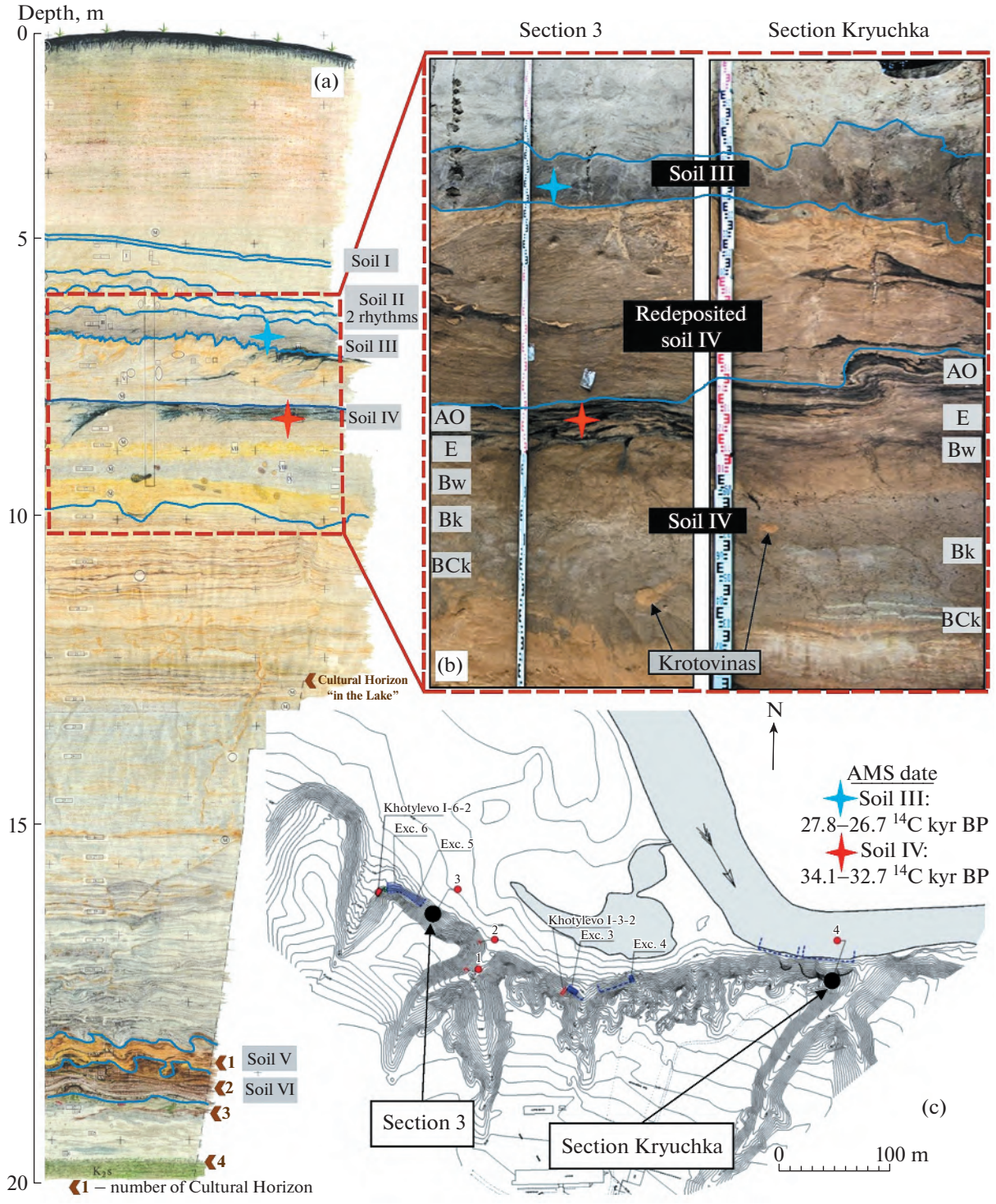

Fig. 2. Position of the Middle Valday polygenic paleosol: on the principal scheme of Section 3 ((a) – based on the results of work from 2019, 2021) and the photos of sections 3 and Kryuchka (b) with the indication of their position on the relief (c).

Рис. 2. Положение средневалдайской палеопочвы: на принципиальной схеме разреза 3 ((a) – по результатам работ 2019, 2021 годов) и фотографиях разреза № 3 и разреза Крючка (b) с указанием их расположения на рельефе (c).

The paleosols of this block are presented by two levels of soil formation separated by an interlayer of olive gray sand. Loamy sandy soil V, 30–50 cm thick, presents as very dark gray, dark gray, reddish brown and dark yellowish brown layers. The soil is pushed in the direction of the river channel by 60–90 cm.

Soil VI, 20–30 cm thick, light brownish gray, with abundant inclusions of marl, chalk and flint debris, is underlaid by heavy chalky loams. The soil is extensively crumpled by underlying rock.

Data on the stratigraphy of Section 3 which were obtained in 2021 can be compared to Section Kryuchka, which was established in 2013 in the exposure of the promontory (more than 300 m down the course of the Desna River from Section 3) (fig. 2, (c)). There is no preserved record of the paleoecological environment during the Early Valday time in Section Kryuchka, but there are two main levels of Middle Valday paleosols which match in morphology those described by us in Section 3 (fig. 2, (b)). A brief description of this section is provided below, seeing as the material has not been published previously:

1. Late Valday loams approximately 2 m thick, in which a modern highly eroded Holocene Luvisol is described.

2. 1.9 (2.1) m. Middle Valday loess-like loams. In the upper part of the unit (on the boundary with Early Valday deposits) there are signs of residual soil formation (stands out in color, leftover soil structure, light gleiing).

– 2.4 (2.5) m. Paleosol (analogous to soil III of Section 3) presenting as a grayish brown humified thickness which is heterogeneous in color (zones of very dark gray or grayish brown material), up to 50 cm thick, saturated with Fe-Mn mottles, nodules and soft concretions, ferruginous spots. Like in soil III of Section 3, the upper part of the thickness is disturbed by small cryogenic wedges filled with material from the loess unit above. It is underlaid by a layered loamy sand horizon (interlayers of fine and coarse sand) of a yellow color.

– 3.4 (3.8) m. Paleosol with horizons AO-E-Bw-Bk-BCk, which match the horizons of soil IV from Section 3: horizons AO and E present as lenses (the result of sliding) from 2 to 30 cm thick. The color is very dark gray (AO) and light yellowish brown (E). Charcoal is present in the lenses. Horizon E was fragmentally preserved under the lenses. Heterogeneous, very pale brown, 10–15 cm thick. The transition to horizon Bw is noticeable. The thickness of Bw is approximately 30 cm. It is pierced by dessication cracks from the overlapping horizon. Dark yellowish brown. There are many Fe-Mn soft concretions and mottles, nodules. Bw is well-pronounced stratigraphically. The transition is abrupt, the boundary is straight. Horizon Bk, approximately 70 cm thick, consists of two subhorizons: an upper light greenish gray one and a lower light brownish gray one. In the lower part the material is lighter, sometimes layered (interlayers from horizon BCk below). Pierced by Fe-Mn soft concretions and mottles, nodules. Pale olive gleyification spots and carbonate veins and filaments are present. Many krotovinas are present. The horizon is disturbed by a network of cracks. The transition is gradual, the boundary is straight. The BCk horizon is layered, loamy sandy, grayish brown. Fe-Mn mineral concentrations occur in soft segregation.

– 5.1 (5.3) m. A unit of layered very pale brown sands.

– 7.2 (7.5) m. Cenomanian sand.

Archaeological context. Comprehensive study of the paleogeographic conditions of the Khotylevo I archaeological site allows us to clarify the structure of the lower alluvial thickness containing a series of human habitation levels, the extent of its preservation, confirm the location of some of the Middle Paleolithic cultural horizons (CH) in situ. In the bottom part of Section 3 four CH of varying extents of preservation, with Middle Paleolithic tools and debitage, were documented:

CH 1 presents primarily as cores and different-sized flakes, as well as infrequent findings of bones. All tools in CH 1 are situated in accordance with the angles of the slope of displaced soil V tongues;

CH 2 is composed of small areas of concentration of debitage, with individual cores and their fragments, areas of concentration seen in CH 2 are situated subhorizontally on the surface and within soil VI;

CH 3 was documented on exposed areas in a displaced condition in lenses and interlayers of carbonate loams and loamy sands which are part of the composition of marly chalky colluvium which underlies soil VI, among the findings it is necessary to highlight expressive tool shapes, which indicates that the given cultural horizon belongs to the Micoquian/KMG;

CH 4 is the most structurally complex in the cultural horizon series of Section 3. The tool set and specific debitage from this cultural horizon also indicate that it belongs to the Micoquian/KMG of Eastern and Central Europe.

In Section Kryuchka, the Khotylevo I site is presented only by the cultural horizon situated in alluvial deposits which overlap the thickness of Cenomanian sand. The characteristics of the cultural layer match CH 4 both in terms of location conditions and assemblage composition.

Palynology (Soil IV). Pollen and spores were absent or presented by single grains of *Betula nana*, *Salix*, Poaceae pollen and *Botrychium* sp. spores in loamy sand samples. In peaty (organic-rich) samples from horizon AO pollen and spores were presented in insignificant amounts, from 15 to 80 grains per slide, and their total concentration varied from 172 to 2800 grains g^{-1}. Such extremely low grain concentration is observed in sediments of different genesis which formed during cold conditions in the past. For example, between 200 and 5000 pollen grains g^{-1} were registered in bottom deposits of Lake Ladoga, which were sedimented during the Younger Dryas stadial (Savelieva et al., 2019). The poorly preserved pollen (mineralized, flattened, crumpled) dominated in all analyzed samples.

Herb pollen presented mainly by Poaceae and poorly preserved tricolpate pollen, which could not be identified more specifically, dominated in the pollen spectra of peaty samples. *Artemisia*, Asteraceae, Brassicaceae, Cyperaceae pollens are also presented in the spectra, as well as shrub pollen of *Betula nana* and *Salix*. Single grains of *Botrychium* sp. and *Huperzia* sp. are noted among spores.

4. DISCUSSION

The obtained composition of pollen spectra, poor preservation of pollen grains and the presence of aquatic non-pollen palynomorphs allow us to suppose that the formation of the top soil horizons occurred in floodplain conditions. The pollen results possibly indicate cold conditions and open landscapes with a dominance of grasses and meadow herbs within the studied area, as well as the dwarf birch and willow. The pollen results may also indicate vegetation of the latest stage of the development of the paleosol and the beginning of significant cooling.

In Section Kryuchka and in the top part of Section 3 the most preserved soils have a common morphological structure, similar secondary properties and matching sedimentary layers. The main feature of the sections is the presence of a well-preserved Middle Valday paleosol with a complete set of genetic horizons, the closest modern equivalent of which are the palevye (pale) soils, or Cambic Cryosols (according to WRB (IUSS Working Group WRB, 2015)), of Yakutia. These soils form under conditions of extracontinental semi-arid climate on the territory of the middle taiga zone. Cambic Cryosols have weak cryoturbation (or no cryoturbation at all) and a carbonate Bk and dark yellowish brown Bw horizons. Based on the same indicators (middle horizons, minimal cryoturbation), we can attribute our soil (AO-E-Bw-Bk-BCk) to the Cambic Cryosol of Yakutia. At the same time, this soil's profile is polygenetic and inherits the change in climate: from a Cambic Cryosol, which forms under cryo-arid conditions underneath taiga vegetation, with powder carbonates and krotovinas, to a Gleysol (IUSS Working Group WRB, 2015), with a peated humus horizon and secondary gleiing of the profile. Similar Cambic Cryosols of the middle of the last cryochron which are undisturbed by cryogenic deformations are described in Germany and Austria. These soils correlate with the Cambic Cryosol we describe in the sections of the Khotylevo I archaeological site.

The Middle Valday soils of the East European Plain which have been described by numerous authors are disturbed by cryogenic deformations of the LGM (for example, the Middle Valday soils of the Alexandrovskiy quarry). Usually, these soils are located close to the modern surface, and in some cases are even part of contemporary pedogenesis. The Bryansk paleosols in Khotylevo I sections differ in the absence of signs of secondary cryogenesis in the soil profile. Our hypothesis is that this may be related to the magnitude of the thickness of the overlapping deposits, which have preserved the Middle Valday soils and kept their full genetic profile intact, spatially dividing the stages of pedo- and cryogenesis. The obtained results serve as evidence that, owing to high deposition rates and the development of weak sliding slope processes, a detailed paleosol record reflecting short-term climatic fluctuations has survived in Khotylevo I sections.

DETAILED PALEOENVIRONMENTAL RECORD FOR THE VALDAY CRYOCHRON (MIS 4-2) FROM THE SOIL-SEDIMENTARY SEQUENCE OF THE MIDDLE PALAEOLITHIC SITE KHOTYLEVO I

M. A. Korkka[a,b,#], T. V. Romanis[c,d], L. A. Savelieva[a], S. N. Sedov[e,f,g], and A. K. Otcherednoy[h]

[a] *Saint Petersburg State University, Institute of Earth Sciences, Saint Petersburg, Russia*

[b] *Institute of Geography RAS, Moscow, Russia*

[c] *Dokuchaev Soil Science Institute, Moscow, Russia*

[d] *Melnikov Permafrost Institute, Yakutsk, Russia*

[e] *Instituto de Geología, Universidad Nacional Autónoma de México, Del. Coyoacán, Mexico*

[f] *Earth Cryosphere Institute, Tyumen Scientific Centre SB RAS, Tyumen, Russia*

[g] *Tyumen State University, Tyumen, Russia*

[h] *Institute for the History of Material Culture RAS, Saint Petersburg, Russia*

[#] *E-mail: maria.a.korkka@gmail.com*

Khotylevo I, one of the largest Middle Paleolithic sites in Eastern Europe, is located in Bryansk Oblast', 400 km southwest of Moscow, in the upper course of the Desna River. The site's sections are presented by soil-sedimentary deposits of the last macro-cycle MIS 5-MIS 1 (OSL, AMS dating). Paleosols of varying degrees of preservation have matching pedofeatures and stratigraphic patterns throughout the area.

In the bottom part of the sections, soils MIS 5 a-c contain a group of areas of different ages varying in the extent of preservation of cultural deposits, their cultural appurtenance and human habitation intensity. The MIS 3 soil presents as several levels of soil formation. One of the soils (soil IV, AMS date 34.1–32.7 ^{14}C kyr BP) has a full set of genetic horizons undisturbed by cryogenesis (similar paleosols are described in Germany and Austria), AO-E-Bw-Bk-BCk, the contemporary analogue of which is Yakutia's Cambic Cryosol. The formation of these soils occurs in extracontinental semi-arid climate conditions on the territory of the middle taiga zone. In Khotylevo I sections the paleosol inherits the change in climate: from Cambic Cryosol to Gleysol. Owing to high deposition rates and the development of weak earthslide slope processes, a detailed paleosol chronicle reflecting short-term climatic fluctuations has survived in these soils' profiles.

Keywords: Middle Paleolithic, Khotylevo I, Micoquian/KMG, paleosol, MIS 3, Cambic Cryosol, Middle Valday

ACKNOWLEDGMENTS

The study was funded by RFRB research projects No. 19-29-05267 mk and RFBR No. 20-09-00233, within the framework of the Program of Fundamental Scientific Research of the State Academies of Sciences, State Assignment No. FMZF-2022-0012.

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