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The Area of Distribution and Conditions of Formation of Loess in the Southern Urals

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Abstract—This report presents the results of comprehensive studies of loess-like formations that are common within the drainage basins of the Ai and Yuruzan Rivers (Southern Urals). Loess complexes are associated with the third fluvial terrace. The lithological composition, structural, and textural features indicate that the loess were formed like the part of alluvial fans under the third fluvial terrace. The obtained palynological data indicate the formation of deposits in the Middle Pleistocene during the Odintsovo interglacial and Moscow glaciation.

Keywords: Southern Urals, Quaternary deposits, Middle Neopleistocene, loess, palynology, formation conditions

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INTRODUCTION

Loess and loess-like rocks, which are common in the drainage basins of the two largest tributaries of the Ufa River, that is, the Ai and Yuryuzan rivers, have not yet received due attention among researchers. However, the studied formations are an important component for the reconstruction of the region's development in the Pleistocene.

Questions of the genesis of loess strata remain unresolved (Bolikhovskaya, 1995), as well as, in relation to a specific topic, the age of loess formation.

Spore–pollen analysis, together with structural and lithological studies, allows us to answer these questions. The geomorphological position of the loess-like complexes, the lithological composition, as well as the textural and structural features of the deposits make it possible to determine the conditions and mechanisms of their formation. The reconstruction of spore–pollen spectra of different levels of loess-like deposits, as well as the study of their evolution, gives some idea of climate change and allows comparison with regional scales: the relative age of the deposits, especially considering that local climate features reflect the global climate background to one degree or another, and the sequence of vegetation cover succession for each interglacial period is uniform over a broad regional framework (Kukla et al., 2002; Tzedakis, 2003).

Due to the large number of definitions of the term "loess," associated, of course, with the variety of properties of the rocks themselves, as well as with the specialization of researchers studying them, it is necessary to indicate the meaning of the term as used in this article. By the terms "loess" and "loess-like rock" we mean the definitions proposed by N.I. Krieger: "*Loess is a light yellow aleurite with a total porosity of 40–55%, with tubules visible to the naked eye, unlayered, calcareous (but not cemented to the state of semi-rock), more or less microaggregated, prone to collapse in vertical blocks, overlying a cloak (including number, often at the highest points of watersheds), usually with a thickness of at least several meters. A characteristic property of loess is the homogeneity of the texture in the profile at different depths and in plan view in different areas. Interlayers of pebbles and sands, as well as individual inclusions of boulders and pebbles, are exceedingly rare. The characteristic, but not obligatory properties of loess are cases of its alternating with buried soils, as well as the inclusion of shells of terrestrial mollusks and calcareous "cranes" (single ones or interbeds). Rocks that morphologically resemble loess, but do not have the full complex of the above characteristics, are called loess-like*." (Krieger, 1965, p. 27).

Since we did not carry out exhaustive studies (porosity measurements, determination of grain size distribution, mechanical properties of rocks, etc.) that are necessary for the legitimate use of the term "loess," it is terminologically correct to call all the mentioned in this study rocks "loess-like rocks," although, in our opinion, many of them are undoubtedly loess.

According to the literature data, loess deposits in the territory of the Southern Urals are distinguished in the Ai-Yuryuzan and Sakmara regions of the Cis-Urals structural-formation region. These deposits are also considered to be a distinctive feature

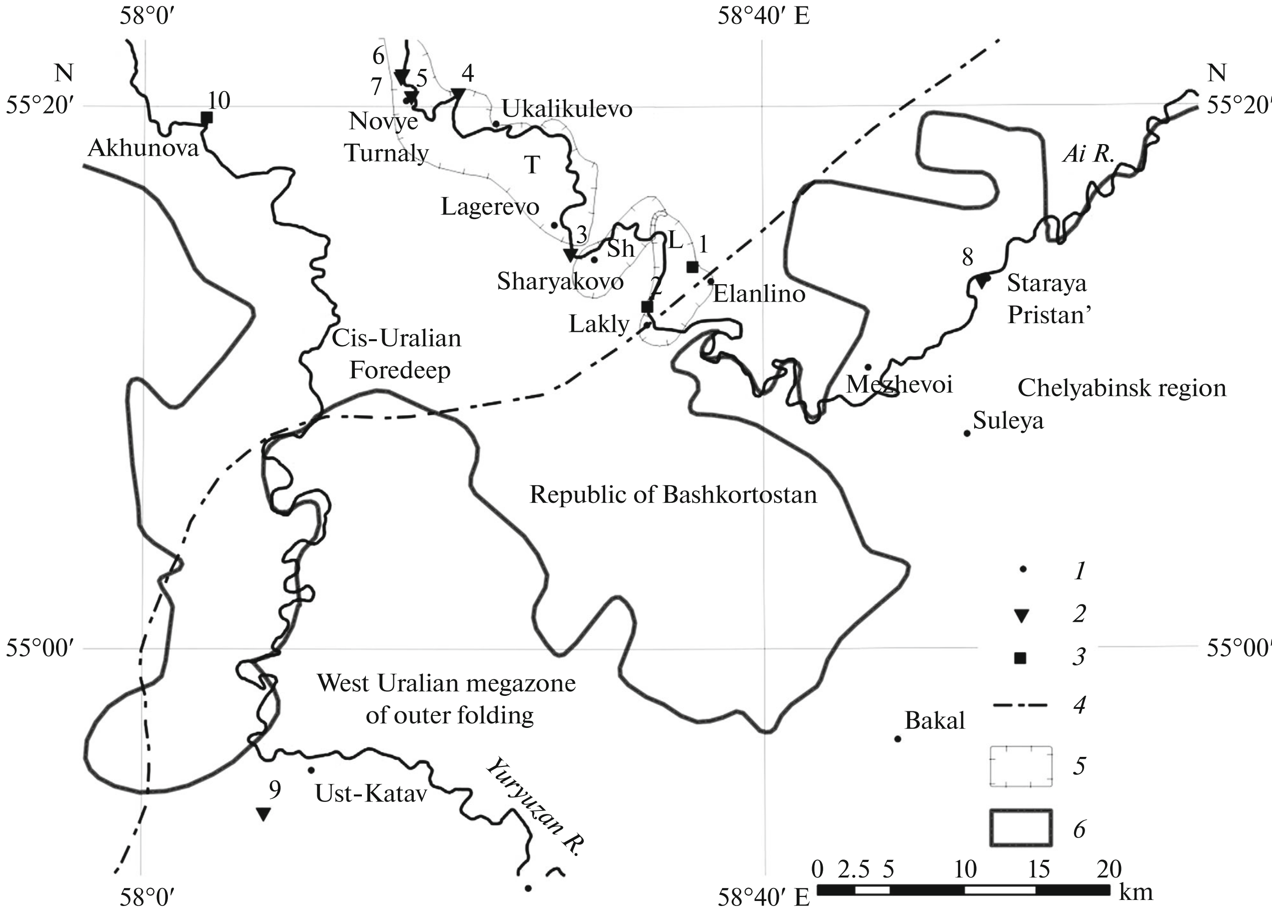

Fig. 1. The scheme of the studied area: (*1*) settlements; (*2*) support outcrops; (*3*) minor outcrops; (*4*) tectonic zones boundaries; (*5*) valley depressions boundaries (T, Turnaly; L, Lakly; Sh, Sharyakovo); (*6*) boundaries between regions. The numbers on the map corresponds to the observation points.

of the structure of this taxon (Knyazev et al., 2013), however, they have not yet been studied.

The region of the studies. The work was carried out in the Salavat region of the Republic of Bashkortostan and the Katav-Ivanovsk district of the Chelyabinsk region. The studied profiles are confined to the valleys of the Ai and Yuryuzan rivers and are located near the settlements of Staraya Pristan', Elanlino, Lagerevo, Novye Turnaly, Akhunova, and Ust-Katav. In the valley of the Ai River representative profiles were studied near the villages of Staraya Pristan', Lakly, and Novye Turanaly (the area of the villages of Staraya Pristan' and Lakly corresponds to the mountainous frame of the river valley, while in the area of the village of Lakly the mountainous environment is replaced with a plain).

In geomorphological terms, the area is confined to the western slope of the Southern Urals, namely to the area where mountain structures are replaced by foothill plains. Structurally, the studied profiles are in the West Uralian megazone of outer folding and the Ural foredeep (Abramova et al., 2002) (Fig. 1, Table 1).

MATERIALS AND METHODS

The geomorphological position and structural features of loess-like strata. Loess-like formations, which are widespread within the drainage basins of the Ai and Yuryuzan rivers, are mainly associated with the third fluvial (Iset) terrace, which rises 12–16 m above the water's edge, whose relics have been preserved fragmentarily. Areas at this level are usually flat, sometimes covered with a network of small erosional hollows and swamp depressions. Many settlements are located on them: Urgal, Khaibatovo (located to the east of the studied area), and Novye Turanaly. The rocks of this complex are characterized by easy erosion and, at the same time, the ability to support multimeter vertical ledges.

The most representative outcrops of loess-like rocks are confined to the valleys of large rivers and their tributaries. As a rule, they are located in the mouth parts of ancient erosional troughs, which are currently relatively weakly expressed in the relief. In general, these are deposits of deltas of ancient tributaries of the Ai River, which were located at the third flu-

Table 1. The coordinates of the observation points

Observation point number	Latitude	Longitude	Observation point number	Latitude	Longitude	Observation point number	Latitude	Longitude
1	55°14′6.9″	58°35′27.7″	5	55°20′19″	58°17′17.4″	9	54°53′53.7″	58°7′50.8″
2	55°12′39.1″	58°32′32″	6	55°21′8″	58°16′41.6″	10	55°19′37″	58°4′0.5″
3	55°14′31.1″	58°27′34.4″	7	55°21′2″	58°16′36.8″			
4	55°20′26″	58°20′19.1″	8	55°13′27.7″	58°54′9.8″			

vial terrace level of the river, and only narrow fragments have survived from them in the edges of very steep floodplain ledges.

In total, 20 profiles were studied at ten observation points, whose structures contained loess-like deposits (Figs. 2, 3). A palynological analysis was performed for the deposits of the seven most representative profiles.

RESULTS AND DISCUSSION

Ai River profiles. The first outcrops of loess-like rocks were described in a ravine on the northwestern outskirts of the village of Elanlino (profile1), where a stratum of cover loess-like rocks is exposed on the right side of the river of the same name at the junction of the wide surface of the first fluvial terrace, which is occupied by agricultural land and a higher structural surface. The maximum thickness of the sediments described here does not exceed 4 m and thin sandy-clay lenses and interlayers appear in the lower parts of the prevailing loess-like loams (Fig. 2). The ravine on the slope above the modern water edge in the Ai River exceeds the 16 m point. It is not entirely clear whether the loess-like rocks fill the entire high surface or "lean" against it and only constitute its framing.

The next outcrop of loess-like rocks is 4 km southwest from the first outcrop and 300 m to the north from the village of Lakly, on the left side of the Ai River valley (profile 2). A steep crevice uncovered a multi-meter, well-exposed strata of eluvated silt-argillite flyschoids forming an inclined fold, on which beige loams with abundant inclusions of clastites, thin sandy-argillaceous interlayers with a weakly pronounced vertical separation lie. The number of clastites gradually decreases and the last 3 m of the outcrop are represented by loess-like loams and sandy loams with a well-defined bastion separation (Fig. 2). We interpreted this sequence of rocks as an ancient fan. This assumption is confirmed by the conical morphology of the site on which the section was laid. The position of the edge of the outcrop above the water edge in the Ai River is 15 m.

The presence of a significant amount of unsorted and often unstructured clastites in the lower part of the section indicates a vigorous flow sedimentation regime and loess-like loams in the upper part indicate a stagnant regime, possibly under cooling conditions. The alternation of fine-earth deposits, sands, and clays, in which lenses and interlayers of coarse material are found, which resemble a terrigenous–carbonate complex of the substrate, we interpret as a proluvial complex; the loess-like rocks that crown it are extremely similar to the rocks described at observation point 1.

Downstream, in the region of the Sharyakovo valley depression, 1 km to the west from the village of the same name, on the left side of the river valley, a huge outcrop of loose rocks is described at the bend of the river (profile 3). Its apparent thickness in an almost vertical scarp is approximately 9 m. Below there is an inaccessible and unexposed part of the scarp approximately 7–9 m high. In addition to color differences, the rocks are distinguished by the presence in individual members of interlayers of dense gray-ocher sands with unsorted weakly rounded clastites of all sizes, as well as whitish carbonate inclusions of up to 5 cm (Fig. 2). The position of the edge of the outcrop above the water edge is approximately 18 m.

We regard this complex as a valley fan that is located below the level of the third fluvialterrace. This is confirmed by irregular bedding, the presence of rubble-gritty lenses, interlayers and layer-by-layer chains and, at the same time, the presence of loamy members that are loess-like.

Downstream, in the region of the Turnaly depression, several representative profiles of loess-like rocks were investigated. Similarly located, that is, directly in the river clamps and at the outlets from them, many-meter outcrops of loess-like rocks were found 2.5 km to the northwest of the village of Yukalikulevo (profile 4), as well as directly in the village of Novye Turnaly (profile 5) and 2 km to the north of it downstream of the river (observation points 6, 7).

On the right bank of the Ai River, to the north of the village of Yukalikulevo, within a large and narrow meander, there is a huge outcrop of loose rocks in a system of narrow small ravines reaching the river floodplain. The edge of the surface rises 12 m above the water. The upper and most exposed part of the profile is represented by loess-like loams of beige-gray and reddish-gray color with pronounced vertical separation. They contain centimeter-long interlayers of fine-grained sands and clays, lenses of flat, well-laid fine gravel and gruss. Loess-like loams are underlain

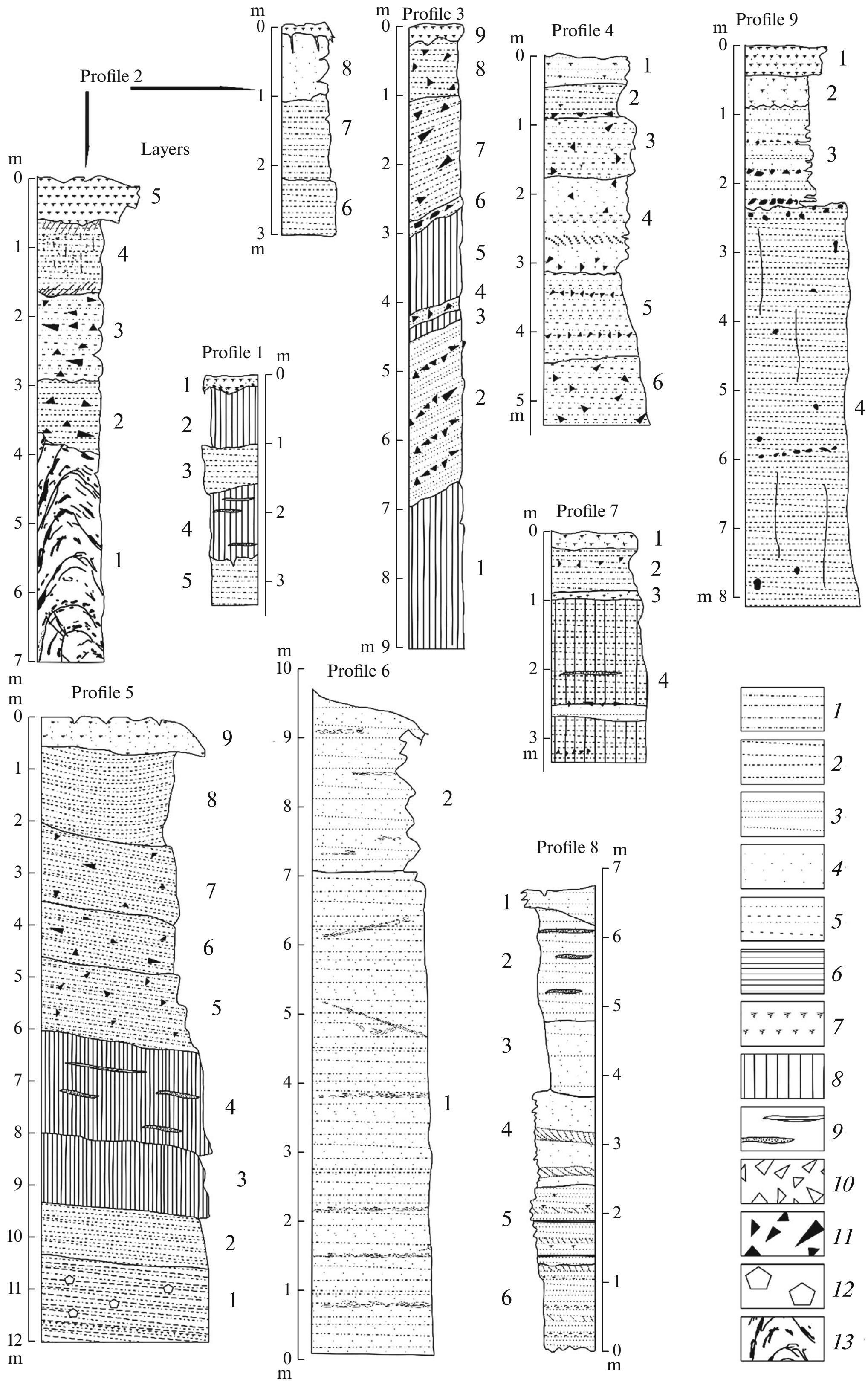

Fig. 2. The lithological columns of loess-like rocks in the valley of the Ai River: (*1*) sandy loam; (*2*) loam; (*3*) sand; (*4*) silt; (*5*) sandy-clay matrix; (*6*) clays; (*7*) sod-soil horizon; (*8*) loess; (*9*) lenses of clays and sands; (*10*) gravel; (*11*) gruss; clastites; (*12*) carbonate cranes; (*13*) turbidites.

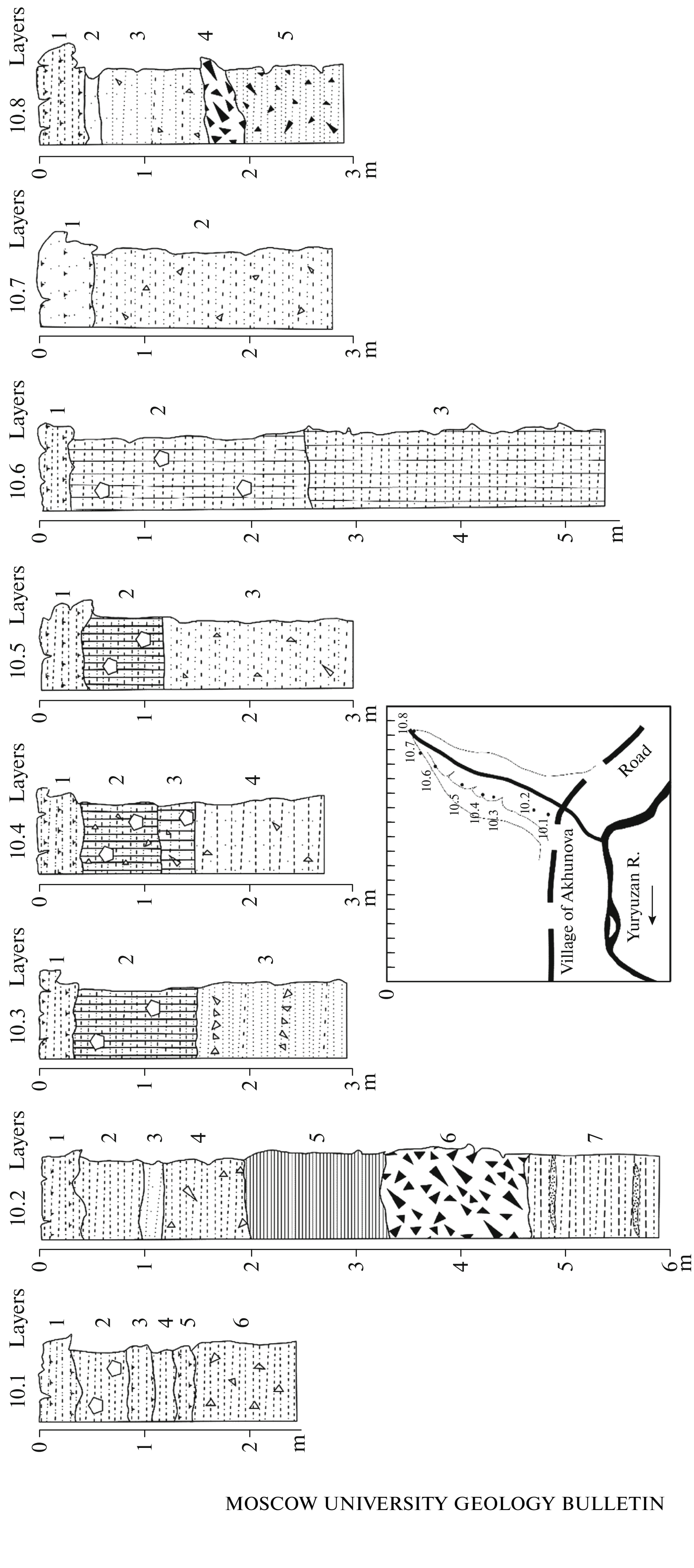

Fig. 3. The lithological columns of profiles (profile numbers at the top) of loess-like rocks composing a ravine to the north of the village of Akhunova. See legend in Fig. 2.

by alternating sands and clayey sands with rare inclusions of fine gravel (Fig. 2). The thickness of the loess-like loams holding the vertical wall is 3 m; lower, starting from the level of the sandy-clay member, a slope cover develops.

A profile that is similar in structure is described at observation point 3 (see above); it can also be interpreted as an ancient fan.

On the eastern outskirts of the village of Novye Turnaly is a natural 12-meter outcrop of red loess-like loam, revealing a section of a flat surface on which the village is located (profile 5); the edge of the surface rises 15 m above the water.

The profile is represented by alternating loess-like loams and sandy loams of different colors (from reddish-brown to beige-gray). All strata have a well-defined vertical separation (Fig. 2). The rocks are inclined northward at an angle of 16–18°. Small carbonated channels are present in the lower part of the outcrop. In the central part, the loam is so dense that it resembles “stone loess”; it contains rare lenses of lumpy paleosols; in general, the rocks are somewhat sandy. In the upper part of the outcrop, the rocks become less dense (this is evident from the large number of insect and bird burrows), in addition, small rubble appears in them, which disappears in the uppermost part of the cross-section.

The Turnaly profile represents the end of a huge 30-meter outcrop located 1.5 km to the north on the same left side of the Ai River.

The surface is exposed in a vertical scarp with an absolute height of 240–250 m at the edge, 20–25 m above the level of the Ai River. In a huge outcrop, reddish rocks, “red clays,” resembling rocks of the Kustanai Formation (Aulov et al., 2005), are exposed, similar in appearance to the rocks in the Turnalinsky reference cross-section. The lower part of this outcrop was studied at the northern and southern ends, whose structure is somewhat different. At the northern end (profile 6) the deposits are represented by silty-sandy loamy beige-gray loess with lenses and interlayers of reddish sandy loam with inclusions of fine-medium-grained sandy material, alternating up the profile with similar, but slightly brighter and less dense loamy sands. In the southern end (profile 7), the section is somewhat different; there are interlayers of paleosols up to 0.5 m thick in the sandy loamy loess (Fig. 2). In the lower part, inclusions of crushed stone and pebbles appear, which, form a basal horizon at the level of the modern edge of the Ai River.

Loess-like deposits were found in the upper course of the Ai River. On the southern outskirts of the village of Staraya Pristan’, on the left bank of the Ai River, next to a rural cemetery is a quarry cut into a steep slope of the Ailino surface with a height of 360–380 m (profile 8). The slope is drained by a steep, overgrown, and dry ravine.

A multi-meter stratum of sands, silts, and clays was uncovered in the quarry in its only ledge. The base of the quarry wall has a height of 293 m, the upper edge is at 300 m, which at the edge of the Ai River of approximately 270 m corresponds to the level of the third–fourth fluvial terrace. In the adjacent ravine, the stratum continues well below the bottom of the quarry, at least up to a level of 285 m. The upper part of the outcrop is represented by loess-like sandy loam with rare interlayers of fine-grained sand. Downward, sandy loams are replaced by silts with rare lenses and interlayers (up to 10 cm) of cross-bedded sands, which in turn are replaced by alternating sands of different dimensions and clays (Fig. 2).

The rhythmic alternation of sandy-clayey sediments indicates the formation of deposits in a very calm hydrodynamic environment, and the presence of lenses and sand interlayers with elements of oblique bedding, in contrast, indicates an active hydrodynamic regime. The combination of the above structural features of the strata suggests that its formation took place in the intravalley basin, which from time to time was isolated from the channel “feeding.”

The profiles of the Yuryuzan River. There are outcrops of loess-like rocks in the road cut of the M5 highway (profile 9) in 1 km to the west from the turn to Ust-Katav and 2.2 km to the east from the turn to the village of Orlovka. The wall, which is approximately 50 m long and up to 10 m high, contains outcrops of loess-like red loams, which are similar in appearance to the rocks described earlier. The general occurrence is like that of a cape. The rocks form a surface with an absolute height of 380–390 m, which is quite well maintained as in the north of the outcrop, around the village of Paranino (southern edge of Ust-Katav), and to the southwest of it. At the observation point, the surface is not wide (approximately 20 m), since from the north it is sharply cut by a stream, a tributary of the Katav River. The profile is almost entirely composed of a monotonous stratum of reddish-beige loess-like loam with a well-developed bastion jointing and rare carbonate inclusions. Loess-like loams are overlapped by silts and sandy loams, which form a system of subsoil incisions, and chernozem soils (Fig. 2).

A stratum of loess-like rocks was observed, which is similar to gully deposits in the area of the Elanly River (profile 1) in the area of the village of Akhunov in the western wall of the steeply incised right tributary of the Yuryuzan River (profile 10). Here, an unnamed stream, which has a narrow V-shaped valley, erodes a strongly modeled flat surface, the edge of which is 16–20 m above the Yuryuzan River, which corresponds, in our opinion, to the level of the third terrace of this river. Alluvial, proluvial, slope, and eluvial genetic types of sediments are represented in numerous sections uncovered in this highly informative area. The predominant alluvial–proluvial complexes are represented by fine-grained clayey sands with varying contents of coarser fractions, which are usually overlain by loess-like complexes and chernozem soils and are in many cases underlain by coarse clastites, processed rocks, probably, of the Akhunov Formation. The maximum thickness of the sandy–argillaceous complex in the described sections reaches 3 m, while the loess-like complex reaches 2.7 m (Fig. 3).

The palynological characteristics of loess-like strata. The palynological analysis was performed by G.N. Shilova. The content of each component in the spore–pollen spectra was calculated from the total amount of pollen and spores in the sample. A total of 35 samples from seven profiles were examined. Sampling was carried out for contrasting lithological differences within the cross-section; in some cases, some lithological varieties were sampled by several probes from different depths.

In *profile 3*, palynological analysis was performed for the deposits of the upper (loess-like loams with crushed stone inclusions) and the lower parts of the section (loess-like loams and dense, silty fine-grained sands), which are the only deposits available for sampling. The total number of palynomorphs in the sample from stratum 1 was insufficient for counting (<30 palynomorphs). In the palynological spectra of samples from stratum 2 and 7, pollen of arboreal and shrub forms prevails (up to 60%), the amount of herbaceous and subshrub pollen reaches 36.5%, and spores account for up to 20%. Up the profile, spores are systematically replaced by pollen of arboreal forms (Fig. 4).

Spore–pollen analysis showed that during the formation of the studied sediments, pine-birch forests with an undergrowth of shrubby birches with a cover of forest-meadow forbs were widespread in the area. In some areas, dark coniferous forests of spruce and cedar pine grew with ferns in the cover. The open habitats were occupied by cereal–wormwood associations.

The loess-like loams and sandy loams of the high terrace of the Ai River were probably formed during some warming and climate moderation during the Odintsovo interglacial of the Middle Neopleistocene Q_{II}^{3od}.

The palynological spectra of the deposits of *profile 4* are the most informative. Several stages of the Odintsovo interglacial are distinguished here (Fig. 5).

In the lower part of the section (strata 5 and 6), herbaceous species dominate (%) at 59%, and among them are xerophytes: hazel 41.2%; wormwood 7.9%; ephedra 3.1%; and singly, forbs 6.3% (aster and buckwheat). In the group of trees and shrubs, conifers predominate at 20.6% (pine and hemlock). Broad-leaved species are diverse and account for 14.3% (hazel, hornbeam, and linden), small-leaved species (shrub birch) account for 4.8%. The combination of open habitats with xerophytes and birch-pine forests with broad-leaved species is like that described for the third phase of the third fluvial terrace of the Volga River (Gubonina, 1978) and is dated by the Glazov optimum of the Odintsovo interglacial period of the Middle Neopleistocene $Q_{II}^{3od}{}_{gl}$.

In the sediments of the middle part of the profile (strata 3 and 4), the amount of pollen of arboreal forms decreases with an increase in herbaceous and dwarf shrubs. The dominance of open habitats with forbs and xerophytes reflects cooling and moisture, probably corresponding to the Krasnoborsk cooling of the Odintsovo interglacial $Q_{II}^{3od}{}_{kr}$.

In sample 2, taken from a depth of 0.5 m from gray loams with gravel, linden pollen is abundant at 79%; pollen from hornbeam, elm, and shrub birch is rare. Herbaceous species are represented by single pollen of Asteraceae, Chicoryaceae, and Dipsacaceae. Such a composition of the spore–pollen spectrum indicates that loams were formed under warm and humid conditions, probably at the Roslavl' optimum of the Odintsovo interglacial of the Middle Neopleistocene $Q_{II}^{3od}{}_{rs}$.

In sample 1, taken from a depth of 0.1 m from sandy loam with sand, the pollen of shrubby birch is abundant (43%), conifers make up 24.3% (pine, spruce, and fir). Pollen of hornbeam and oak are rare. The herbaceous group is represented by forbs (15.7%, aster, chicory, buckwheat, willow herb, norichnik, and buttercup), wormwood (2.7%), and cereals (0.9%). Fern spores are present in the spore group.

The appearance of coniferous forests, thickets of shrubby birches, wormwood-grasses, and herb-grasses reflects a cooling, probably during the Moscow glaciation of the Middle Pleistocene Q_{II}^{4m}.

Profile 5 reveals an outcrop of red loess-like loams on the left bank of the Ai River near the village of Novye Turnaly. The thickness of the deposits in the profileis approximately 12 m.

Samples 1–4 were collected in the lower part of the cross section. Sample 1 was taken at a depth of 11 m from reddish-brown loams, with gravel and pebbles, sample 2 was collected at a depth of 10 m, from dark-brown and lighter loams – brownish gray, sample 3 was collected at a depth of 8.9 m from slightly whitish loams, and sample 4 was collected at a depth of 7.6 m from brown loams.

The general composition of the spore–pollen spectra (Fig. 6) of these strata contains approximately equal amounts of arboreal and shrub pollen and herbaceous and subshrub pollen. In the group of pollen of trees and shrubs, the pollen of broad-leaved species is diverse: walnut, elm, oak, linden, beech, maple, hazel, and hornbeam, which in total make up 22%. Conifers (spruce, fir, pine, and larch) and small-leaved species (birch, alder, and willow) are represented singly. In the group of herbaceous and dwarf shrubs, forb pollens predominate at up to 30% (aster, chicory, umbelliferous, norichnik, valerian, primrose, and buttercup). Pollen of wormwood, hazel, and cereals is rare. In the group of spores, green mosses, sphagnum mosses, and moss were noted.

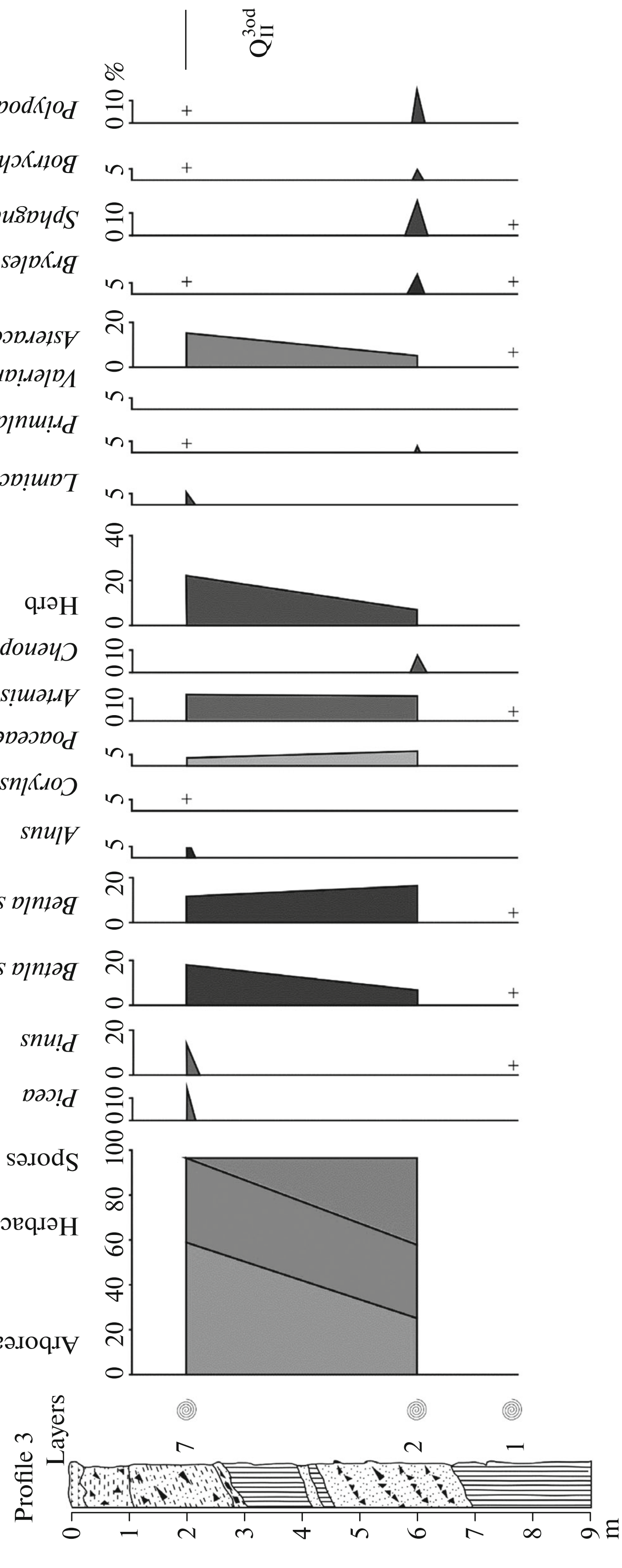

Fig. 4. The spore–pollen diagram of profile 3: "+", values not exceeding 2%; round icons near the profile corresponds to sampling points.

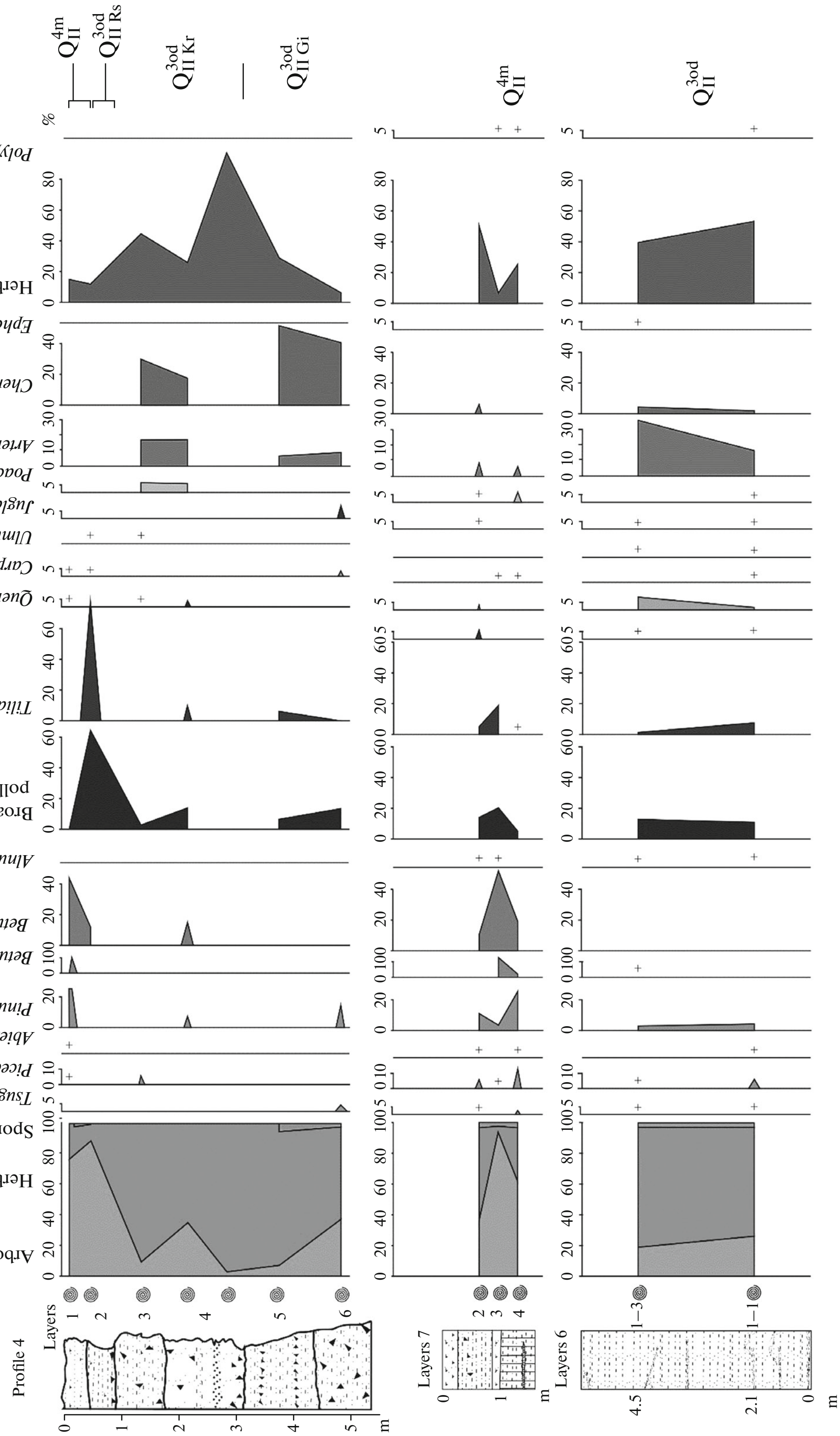

Fig. 5. The spore–pollen diagrams of profiles 4, 6, and 7.

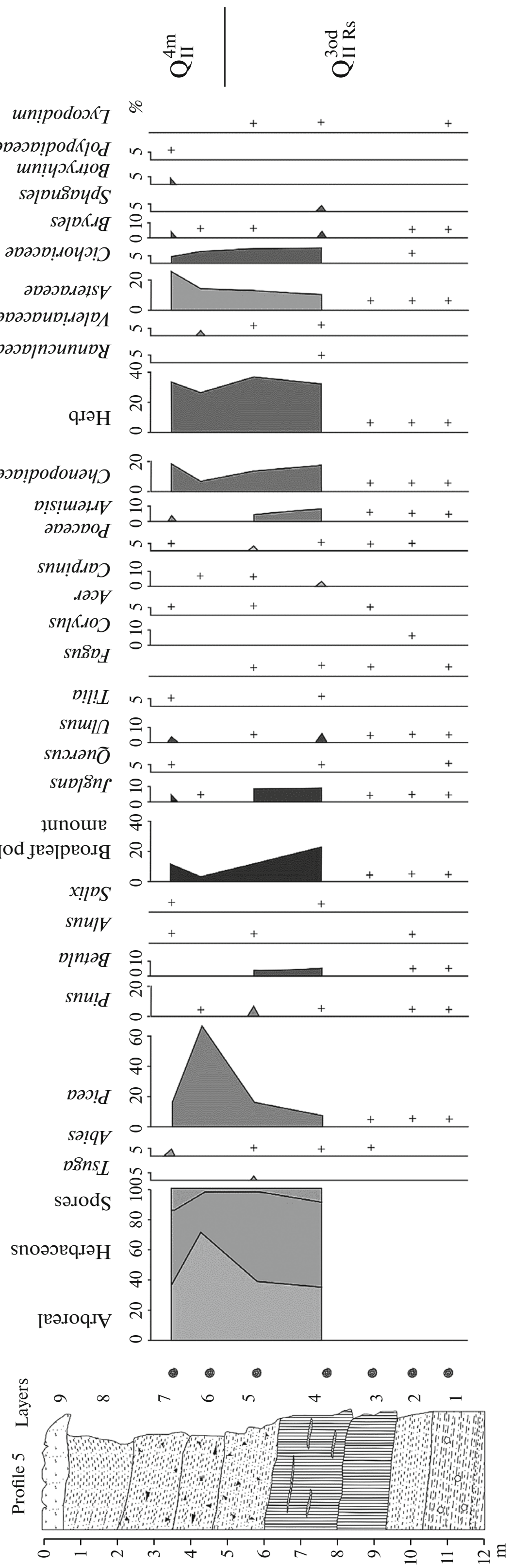

Fig. 6. Spore–pollen diagram of profile 5.

The palynological composition of the sediments indicates that forest-steppes, open woodlands of birch and broad-leaved species, and herb-grass steppes prevailed. Alder and willow were confined to the flooded depressions. Wormwood-hazel steppes occupied small areas.

The spore–pollen spectra of the upper (most representative) part of the profile (strata 5, 6, 7) reflect a consistent decrease in the sum of broad-leaved associations with an increase in conifers.

The change in the composition and volume of forest groups indicates a gradual cooling and a change from the Odintsovo interglacial epoch to the Moscow glaciation.

The abrupt change of the forest-steppe to taiga and again to the forest-steppe resembles the early and late Akkulaevsk time in the Cis-Urals, which dates from the end of the middle and the beginning of the late Akchagyl (*Pliotsen* ..., 1981). At the same time, a sharp boundary is traced in the composition of the spore–pollen spectra of the sediments, passing along the bottom of the fourth layer, due to a sharp (twofold) decrease in the total amount of pollen and spores. The Pliocene age is supported by the presence of such exotic genera as *Tsuga*, *Picea* sect. *Omo rica*, *Carpinus*, *Pterocarya*, *Morus*, *Cyatheaceae*, and *Osmunda*.

Profile 6 reveals deposits of the Bolshoi Aisky outcrop to the north of the village of Novye Turnaly (Fig. 1). The only available stratum of loess-like sandy loam with interlayers and lenses of red sands was sampled in the lower and upper parts (Fig. 5).

In the general composition of the spore–pollen spectrum, herbaceous and dwarf shrubs prevail (73.5–81%), among which the most widespread are forbs, wormwood and hazel; trees and shrubs account for up to 26.3%, with more (up to 14.2%) pollen of broad-leaved species (linden, hornbeam, oak, elm, hazel, maple, hazel, lapina), conifers (pine, spruce, spruce sections *Omorica*, cedar pine, fir, hemlock) make up 3.6–10.9%, birch and alder pollen is isolated (1.4–4.7%). This combination of palynomorphs indicates that at the time of the formation of the sediments, forb steppes and dry steppes with wormwood and hazel steppes prevailed. In favorable (dry and warm) conditions, there were birch-pine forests with broad-leaved species, as well as spruce-pine forests with hemlock. A similar setting is described for the outflow of the right tributary of the Malaya Karaganka River around the village of Novopototsky (Orenburg region) (Shilova et al., 2008) and the third horizon of the third terrace of the river. The Volga River in the area of Togliatti (Gubonina, 1978) dates from the Odintsovo interglacial Q_{II}^{3od} of the Middle Neopleistocene (Fig. 5).

Profile 7 was laid at the southern end of the Bolshoi Aiskii outcrop. Sample 4 was collected at a depth of 1.5 m from sandy loess beige-gray loess with crushed stone lenses (Fig. 5). In the total composition of the spore–pollen spectrum, pollen of trees and shrubs prevails (61.6%), pollen of herbaceous and dwarf shrubs is 33.8%, spores account for 4.6%. A large amount of pine pollen, 25%, and less spruce pollen, 9.8% (spruce of the section *Omorica* appears). Fir and hemlock pollen is rare. Birch pollen is 20%, single pollen of broad-leaved species (spruce, hazel, and hackberry) equal 3.8%. In the group of herbaceous and subshrub pollen, the pollen of forbs was noted at 23.6% (chicory, aster, clove, legume, labiate, buttercup, saxifrage, rosaceae, and wolfberry), wormwood, and cereals.

Fern spores are present. The appearance of coniferous forests of pine and spruce with undergrowth of shrubby birches and a cover of ferns, herb-grass and wormwood-grass steppes, and chicory in nonsodded areas reflects a cooling climate, probably during the Moscow glaciation. Similar vegetation was described for the sixth horizon of the third terrace of the Volga River (Gubonina, 1978) and was dated by the Moscow glaciation of the Middle Neopleistocene Q_{II}^{4m}.

The spore–pollen spectrum of buried silty soil of stratum 3 differs sharply from the spectra of the surrounding sediments (Fig. 5). The amount of arboreal and shrub pollen increases significantly, by up to 93.6%, herbaceous and subshrub pollen accounts for 5.9%, and spores are 0.5%. The pollen content of broad-leaved species increases to 20% (linden, hazel, and maple). Birch-deciduous forests were widespread, the climate became warmer and drier. The buried soils were probably formed during the interstadial of the Moscow glaciation.

Up the profile (sandy loam, member 2, sampling depth 0.9 m), the amount of arboreal and shrub pollen decreases to 37.6%; herbaceous and subshrub pollen predominates at 61.7%, among which a large amount of herb pollen is noted. Open habitats with forb steppes and wormwood–cereal associations with hazel were spread. The valleys could grow birch-pine woodlands with the participation of broad-leaved species.

The sandy loam of stratum 2 was formed during the cooling with some moisture, probably during the Moscow glaciation stage Q_{II}^{4m}.

Cross-section 8 was laid on the left side of the Ai River valley and exposes the Aylinskaya surface with an absolute height of 360–380 m. The total thickness of the section is 6.6 m (Fig. 7).

In the lower part of the section (stratum 6), the total composition of the spore–pollen spectrum is dominated by pollen (%) of arboreal and shrub (50), among which the pollen of conifers (14.4), dark coniferous (17.8) and broad-leaved (18.3) species. In the group of herbaceous and dwarf shrubs, herb pollen predominates (39.6%) and spores of ferns are rare. At the time of the formation of these deposits, pine forests with the participation of broad-leaved species, dark coniferous forests with hemlock and ferns in the cover were widespread here.

Up the profile (stratum 5), the amount of arboreal pollen decreases to 26.2% due to a decrease in pollen of all forms present in stratum 6. Herbaceous and subshrub pollen (%) accounts for 62.3; the pollen of forbs also dominates (up to 50%), the amount of pollen of the hazel increases (up to 15%), and pollen of wormwood appears (8). Changes in the spore–pollen spectrum of sediments indicate a reduction of forest area and the emergence of open steppe habitats with forbs, hazel and wormwood.

Then, in the composition of spore–pollen spectra of members 4 and 3, the content of arboreal and shrub pollen increases to 78% due to the dominance of pine pollen. The composition of conifers is varied. The amount of herb pollen is reduced to 20%. Fern spores are rare. Steppe habitats are retreating, and the main areas are occupied by pine forests; dark coniferous forests with hemlock are in a subordinate position there are.

In the upper part of the profile (stratum 2), the pollen of arboreal and shrub forms also dominates in the spore–pollen spectrum (up to 80%), while the composition of palynomorphs changes: pine species change, and single birch and alder pollen appears. There is still a large amount of broadleaf pollen (hornbeam, oak, elm, and walnut). Accordingly, at this moment, pine forests with the participation of broad-leaved species were wide spread.

The spore–pollen spectra obtained from the profile of the Aylinskaya surface in the valley of the Ai River (Fig. 7) characterize forest formations with pine and spruce, alternating with deciduous ones and are close to the forest complexes with pine and dark coniferous species with forest–steppe elements described for the lower Kama and Kuibyshev-Saratov Trans-Volga region (Kuznetsova, 1959). The complexes of the studied sediments contain representatives of the Turgai flora (*Tsuga*, *Taxodium*, *Picea* sect. *Omorica*, *Osmunda*), which additionally indicates the possibility of the formation of deposits of the Ailino surface in the middle Akchagyl under a milder climate than in the modern taiga.

Profile 9 was laid in a road cut on the M5 highway, 1 km to the west from the turn to Ust-Katav and 2.2 km to the east from the turn to village of Orlovka (Fig. 8).

During the accumulation of sediments of stratum 3, the spore–pollen spectrum was dominated by herbaceous and subshrub pollen (65%), which are dominated by forbs (40%); hazel, wormwood, and legumes are present. Woody and shrub species are represented by pine, birch, maple, and walnut. Fern spores are rare.

At this time open habitats predominated here, occupied by forb steppes with wormwood–hazel associations. Pine-birch woodlands spread along the valleys. Silt and sandy loam were probably formed during the Moscow glaciation of the Middle Neopleistocene Q_{II}^{4m}.

Below, in the spore–pollen spectrum of deposits of stratum 4, the amount of woody pollen increases (up to 42%) due to the appearance of spruce pollen. The

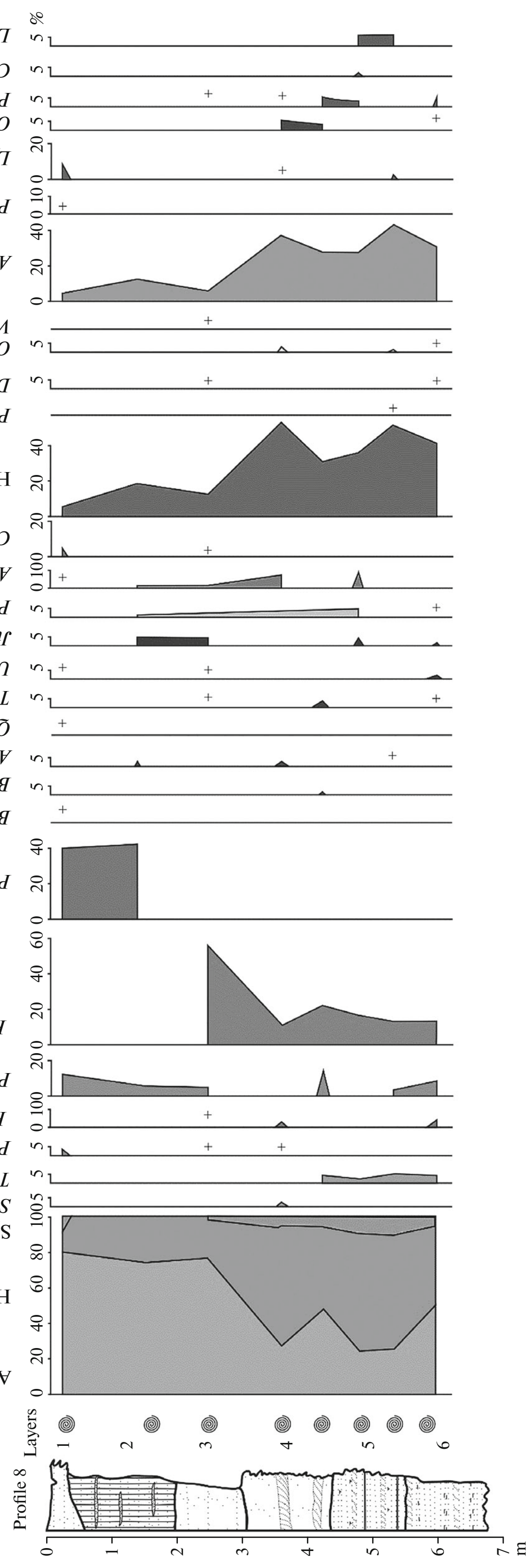

Fig. 7. The spore–pollen diagram of profile 8.

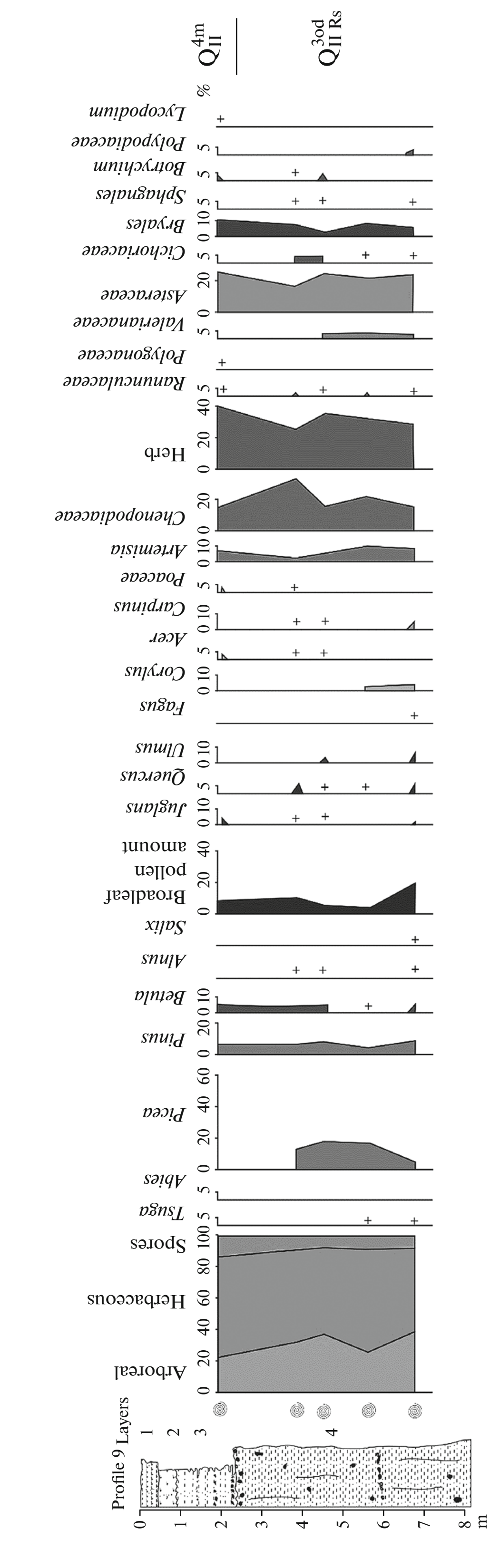

Fig. 8. The spore–pollen diagram of profile 9.

content of broadleaf pollen also increased: pollen of alder, elm, and beech species appears.

This territory was dominated by forb steppes with wormwood and hazel associations. Birch–pine forests gradually gave way to spruce–pine forests with hemlock. The number of mosses and ferns decreased (Fig. 8). Correlation spectra were obtained for the breach of the right tributary of the Malaya Karaganka River around the village of Novopototsky (Orenburg region) (Shilova et al., 2008) and the third horizon of the third terrace of the Volga River near by Togliatti (Gubonina, 1978) and dates from the Odintsovo interglacial period of the Middle Neopleistocene Q_{II}^{3od}.

CONCLUSIONS

Loess-like strata are fragmentarily distributed on the territory of the Southern Urals and are confined mainly to the level of the third (Iset) fluvial terrace (~18 m above the modern water line). The largest number of outcrops has been studied around the Cis-Uralian Foredeep, where the mountainous surroundings of the river valley are replaced by plains, and only a few for the Main thrust zone of the West Uralian megazone of outer folding.

Loess-like complexes, as a rule, are underlain by gray and brownish-red clays, clay sands, sandy loams and loams, often with abundant inclusions of detrital material, no more than 2-m thick. The thickness of loess-like strata varies from several meters to several tens of meters. Their structure often contains lenses and interlayers of coarse sand and crushed stone, as well as elements of oblique bedding, which indicates a vigorous flow sedimentation regime. Loess-like strata, which are a natural continuation of alluvial, proluvial, deluvial, and eluvial complexes, inherit the textural and structural features of the latter.

The structure and composition of the studied sediments make it possible to distinguish two environments of sedimentation: (1) ancient alluvial fans; (2) intra-valley basins with predominantly calm hydrodynamic conditions (one example of such a situation is the modern valley depressions of this region: Sharyakovo, Turnaly, and Lakly).

The obtained spore–pollen spectra of the studied profiles make it possible to distinguish two stages of the formation of loess-like rocks: (1) the Pliocene–Early Neopleistocene stage; (2) the Middle Neopleistocene stage (Table 2). The first stage is distinguished by the presence of rare thermophilic exotics of the Turgai flora in the spore–pollen spectra, that is, *Tsuga*, *Picea* sect. *Omorica*, *Carpinus*, *Pterocarya*, *Morus*, *Cyatheaceae*, and *Osmunda*, as well as a sharp change from forest-steppe to taiga and back to forest-steppe. The second stage is based on the similarity of the structure of the strata and the composition of the spore–pollen spectra with the previously described sections (section of the B. Urgala River, Likh-

Table 2. A brief description and interpretation of the studied profiles of loess-like complexes

Profile	Age by SPA	Stratum thickness, m	The position of the edge above the water, m	Features	Structural position in modern relief	Possible formation conditions
6	Q_{II}^{3od}	6	25	Oblique bedding, emphasized by interlayers of red sands. Rare inclusions of carbonate crushed stone in the lower layers	Framing the modern valley of the Ai River in the area of the Turnalinsky graben	Valley alluvial fan
7	Q_{II}^{4m}	3	25			
4	Q_{II}^{3od}–Q_{II}^{4m}	9	12	Sub-horizontal bedding, crushed stone and gravel carbonates		
5	N_2-Q_I/ Q_{II}^{3od}–Q_{II}^{4m}	12	15	Inclined bedding, rare inclusions of carbonate crushed stone in the lower layers		
8	N_2-Q_I	15	30	Thin loess strata underlain by alternating sandy-argillaceous interbeds with gently inclined and oblique bedding	Remnant of the third (fourth) terrace. The edge of the Ailino alignment surface	Intravalley basin
9	Q_{II}^{3od}	8	32	Loesses are overlain by a member of sandy-silty old composition with a clear erosional boundary between them	Covering loesses. Framing the erosional network. The edge of the Ailino alignment surface	Valley alluvial fan
10	–	>6	35	The presence of sandy interlayers and horizons of crushed limestone		
1	–	6	16	Loosely layered texture		
2	–	7	15	Presence of underlying limestone in loesslike loams of crushed stone	Framing the Ai River valley in the areas of the Lakly and Sharyakovo depressions	Valley alluvial fan
3	Q_{II}^{3od}	10	18	Presence of carbonate nodules and crushed limestone in the lower and central parts of the section		

vin/Chekalin profile), reflecting the change from forb steppes with broad-leaved and pine-birch open forests to wormwood–hazel steppes with coniferous open forests indicating climate aridization and cooling (Bolikhovskaya, 2007; Tevelev et al., 2015).

The spore–pollen spectra, as well as the confinement of loess-like deposits to the level of the third (less often fourth) fluvialterrace indicate that the main stage of their formation falls on the Middle Neopleistocene (the era of the Odintsovo interglacial–Moscow glaciation).

Rare thermophilic exotic species that are found in the spectra of profile 8 (Fig. 7), which make the age of the corresponding strata older before the Akchagyl, require confirmation, since they may have been redeposited.

In addition, according to the results of palynological studies, it was possible to determine that the formation of loess-like complexes is not exclusively associated with glacial or interglacial epochs, which is consistent with the results of other researchers (Bolikhovskaya, 2007).

The assumption of the glacial nature of loess complexes (Tevelev et al., 2015), which formed in the periglacial region of local glaciers, seems to be justified, since redeposited moraine deposits could be a source of finely dispersed material (Abramova et al., 2002) composing loess complexes, and the presence of a layered texture and coarse inclusions in loess-like deposits is probably associated with the most pronounced stages of warming, when the flow sedimentation regime was most active or with short-term stages of tectonic activation (Abramova et al., 2002).

Most likely, loess-like deposits were formed everywhere by a thin cover in the periglacial region of local glaciers. However, due to the easy erosion of such rocks, only their remnants were able to survive only in areas where the thickness of the deposits was maximum: in ancient alluvial fans, confined to the large rivers of the region and located to match the level of the Iset terrace that was forming at that time.

The area of distribution of glacial centers could be the ridges of the Bashkir mega-anticlinorium (Zigalga, Nurgush, and Urenga ridges) located in the southeast of the observation points (Abramova et al., 2002).

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