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ПРОБЛЕМЫ ПАЛЕОПОЧВОВЕДЕНИЯ И ГЕОАРХЕОЛОГИИ

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ЛОКАЛЬНАЯ СТРАТИГРАФИЯ И ПАЛЕОЭКОЛОГИЯ СТОЯНКИ ПОЗДНЕЙ ПОРЫ ВЕРХНЕГО ПАЛЕОЛИТА ДИВНОГОРЬЕ 1 В БАССЕЙНЕ СРЕДНЕГО ДОНА

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Верхнепалеолитическая стоянка Дивногорье 1 расположена на низкой террасе реки Тихая Сосна, сложенной перигляциальным аллювием, который перекрыт пролювиально-делювиальными отложениями. В позднеледниковой толще фиксируются два уровня слабого педогенеза, два уровня мерзлотных и эрозионных нарушений, а также культурный слой стоянки с радиоуглеродным возрастом 13 800–13 300 л. н. Проведенные междисциплинарные геоархеологические исследования показали смену перигляциальной флювиальной обстановки субаэральной – вначале перигляциальной (в позднеледниковье), а затем межледниковой – лесостепной и периодически степной (в голоцене). Очень динамичный характер климата и ландшафтов был характерен для начала голоцена и особенно ярко выражен для позднего ледникового периода.

Ключевые слова: позднеледниковье, стоянка верхнего палеолита, терраса, конус выноса оврага, перигляциальная растительность, педо-, крио-, биоиндикаторы

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1. INTRODUCTION

The final stage of the last – Valdai – glaciation (15.000–11.700 years ago) was a time when the glacier over north-western Europe was retreating and there was an improvement in the climate after the maximum cryochron (Karpuz, Jensen, 1992; Peltier, Fairbanks, 2006; Lavrushin, 2007; Velichko et al., 2017). This process did not proceed smoothly, but with sharp fluctuations. Short periods of warming (between phases) would give way to periods of cooling (Broecker et al., 1985; Dynamics ..., 2002; Borisova, 2011). During the warming in subaerial conditions, soils would begin to form (Sycheva, 2006 a, b). During the periods of cooling destruction of soils would begin or they would be buried beneath new deposits, mainly wind-borne sediments or slope deposits. Abrupt and frequent changes in climate are conducive to destabilisation of surfaces. The degradation of permafrost and increasing sediment loads in the transitional periods between cooling and warming would lead to the creation of new erosion forms in the mesorelief and the partial filling of these in the next "warming – cooling" sequence (Panin et al., 2011; Sidorchuk, 2015). At that time major changes were taking place in the landscapes of the area being investigated – landscapes ranging from extraglacial steppe to forest-steppe (Spiridonova, 1991). Pleistocene animals were dying out on a mass scale. The feed base for humans also underwent change. The ancient population led an active way of life and people were used to adapting to unstable conditions: they used to settle near bodies of water on the newly formed surfaces of slopes, flood-plains and terraces.

Sedimentation archives preserving data about the rapid and often changing natural situation in the Late Glacial period are not often available. As a rule, they are patchy and incomplete. This is why each new find of a site like this is of major scientific interest. Sites which provide information not just about changes in climate and landscapes, but also about traces of habitation of ancient humans living in such unstable environmental conditions, are particularly significant.

The sites Divnogorie 1 and Divnogorie 9 in the basin of the middle reaches of the River Don are just such features (Bessudnov et al., 2012, 2020; Sycheva et al., 2016). The importance of studies of how the landscapes and climate in the environs of Divnogorie developed is bound up not only with the discovery of new Late Upper Palaeolithic sites at the beginning of the 21st century but also with the unique nature of their position within the relief. The Divnogorie 1 and Divnogorie 9 sites were located on different geomorphological surfaces formed at the end of the Valdai glaciation. It has been established that the geoarchaeological site Divnogorie 9, which is an extensive accumulation of bones – mainly those of horses – and also a place which ancient hunters used to inhabit on a temporary camp, is located at the bottom of the half-filled ravine (Bessudnov, Bessudnov, 2010; Burova et al., 2019). It is not possible to give such a categorical definition of the position of the Divnogorie1 site. In the opinion of A.N. Bessudnov and A.A. Bessudnov (2010) the site is located on the low fluvial terrace above the floodplain. Yu.A. Lavrushin and A.V. Berezhnoy (pers. com.), however, believed that the cape-shaped hill was a fragment of a deluvial-proluvial tail, since no specifically alluvial deposits were found in the trenches.

Although both sites date from the Late Glacial period (OIS 2.1), their different geomorphological positions would indicate differences in the stratigraphy of their sections. Scope for compiling stratigraphic diagrams of such features through study of basic geological sections is limited. Diagrams of that kind give an idea of the general, regional structure of the Quaternary deposits and do not reflect local characteristics of the stratigraphy of Palaeolithic sites. Research into features of this kind requires the compilation of a local stratigraphy of sediments containing ancient cultural layers (Sycheva, 2006b).

2. SITE AND METHODS OF THE RESEARCH

A geological test-pit was sunk at the Divnogorie 1 site, in an area of the low terrace on the east bank of the Tikhaya Sosna River within the confines of the Divnogorie Farmstead in the Liski District of the Voronezh Region. The test-pit and the site were on a low elevation (Coordinates: N50°56′57.774″ E39°16′46.746″), at a height of approximately 3–5 metres above the floodplain of the Tikhaya Sosna (fig. 1). The area on which the site was located was approximately 50 m wide and along the edge of the road it was adjacent to the valley slope of a chalk plateau reaching a height of 55–60 m above the river valley (fig. 2).

The site was discovered by A.A. Bessudnov in 2008 and was investigated in the years that followed. In 2018, after the investigation of the Palaeolithic cultural layer in the southern part of the trench, a stratigraphic test-pit was sunk down to a depth of around 5 m. Subsequently the section of that test-pit was the object of detailed palaeo-geographical research.

Multidisciplinary field research into the test-pit involved detailed morphological description and was followed by careful selection of samples for later lithological, palaeo-pedological and palaeo-botanical investigations.

Colors of the sediments and soils were determined in accordance with the “Munsell Soil Color Charts”. The *particle size analysis* was made using the laser diffractometer Malvern Mastersizer 3000. Only silicate constituent of the sediment, which is most resistant to diagenesis, was analyzed, while both organic matter and carbonates had been removed in the process of samples preparation. The latter included a sequential treatment of the sample with 20% solution of hydrogen dioxide (to remove organic matter), then with 10% solution of hydrochloric acid (to remove carbonates), and finally with 4% solution of sodium pyrophosphate (to disperse the clay aggregates). After the treatment with chemical agents, the material was transferred by pipette to a liquid tray in the material dispersion unit where it was subjected to ultrasonic at a power of 40 W for 100 seconds and intensely stirred at 2400 rounds per minute. After the ultrasonic having been shut down, the measurements were repeated ten times, and the results were averaged using a Mastersizer v.3.62 application. The particle size distribution by fraction was calculated using the Fraunhofer approximation model.

The loss on ignition (LOI) was determined with the aim of estimating the content of organic matter and carbonates in the sample, which is important in the paleosol diagnostics. The LOI values obtained at 550°C show the organic matter content, while the difference between LOI values obtained at 950°C and those at 550°C (LOI 950°C – LOI 550°C) indicates the loss of carbonate CO_2. The samples, each of 10 ml in volume, were dried up for 12 h at 105°C for water (including hygroscopic) removal. Then they were incinerated in a muffle furnace at two temperature regimes (4 hours at 550°C and 2 hours at 950°C). The loss on ignition was found as the difference in weight before and after ignition using the electronic balance with the accuracy of 0.01 g. The resulting values formulas are:

$$LOI550 = \frac{DW105 - DW550}{DW105} \times 100;$$

$$LOI950 - 550 = \frac{DW550 - DW950}{DW105} \times 100,$$

Fig. 1. Location of Divnogorie on the map of Europe (a) and location of Divnogorie 1 and Divnogorie 9 Palaeolithic sites on the topographic map of the area where the Tikhaya Sosna River flows into the River Don. Liski District, Voronezh Region (b).
Рис. 1. Расположение Дивногорья на карте Европы (а) и палеолитические стоянки Дивногорье 1 и Дивногорье 9 на топографической карте района, где р. Тихая Сосна впадает в р. Дон. Лискинский район, Воронежская область (b).

where DW is dry weight. *Magnetic susceptibility (MS)* measurements were performed using the magnetic susceptibility meter ZH Instruments SM-30.

The maceration of pollen samples was performed by the method adopted in the Geological Institute of the RAS, which is a modification of the separation method, namely, the samples were additionally treated by sodium pyrophosphate and hydrofluoric acid. The study of palynological preparations was carried out on an optical microscope Motic BA 400 with a camera Moticam 2300, at working magnification ×400. Pollen diagrams were constructed in Tilia 2.0.41 program, which allows to calculate the general spectrum (arborescent pollen + nonarborescent pollen + + spores = 100%) and individual components as a portion of the total amount of pollen grains.

3. MATERIALS AND RESULTS OF THE RESEARCH

3.1. Archaeology. At the present time the total area of the Divnogorie1 site, which has been investigated using trenches and test-pits, amounts to 85 m^2. In the Upper Palaeolithic cultural layer in most of the cleared sections, the finds have included bones, lithics, chips of stone plaques and occasional pieces of red ochre. The absence of any habitation structures reflects the fact that Palaeolithic humans spent only relatively short periods here. The lithic assemblage includes over 2.500 pieces and among these the most common tools are end-scrapers, burins on truncations, backed implements, oblique points and truncated blades. The appearance of the collection is typical for the Eastern Epigravettian sites (Bessudnov et al., 2012).

A trench was sunk in 2018 in order to investigate a peripheral section of the site, in which the density of finds within the cultural layer was significantly less than in the central section. The Palaeolithic cultural layer was represented by a thin level of finds, which had been seriously damaged by burrowing animals at a depth of between 1.75 and 1.85 m from the surface and which consisted of intact and fragmentary animal bones, flint and quartzite items and fragments of stone plaques. The total number of lithics from the 2018 trench came to just over 100. Items with secondary modification were tool types traditional for the site.

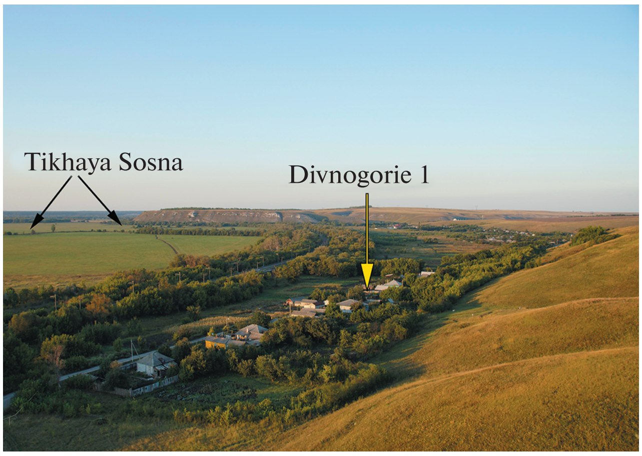

Fig. 2. View over the valley of the Tikhaya Sosna River and the Divnogorie 1 site. Photograph taken from the chalk plateau.

Рис. 2. Вид на долину р. Тихая Сосна и стоянку Дивногорье 1. Фото сделано с мелового плато.

In the osteological collection from Divnogorie 1, obtained in 2018, in total 98 bone fragments were identified from Pleistocene and modern species of large mammals. Among the Pleistocene fauna, bones of a wild horse (Equus ferus Boddaert, 1785), reindeer (Rangifer tarandus Linnaeus, 1758) and, for the first time at this site, those of a musk ox (Ovibos moschatus Zimmermann, 1780) were found (Bessudnov et al., 2020; Burova et al., 2019).

On two of the bones found in the cultural layer – the calcaneus of the musk ox and a long bone of the horse – cut-marks made with stone tools were identified. On certain diaphysis fragments, and also on proximal and distal bone parts, flake scars resulting from targeted blows were recorded (Burova et al., 2019).

In the stratum containing Holocene levels, traces of humans from various archaeological cultures were identified (Repin, Late Abashevo, Srubnaya and Saltovo-Mayatskaya cultures), which did not occupy clearly defined positions in the stratigraphy. In general, the collection was represented by ceramic and osteological material (Bessudnov et al., 2020).

3.2. Structure of the section. Nine main layers have been singled out in the structure of the section at the Divnogorie 1 site: a redeposited layer (surface level of mixed soil) containing a newly created undeveloped soil (Layer 1), a modern cultural layer (2a), a Holocene layer consisting of thick chernozem, which has been anthropogenically reconstituted (2b, 2c), a Late Glacial proluvial stratum (3–6) and a Late Valdai periglacial alluvium (7–9) (fig. 3, tabl. 1). The Late Glacial sequence of deposits is the most complex: it consists of four layers of loam and loamy sand – two of them with permafrost features (top of Layer 4 and Layer 6) and another two with fossil-soil features (bottom of Layer 4 and Layer 7) covered by loess-like loams (Layer 3) and separated by a layered loess-like stratum (Layer 5).

3.3. Lithological Investigation. The highest levels of magnetic susceptibility (MS) are to be found, as a rule, in buried soils (Babanin et al., 1995). In the Divnogorie 1 section, the maximum values for MS coincide with the modern cultural layer (Layer 2a) for which the average MS values are $0.7605–0.632 \times 10^{-3}$ SI. In Layer 3 immediately beneath the soil consisting of loess loams, the MS values drop sharply to $0.05 \times \times 10^{-3}$ SI while in Layer 4 a substantial increase in MS is to be observed, up to 0.25×10^{-3} SI, which is most probably linked to processes in initial soil formation. Lower down (Layers 5-9) MS values are fairly consistent.

As regards granulometric composition, the share of sand is represented by thin, shallow and medium fraction sand fluctuates significantly between 9 and 48%. The higher values for sand are found in the upper part of the section (Layer 1). There are also peaks to be observed in Layer 4, in the lower part of Layer 5 and in the upper part of Layer 9. In certain layers, sands with a large and coarse fraction are noted: the highest level of that sand content is ~10%, which was recorded in the upper part of the section, in Layer 1. The share of aleuritein the section fluctuates between 30 and 75%. The highest values coincide with the lower part of the section starting from Layer 6, while the content of the clay fraction varies from 10 to 22% (in the lower part of Layer 2b).

The loss on ignition (LOI) values at 550°C reflecting the content of organic matter, change over the section within the range 1.41 to 9.64%. The maximum values are to be found in the upper part of the section, in Layer 2, the humus-rich Chernozem levels. Starting from Layer 3, fluctuations are very small: between 1.41 and 4.41%. A slight increase – up to ~ 3.5% –was to be observed in Layers 4 and 6, connected with low humus formation.

The LOI values at 950°–350°, reflecting the carbonate content, change through the section from 1.12 to 20.15%. The maximum values coincide with Layers 1 (anthropogenic), 3 (Bk horizon of Chernozem) and 4. An increase in that indicator has also been observed at the base of the section at a depth of 4.75 m.

3.4. Spores and pollen analysis. The abundance of palynomorphs in the samples is not the same throughout the section. The largest concentrations of pollen and spores are to be found in the top 1.6 m. On the basis of changes in the composition of the spore-pollen spectra, the diagram was divided up into 8 palynozones (from now on PZ; fig. 4).

PZ I (4.35–4.75 m) distinguishes Layer 9. Isolated grains of *Picea*, *Pinus*, Asteraceae, Chenopodiaceae are found there. Pollen grains of *Picea* and *Pinus sibirica* are present.

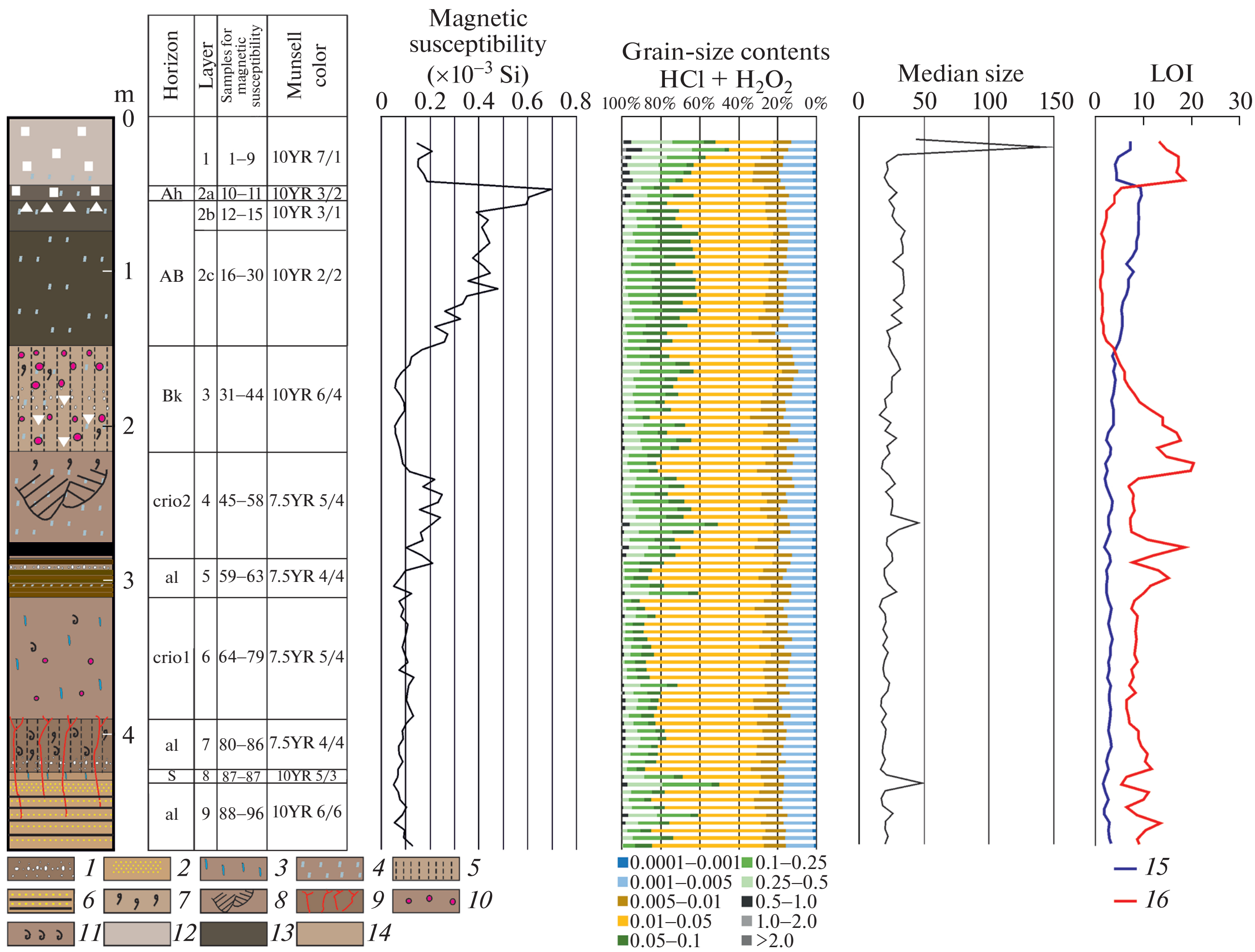

Fig. 3. Lithological research data. The numbers correspond to the layer numbers in the text.
1 – crushed stone, *2* – sand, *3* – carbonate tubules and other carbonate concretions, *4* – chalk crumbs, *5* – loess-like loam, *6* – interbedding of sands and loams, *7* – cutans, *8* – scours with layered filling, *9* – cracks, *10* – molehills, *11* – mollusc shells, *12* – modern cultural layers, *13* – Bronze Age cultural layers, *14* – Upper Paleolithic cultural layers, *15* – LOI 550°, *16* – LOI 950°.

Рис. 3. Данные литологических исследований. Цифры соответствуют номерам слоев в тексте.
1 – щебень, *2* – песок, *3* – карбонатные трубочки и др. карбонатные конкреции, *4* – меловая крошка, *5* – лёссовидный суглинок, *6* – переслаивание песков и суглинков, *7* – кутаны, *8* – промоины со слоистым заполнением, *9* – трещины, *10* – кротовины, *11* – раковины молюсков, *12* – современные культурные слои, *13* – эпохи бронзы, *14* – верхнего палеолита, *15* – ППП 550°, *16* – ППП 950°.

PZ II spectra are found in Layers 5–8 (at depths between 2.9 and 4.35 m) and they contain insignificant amounts of pollen grains. In all these Layers, however, grass pollens predominate (accounting for 70–85%), mainly Asteraceae, Chenopodiaceae, *Artemisia* and Brassicaceae. At a depth of 3.45 m green algae, *Botryococcus braunii,* were found and at a depth of 3.15 m re-deposited grains of *Podocarpus.* In the lower part of Layer 5 (at a depth of 3.05 m) a conspicuous inclusion of plant residues and fungi were noted, including *Glomus.*

PZ III reflects the vegetation in the lower part of Layer 4 (2.6–2.9 m). In the relevant spectra there is an increase in pollen of trees to be observed (up to 50%) – *Pinus sylvestris*, *Betula* sect. *Albae*, *Alnus*. Isolated algae *Botryococcus braunii*, soil fungi and soil mites are found.

In the spectra of PZ IV (1.85–2.6 m) palynomorphs are virtually absent.

PZ V (1.75–1.85 m) corresponds to the upper part of Layer 3. The samples taken there contain isolated pollen grains of *Artemisia*, Asteraceae, and Cichorioideae. Plant residues and charcoal particles are present and also fungi (*Glomus* sp. (NN-126), Quamar, Stivrins, 2021). Re-deposited grains of *Gleichenia* and *Carya* have also been noted.

In palyzones VI-VIII the concentration of palynomorphs increases, as does the variety of fungi remains. Grains of *Pseudoschizaea* sp. ((NN-61); Christopher,

Table 1. Morphological Description of the section at the Divnogorie1 site
Таблица 1. Морфологическое описание разреза стоянки Дивногорье 1

Layer, Level	Depth, cm	Description
1	0–38	Modern Cultural Layer. Dark-grey medium loam. Top 20 cm include numerous anthropogenic remains: brick, glass, nut shells and fruit trees pits. Transition gradual.
2, a+b+c	38–145	Chernozem from Holocene period. Ah. Dark-grey medium loam, of lumpy-granular structure. Molehills and roots of fruit trees are noted. At a depth of 50–60 cm is found a large number of pottery fragments (Bronze Age CL). Abrupt change in colour, edge along the tunnels of burrowing animals. AB. Non-homogenous grey-pale loam, with a fine-porous structure and containing ancient pale-grey and modern black coprolites, chalk crumbs and pebbles; already badly broken up by burrowing animals; thin clay coatings are observed and candidiasis along the pores.
3	145–215	Bk. Light, pale-yellow loam, loess-like and porous; pores are covered with carbonate films. Loam contains a large quantity of small chalk inclusions; prone to rapid boiling from hydrochloric acid; broken up by frequently used tunnels of burrowing animals. Dense carbonate greyish-white colours are observed. At a depth of 175–185 cm, finds from the Upper Palaeolithic from 13300–13800 uncal BP.
4	215–285	Layer badly damaged by cryogenic and erosion deformation. It consists of a series of small rills with finely layered in-fill. The transverse profiles of the rills are cone-shaped, 60–70 cm wide, and between 40–50 and 70 cm deep. The layered nature of the rills can be observed most clearly in their in-fill. In the rills there are secondary erosion potholes also with layered in-fill. Cores of the in-fill of the rills are more homogenous and consist mainly of bright-brown heavy loam with clay coatings. Between the rills and above them lies material consisting mainly of rock debris. An inter-layer containing large pieces of chalk has been crushed by permafrost: it is sometimes embedded underneath the rills or higher up between them.
5	285–310	Layered loamy sequence, consisting of inter-layers (from the bottom up): brown or reddish-brown loam (2 cm); chalk debris (2–3 cm); reddish-brown heavy loam (5 cm); pale-yellow/reddish-brown heavy loam (3 cm); reddish-brown loam (2 cm); pale-yellow /reddish brown loam containing small chalk crumbs (4 cm); reddish-brown medium loam, slightly ferruginous (5 cm); brownish/reddish-brown light loam (5 cm).
6	310–390	Light, reddish-brown loam consisting of three sub-layers and with small pores. In the lower part of the layer, at a depth of 340 cm, sub-vertical veins of pale-yellow heavy loam are visible. Rare molehills used once or frequently are encountered, chalk inclusions, carbonate tubes and concretions greyish-white in colour. Pieces of mollusc shells are found. Sub-vertical cracks at lower limit measuring 8–20 cm penetrating to a depth of 450 cm, sometimes deeper.
7	390–425	Layered mainly loamy, non-homogenous stratum consisting of inter-layers; patches of pale-yellow/grey loam with slight humus content (390–403 cm), with an inclusion of dot-like chalk crumbs and small mollusc shells; heavy pale-yellow/reddish-brown loam (405–414 cm) with reddish-brown coatings; pale-yellow loam containing crushed stone (414–420 cm). In the bottom pale-yellow inter-layer there are carbonate concretions. An inter-layer of chalk crumbs 2–3 mm in size is embedded beneath the horizon containing white spots of lime. Rounded pebbles are also encountered.
8	425–430	Light loam, grey/reddish-brown in colour, non-homogenous, containing grey patches and porous: carbonate tubes along the pores, rapid boiling from hydrochloric acid; contains films of rust. Possibly the initial soil.
9	430–476	Thinly layered sequence of loams, loamy sands and sands. Loams are pale-yellow or very pale yellow, the sands are pale-yellow or yellow. In the middle part of the layer is an inter-layer of chalk crumbs measuring 5–15 cm. Sandy loams and loams boil from hydrochloric acid; the sandy inter-layers do not. In the upper part of the sequence (433–439 cm) there is an inter-layer of pale-yellow sand containing manganese ortsteins. Sand and sandy loam are also layered (thickness 0.1–0.5 mm). On one of the walls of the test-pit a displacement of those layers has been noted, which is associated with the permafrost crack from layer 6, which has broken through this layer as well.

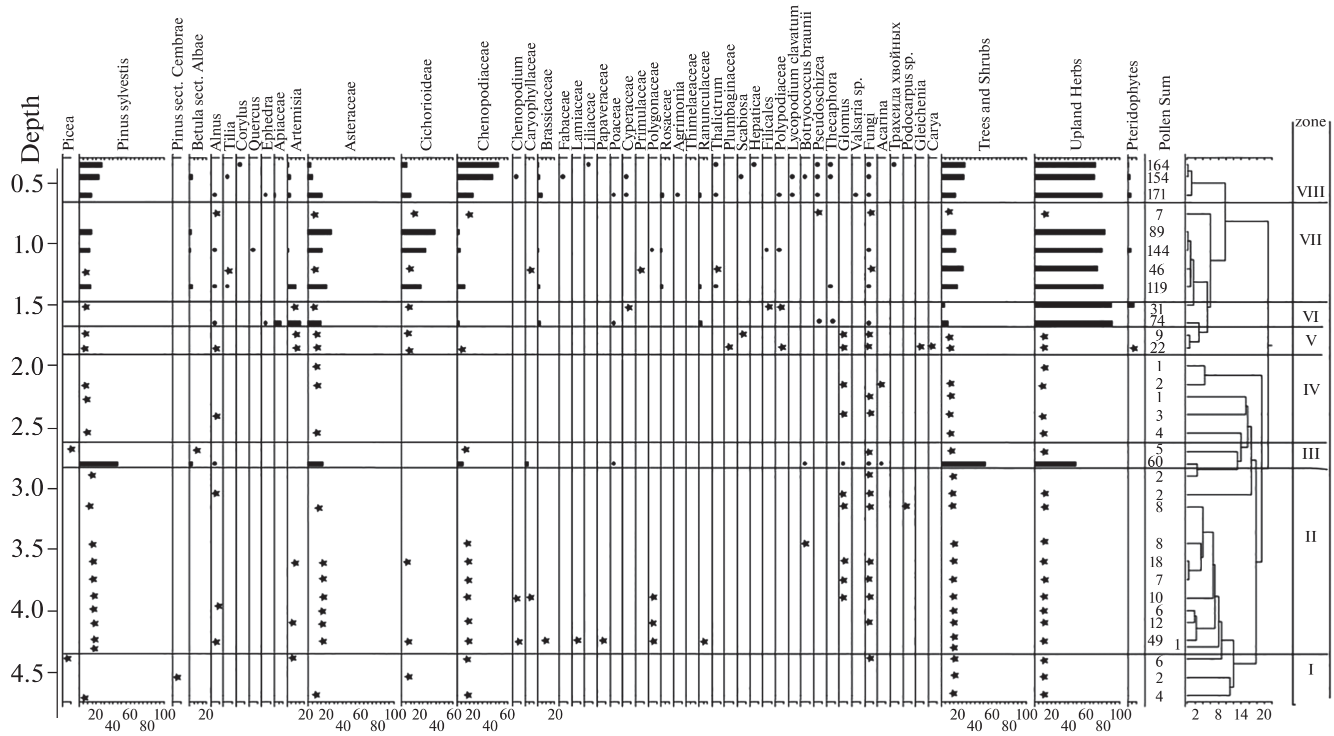

Fig. 4. Results of the spores and pollen analysis. Star – single grains; dot – content in the spectrum less than 3%.
Рис. 4. Результаты споро-пыльцевого анализа. Звездочка – единичные зерна; точка – содержание в спектре менее 3%.

1976), which could belong to algae (Gadens-Marcon, 2014; Mudie et al., 2010).

PZ VI distinguishes Layer 3 (1.5–1.75 m). Pollens of grasses and bushes predominate (up to 95%): in particular pollen of *Artemisia* and Asteraceae. Pollen grains of *Ephedra*, Chenopodiaceae, Brassicaceae and Plumbaginaceae are also present. The spectra indicate the predominance of open steppe and semi-steppe landscapes. Various fungi remains are found in this layer as well: *Thecaphora*, *Alternaria* ((BFA-6), Halbwachs et al., 2021), cf. *Delitschia* sp. ((NN-138); Quamar, Stivrins, 2021) and grains of *Pseudoschizaea* sp.

Pollen spectra from PZ VII (75 cm–1.50 m) were obtained from Layer 2. In these the quantity of tree pollens increased to 30%. Pollen of birch, lime and oak appear and the quantity of Cichorioideae pollen increases up to 40%: also present are Caryophyllaceae, Cyperaceae, Brassicaceae, Polygonaceae, Rosaceae and isolated Polypodiaceae spores. In the samples a large quantity of plant residues and charcoal particles was noted and soil fungi were identified. Forest-steppe landscapes predominated (a combination of meadow-steppe vegetation with some areas of mixed forest).

PZ VIII (35–75 cm) stands out on account of the spectra present: the amount of Asteraceae in them decreases and that of Chenopodiaceae gradually increases (up to 50%). In the tree group the pollens of *Pinus*, *Betula*, *Alnus*, *Tilia* and *Corylus* are present. Grains of *Ephedra*, Brassicaceae, Poaceae, *Agrimonia*, *Thalictrum* and *Scabiosa* were found and spores of *Riccia* and *Lycopodium clavatum*. The samples contain plant residues (including coniferous tracheids), charcoal particles, soil fungi and fresh-water algae. Steppe landscapes predominated, including some areas of mixed forest in conditions of a warm-climate situation.

4. DISCUSSION

In the base of the section alluvium was found which includes a flood-plain-oxbow facies (Layer 7) and a river-bank facies in the low flood-plain terrace of the Tikhaya Sosna River, which are difficult to distinguish from each other. The horizontal layered nature of some sequences, including those of hair – like fineness bear witness to the periodic freezing of the alluvial stratum (Layer 8) (Konischev, Rogov, 1994). A similar structure of deposits indicates that there has been accumulation of periglacial alluvium at the base of the section (Selli, 1981; Handbook ..., 1982). Conditions of this kind are also borne out by the presence of *Pinus sibirica* grains.

Heterogeneous deposits higher up the section (Layers 6–3) are distinguished by their cyclical structure: alternating inter-layers filled with dense chalk crumbs, crushed chalk and chalk pebbles; layered loamy sands; loess loams with features of soil-formation and cryogenesis. The nature of these sediments testifies to their having accumulated in the peripheral zone of alluvial cones in ravines which cut through the nearby valley slopes (Botvinkina, 1965; Guide ..., 1987).

The key role of proluvial processes can be clearly traced from a depth of 3.45–3.15 m (Layer 6) not only on the basis of lithological features, but also on the basis of palynological data, which indicate a water component in the formation of the deposits and the presence of redeposited microfossils, which are represented by *Podocarpus*, *Carya* and *Gleichenia* coinciding in date with the upper parts of Layers 6 and 3. Palaeomorphsare represented in insignificant quantities in Layers 5–7, which also testifies to fine earth having repeatedly been redeposited.

Reddish-brown loess-like loams embedded in the lower part of Layer 4 and in the in-fill of gullies, are probably pedosediments – deposits formed from destroyed soil levels (consisting of illuvial clay) and redeposited a small distance away. It is possible that the gullies had initially been permafrost wedge-shaped cracks, later modified through erosion processes and then filled with layered heavy loams and clays. Smaller gullies often turned into ravines in which crushed stone was deposited.

The results of the lithological research confirmed in the main the sequence of layers which had been identified during field-work. Levels from the final horizons of the Pleistocene era with features of soil formation (Layers 4 and 6) stand out fairly clearly and, for these, growth in the values of magnetic susceptibility was recorded and some increase in the median size of the component particles.

Levels in which humus accumulates and transitional levels of Chernozem stand out clearly, on account of the increase in the LOI 550° values and also the carbonate horizon on account of the increasing difference between LOI 950° and LOI 550°. A small increase in organic matter emerges for Layer 4, the top of Layer 5, the top and bottom of Layer 6, in relation to which initial fossil soils or pedosediments have been described.

The significant quantity of plant residues, the increase in pollen from tree species, the diversity in fungi remains (*Glomus*, *Valsaria* ((Hdv-1008); Van Geel et al., 2011), *Thecaphora*, *Tetraploa* ((Hdv-89); van Geel, 1978), *Alternaria*) and the occasional presence of *Acarina* soil mites indicate that soil processes played a part in the formation of the bottom part of Layer 4 and to some extent Layer 5 as well. It is likely that during the time when those sediments were taking shape, there had been some increase in humidification. In the upper part of Layer 4 where cryogenic and erosion processes used to show up particularly clearly, there are virtually no palaeomorphs to be seen.

Loess-like loams, resulting from deluvium accumulation or aeolian processes (Layer 3) indicate that accelerated ravine erosion processes leading to the formation of removal cones, their merging and the formation of a plume at the foot of a valley slope were far less frequent than before.

The surfaces of ravines had dried out and become more stable and more convenient for temporary habitation. The Upper Palaeolithic cultural layer (assigned an age of 13.300–13.800 uncal BP on the base of radiocarbon dating) is thought to coincide with the top level of loess loams: a characteristic feature of that time period was an increase in plant and charcoal residues and the appearance of hazel trees.

A predominance of limb bones (mainly feet), i.e. “non-fleshy” parts, a specific lithic assemblage and the thin cultural layer at the Divnogorie 1 site would indicate that the site is an accumulation of remains from a short (possibly, seasonal) camp, where the inhabitants specialised in butchering horse carcasses (Bessudnov et al., 2013; Burova et al., 2019). The question of belonging to the surface on which the camp of Divnogorie 1 was located was whether it was a low river terrace above the floodplain of the Tikhaya Sosna River or a proluvial plume? This question had already been resolved during the investigation in the field of the geological-lithological structure of the section and the answer to it subsequently confirmed on the basis of data obtained through laboratory research. It is the surface of a low fluvial terrace above the flood-plain – a terrace which has been covered over by deluvium and proluvial deposits, incorporating initial soils, their pedosediments and layers with cryogenic deformations.

The presence of *Pseudoschizaea* and absence of *Glomus* spores in the spectra within the upper 1.60 m of the test-pit could indicate the substitution of ravine-alluvium deposits by an accumulation of humus in conditions with a stable surface in the Holocene period. *Pseudoschizaea* is often present in the spectra of archaeological sites from the Bronze Age onwards (Environment ..., 2019).

On the loess-like loams (Layer 3) covering the proluvial-alluvial stratum, a typical Chernozem formed, containing accumulations of humus, transitional and carbonate levels. The presence of artefacts from various archaeological cultures in the humus profile of the Chernozem shows that from time to time it took shape under the influence of the anthropogenic factor. The Bronze-Age finds were encountered mainly at a depth of 50–60 cm. It is at that level that pollen of ruderal species and garden plants appears.

The upper part of the section consists of modern cultural layers: a redeposited layer (Layer 1) and a layer formed in that position (Layer 2a). Palynological research has revealed that the highest concentrations of pollen and spores coincide in date with the top 1.60 metres – with the profile for Holocene Chernozem. Soil processes are reflected to the greatest degree in Layers 3, 2 and 1. Those layers often contain insignificant amounts of pollen grains, which is a feature characteristic of humus-rich soils in which a high degree of microbiological activity is to be found.

5. CONCLUSION

The site of Divnogorie1 is located on the Late Glacial low fluvial terrace above the flood-plain, which is covered by a proluvial plume. By the time short-term settlement of the area had begun, active relief-forming processes had slowed down considerably. The periglacial type of landscape was confirmed by the results of the palynological research.

The cones of the ravine outflow as a result of the merger turned into a single deluvial-proluvial plume, which covers a low over-floodplain terrace. Initial soils and pedosediments are described in the sediments of the gullies removal cones, which is confirmed by the results of lithological and spore-and-pollen analyses. They formed during short intervals when there was a reduction in relief-forming processes.

Palaeolithic cultural layer of the site was seen to coincide with the upper part of the aeolian and deluvian loams – the parent basis of the Chernozem – which had turned into the carbonate horizon as a result of soil formation. In the cultural layer an increase was noted in plant and charcoal residues. Over the period when the camp was functioning, open-steppe landscapes and even semi-desert ones predominated, which later gave way to forest-steppe landscapes (combinations of meadow vegetation with areas of mixed forest).

Palynological research has made it possible to establish changes in the nature of vegetation and climatic conditions during the time when the deposits in the section were taking shape. In the Holocene there were a number of changes giving rise to either wetter or drier conditions. Steppe landscapes (Layer 3) gradually gave way to forest-steppe ones – to a combination of meadow-steppe vegetation and small areas of coniferous/broad-leaved forest in conditions of a warm climate situation. The drier climate at the end of the Final Pleistocene and during the first half of the Holocene was followed by a moister climate in the second half of the Holocene era.

The multi-disciplinary research carried out has shown consistent change from a periglacial fluvial situation to a subaerial one – initially periglacial and then interglacial – of a wooded-steppe and sometimes a steppe situation of a moderate zone. In the Late Glacial stratum two levels have been recorded for the appearance of features of slight pedogenesis and also two levels of permafrost deformations. A highly dynamic sequence of landscapes was identified both in the Late Glacial period (due to sharp fluctuations in temperature gradients, less humidification) and also in the Holocene (change of aridity and humidity).

LOCAL STRATIGRAPHY AND PALAEOECOLOGY OF THE LATE UPPER PALAEOLITHIC SITE DIVNOGORIE 1 IN THE BASIN OF THE MIDDLE DON

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The Upper Palaeolithic site Divnogorie1 situated on a low terrace of the Tikhaya Sosna River, consists of periglacial alluvium, covered with proluvial and deluvial deposits. In the Late Glacial layer two levels of initial pedogenesis have been identified, two levels of permafrost and erosional disturbances and also a Palaeolithic cultural layer with a radiocarbon age of 13.800–13.300 years ago. The multi-disciplinary geo-archaeological research carried out so far has revealed a shift from a periglacial fluvial situation to a subaerial one – initially

a periglacial one and then an interglacial one – in a forest-steppe and occasionally steppe setting. The highly dynamic nature of the climate and the landscapes was characteristic of the Holocene period and particularly pronounced for the Late Glacial period.

Keywords: Late Glacial period, Upper Palaeolithic site, terrace, ravine removal cone, periglacial vegetation, pedo-, cryo-, bioindicators

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