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Palynological characteristic of Karganian deposits in Surgut Priobye (Late Pleistocene of West-Siberian Plain)

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^{14}C-dating and palynological studies of the Kirias section (the midstream Ob River), which is a stratotype of Kiriasian layers of the Karganian horizon, have shown that the lower part of this section, which earlier had been believed to belong to the Karganian horizon, is of the Zirianian age. Lower layers of the Karganian horizon occur much higher. Palynological studies of Karganian deposits in the Kirias section allowed to distinguish nine palynocompexes, including two palynocomplexes of pre-Karganian and two palynocomplexes of post-Karganian (Sartanian) deposits. Palynological data showed that in the Karganian time vegetation in the Kirias region changed from open woodland of northern taiga to open woodland of forest taiga in warming stages of the Karganian time and reached the parameters of tundra (or transition from forest-tundra to tundra) in cooling stages. Late in the Zirianian and early in the Sartanian glacial time, vegetation changed from tundra to tundra-steppe. Displacement of vegetation zones to the south could exceed 800 km in the time of cooling and reach 300–600 km during the Karganian warming.

Key words: West-Siberian Plain, the Ob River midstream, Kirias section, Karganian horizon, palynology, vegetation history

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INTRODUCTION

In the last glacial–interglacial cycle of West-Siberian Plain, most controversial is the environment of the Karganian (Middle Würm-Wisconsin) time. Some researchers treat this time as interglacial (Кинд, 1974; Лаухин, 1996; Волкова и др., 2003; 2005 и др.) and others as part of the unified Zirianian–Sartanian cryochron (Васильчук, 1992; Фотиев, 2005; Астахов и др., 2005; Астахов, 2006 и др.), not recognizing the Karganian time even as a considerable interstadial.

According to the legitimized in Russia Stratigraphical Scheme of West-Siberian Plain Quaternary (Унифицированная..., 2000), the Karganian horizon is divided into five layers applicable to three warmings and two coolings. Recently both these climatic stages and the horizon layers applicable to them have received the following names (Волкова и др., 2003): Shurishkarian warming 50–44 Ka, Kiriasian cooling 43–42 Ka, Zolotomisskian warming 41–35 Ka, Lokhpodgornian cooling 34–30 Ka, Verkhnelobanovian warming 29–24 Ka. The optimum of the Karganian time (Волкова и др., 2005) is referred to a moderately warm climate, whereas the modern climate is characterized as moderately cold, close to subarctic (Волкова и др., 2005).

The character of palaeoclimates was reconstructed mainly from palaeontological, mostly palaeobotanical, data. The referring of layers containing these data to the Karganian time is made by joint methods of climatostratigraphy and ^{14}C-dating. ^{14}C-dates were obtained in the 60s–70s of the 20th century. Already in the 70s some of ^{14}C-dates raised doubts of S. A. Arkhipov, author all the named stratotypes (Архипов и др., 1980). Later S. A. Arkhipov (1997) called such dates pseudoterminal. However, the main mass of ^{14}C-dates were recognized as valid, and on them is based the division of the Karganian horizon into layers in the Unified Stratigraphical Scheme (2000). In the same 60s–70s were selected and monographically studied the stratotypes and key sections of the Karganian horizon layers (Архипов и др., 1976; 1977; 1980; Никитин, 1970 и др.). Most ^{14}C dates (ten) were obtained for Kiriasian layers (Kirias secton). The detailing of palaeoclimate reconstructions demanded the detailing and refinement of their chronostratigraphy. This refinement of chronology resulted in a full revision of the main layers of the Karganian horizon and a cardinal revision of the supposed paleoclimate of the Karganian time on the West-Siberian Plain (Laukhin et al., 2006). Below, we discuss data of palynological studies of the Kirias section, which were obtained by authors.

DESCRIPTION OF THE SECTION

The exposure Kirias, a stratotype of Kiriasian layers, is on the left-hand coast of the Ob River in its middle stream: 60° 51 ' NL and 75° 45' EL (Fig. 1). It was studied by us in two strippings, which are at a distance of 1 km from each other (Fig. 2). In the stripping Kirias 1 (K-1), the top of the section is latent under a thick talus, but the underlying layer of the stripping Kirias 2 (K-2) is partially uncovered in the stripping K-1. The correlation of layers of both strippings was based on reference horizons of peat accumulations in the bottom of layer 5. From the stripping K-2 they are tracked on the south (Fig. 2) along the exposure as two clear "peat bog" horizons. In strippings of the reference peat bogs no layers are observed: the peaty matter forms concentrations in loams as large spots, less often as lenses occurring in horizontal chains. On the west, towards the stripping K-1, only the lower horizon of peat concentrations was tracked (with interruptions). The upper horizon, as well as the overlying layers, are latent under a thick talus. We had no capability to uncover this talus by a trench, but it was possible for S. A. Arkhipov who disposed of a large group and had time enough to observe layers on the whole exposure (Архипов и др., 1980). Based on the tracing of layers made by him (Fig. 2) and on the lower reference horizon of peat concentrations revealed by us both in the trench K-2 and stripping K-1, we have connected both strippings into a unified section (Figs. 3, 4). The correlation of layer 5 in both strippings is confirmed also by ^{14}C dates (see below).

Both strippings uncover a section of the fluvial terrace III above the flood plain of the Ob River (Архипов и др., 1976; Левина, 1979) which uncovers on its branch Kirias. The stripping K-2 is as a steep trench with the co-ordinates 60° 57' 00.9" NL and 75° 45' 56.6" EL. The co-ordinates of stripping K-1 are 60° 57' 19.0" NL and 75° 45' 42.3" EL. As both strippings uncover the unified section, the numbering of layers in the description is common. The description is given in the abbreviated form (Fig. 3) from the top downwards:

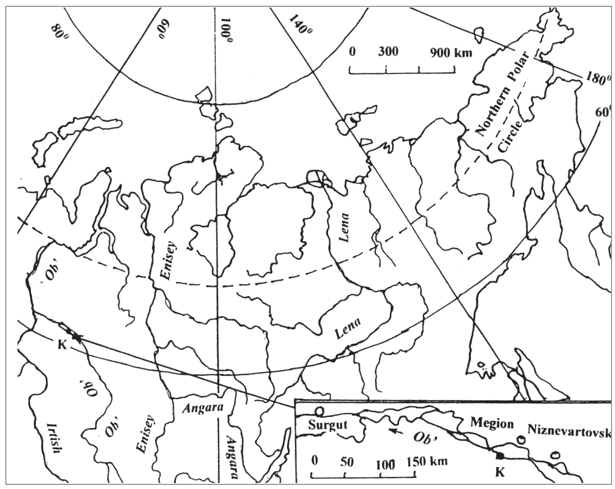

Fig. 1. Disposition of Kirias section (K)
1 pav. Kirjaso pjūvis

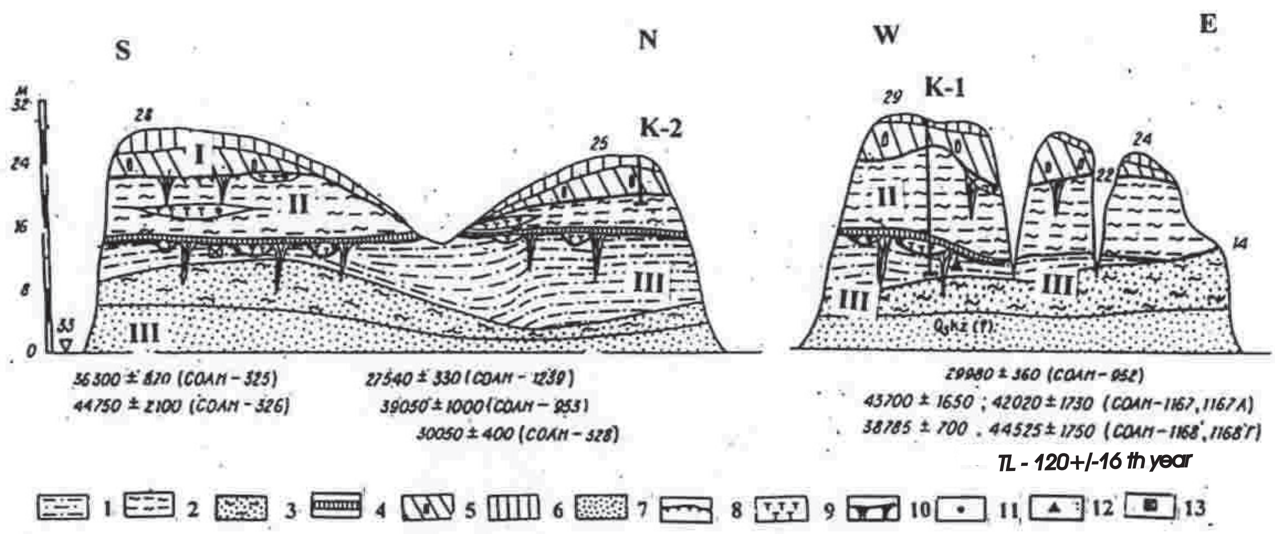

Fig. 2. Kirias section (according Arkhipov et al., 1980).

I–III – series: I – upper, covering; II – middle; III – lower (socle).

1 – clays and aleurites; *2* – interbeds of clay and sandy loam; *3* – interbeds clays, sands and sandy loams; *4* – white sandy loams ("whitish aleurites"); *5* – loams greenish-gray; *6* – loams loess-like; *7* – sands; *8* – buried soils; *9* – peat bogs; *10* – pseudomorphs on ice-viens; *11* – ^{14}C-dates; *12* – TL-dates; *13* – macroflora

2 pav. Kirjaso pjūvis (Archipov ir kt., 1980).

I–III serijos: I – viršutinė, dengianti, II – vidurinė, III – apatinė (cokolinė).

K-1 ir K-2 – prakasų padėtis (žr. tekstą). *1* – molis ir aleuritas, *2* – molio ir priemolio persisluoksniavimas, *3* – molio, priesmėlio ir smėlio persisluoksniavimas, *4* – nubalęs aleuritas, *5* – žalsvai pilkas priemolis, *6* – purus priemolis, *7* – smėlis, *8* – palaidotas dirvožemis, *9* – durpė, *10* – ledo gyslų pseudomorfozės, *11* – ^{14}C datos, *12* – TL datos, *13* – makroflora

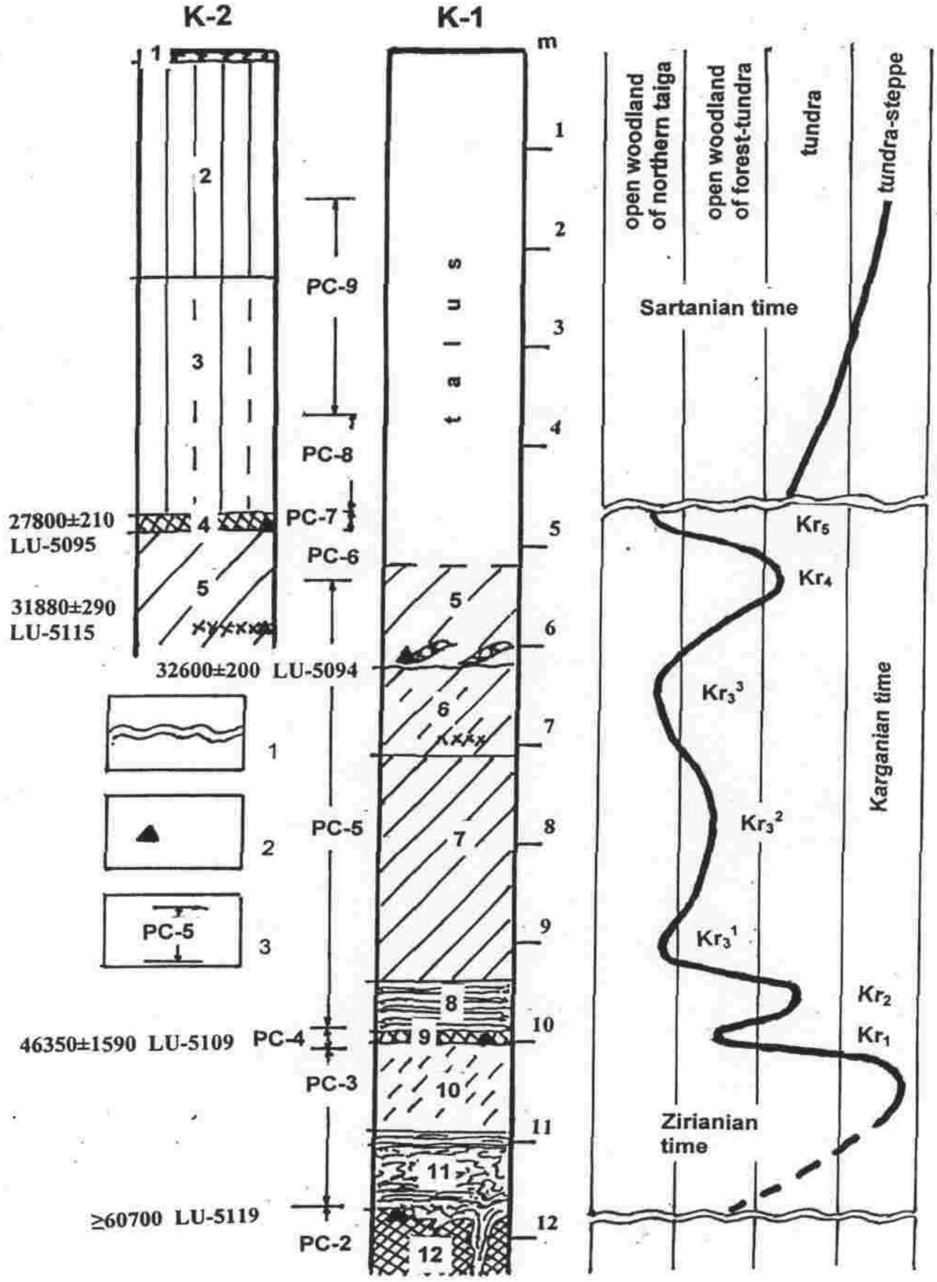

Fig. 3. Upper part of Kirias section (upper and middle strata according S. A. Arkhipov et al., 1980) and curve of changing of vegetation character in this section region during from Zirianian to Sartanian glacial time including. Chipers in layer fields on lithological column are numbers of layers (description see in text); Kr_1 – Kr_5 – stages of vegetation development during Karganian time.

1 – interruptions in sedimentation, *2* – place of selecting samples for ^{14}C-dating by authors, *3* – intervals of section, which were characterized by palynocomplexes from PC-2 to PC-9

3 pav. Kirjaso pjūvio viršutinė dalis (vidurinė ir viršutinė serijos pagal Archipovą ir kt., 1980) ir augalijos kaitos kreivė tirto pjūvio rajone nuo Zyriano iki Sartanio ledyninio laikotarpio imtinai.

1 – nuosėdų kaupimosi pertraukos, *2* – ėminių ėmimo vietos ^{14}C datavimui, *3* – pjūvio intervalai, kuriems būdingi PK-2–PK-9 palinologiniai kompleksai. Litologinėse kolonėlėse skaičiai sluoksnių ribose – sluoksnių numeriai (žr. aprašymą tekste). Kr_1–Kr_5 – Karginio laikotarpio augmenijos raidos etapai

Layer 1. 0–0.1 m. Humus horizon of modern soil, friable, sandy loam, along the strike substituted by a peat bog.

Layer 2. 0.1–2.3 m. Loam grey, clay loam, laminated, aleurite loam, on the top small-fragmentary, with white powdery coating of aleurite on the edges of fragments. Lamination is horizontal, wavy, lenticular. At a depth of about 1 m a line of ortstein is traked. Below it, horizontal concentrations (10–15 × 150 cm) of round (1–3 cm) concentric (5–7 circles) spots of ferruginization are dispersed. From a depth of 1.9 m, flagginess (on lamination) at the expence of aleurite powder on the bedding is observed. Transition from layer 2 to layer 3 is gradual.

Layer 3. 2.3–4.68 m. Loam, ash-grey to blue-grey below, not laminated; clay loam, on the top with earthy chips, below the texture is massive, the loam viscous, from top to bottom passes into

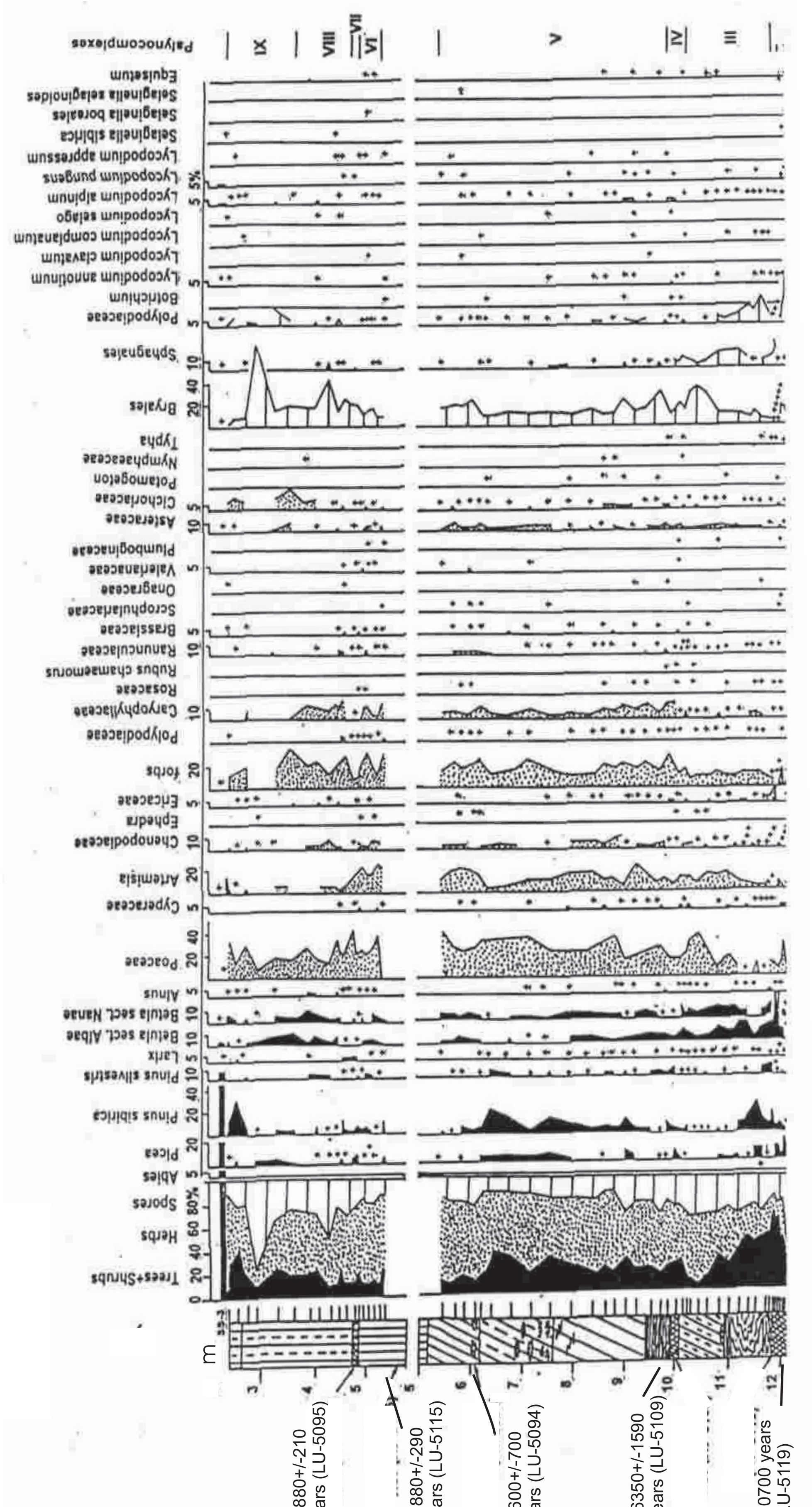

Fig. 4. Spore-and-pollen diagram of Kirias section ss-3 – palynospectra of surface samples, + – quantity of pollen or spores less 1%

4 pav. Kirjaso pjūvio sporų ir žiedadulkių diagrama, ss-3 – paviršinio mėginio palinologinis spektras, + sporų ir žiedadulkių kiekis yra mažesnis negu 1%

aleuritic clay. In clay, round (1–3 cm) and oval (1–2 × 10–15 cm) friable concretions are dispersed. At a depth of more than 2–2.5 m deep into slope concretions become dense.

Layer 4. 4.68–4.85 m. A packet of peat, brownish-grey, foliaceous, dense. The packet consists of two interbeds of peat, divided by loam, ash-grey, not laminated. The upper interbed (5–7 cm), intermittent, is composed of a thin interbedding of light grey loam and brownish-grey peat. The lower interbed (1–3 up to 8–9 cm) is composed of foliaceous peat.

Layer 5. 4.85–6.2 m. Loam silty dove-coloured grey gleyish to brownish-grey, on the top passes into sandy loam and below into clay loam; not laminated, with a swampy odor. Over the whole layer a peaty matter is dispersed. At a depth of 5.8 m peaty matter forms accumulations as 20–30 × 50–70 cm spots, more rarely as lenses; these and others occur horizontally and form on the weathered wall of exposure a clear peaty horizon. The second, intermittent horizon is observed at a depth of about 5.5 m; in stripping at its level no peaty spot is present, a small enrichment with peat being visible only. A sufficient quantity of peat for ^{14}C-dating is present only in the lower peaty horizon.

Layer 6. 6.2–7.6 m. Loam, grey up to dark grey, with a swampy odor, silty up to clay loam, is strongly aleuritic. In the lower half of layer 6 there occur strongly foliated, torn up, separated lenses of aleurite, light grey up to pale yellow. In the bottom of the layer, small-sized (2 × 5 up to 4 × 15 cm) lenses enriched with peaty debris occur. Because of these lenses the bottom part of the layer is dark. Along the strike, separated lumps of peaty matter are crushed (up to 1–3 cm) and occur strictly horizontally, and thin interbeds of whitish aleurite create an impression of an interbedding. The interbeds of aleurite surround and pool the crumplings. In the bottom of the layer, copious crumbs of peat underlie a loamy subhorizontal lamination.

Layer 7. 7.6–9.4 m. Loam light grey, to a depth of 8.3 m with greenish and lower with a blue dove-coloured tint. Above, the lamination is more obvious, horizontal. At a depth of 1.2 m loam is darker, a swampy odor appears.

Layer 8. 9.4–9.9 m. Thin horizontal loam interbedding, grey, aleurites almost white: below up to 15 pairs of thin layers on a 2-cm layer; in the middle of the layer 8 interbeds of aleurites dominate; the upper 17–20 cm of the layer contain deformations such as microwedges, 5–7 cm from each other.

Layer 9. 9.9–10.0 m. Peat is brownish-grey, dense, tenuifolious. The thickness of the layer varies from 5 to 10 cm, its occurrence is horizontal, wavy.

Layer 10. 10.0–10.9 m. Loam, dove-coloured grey, silty, aleuritic with a rough fragmentary texture, a very gentle lamination, crumpled. The crumplings are well visible in the top of the layer. In the base, loam lens (up to 5 cm), dark, weakly peaty, with a weak swamp odor occurs. In the top of the lens, thin (up to 1.5 cm) lens of forest floor, practically not decomposed, occur. The loam step-by-step gains a grey tint in the upper half of the layer.

Layer 11. 10.9–11.9 m. Loam, light grey sandy to almost white. On the top and in the bottom of the layer interbeds (10–15 cm) a thin interbedding of loam grey and sandy loam light, almost white. In these interbeds lamination is very thin, horizontal and lenticular. The upper interbed is horizontal and the lower almost horizontal, in places its roof is clutched by deformations to the middle part of the layer, and the base surface is distorted according to the roof of layer 12. The deposits of a lower thin-laminated packet also fill in a wedge which penetrates into the layer of peat (layer 12). Between interbeds of thin laminated loams and sandy loams, grey loam (50–70 cm), light, very intensively distorted (sintered deformations) occurs.

Layer 12. 11.9–12.9 m. Peat bog strongly distorted, in places faulted, in places is 50 cm thick and in places has pinches up to 1 m and more. On the top: loose peat, saturated with vegetative debris; below in peat the content of clay is higher. In the bottom of the peat bog, 1–2 interbeds are enriched by fragments of branches, chips, thin trunks, fall chips from large trunks and fragments of large stumps. The roof and the base surface of the layer are very rough. From above, a vein formed by deposits of layer 11 is injected.

Layer 13. 12.9–13.9 m. Loam, grey with a weak greenish tint, clay loam, almost clay, weakly aleuritic, on the top not laminated. The quantity of aleurite increases downwards. At a depth of 0.5 m there are lenses and interbeds (up to 2–3 cm) of dark loam. Below the loam is strongly sandy.

Layer 14. 13.9–16.5 m (visible thickness). The interbedding of sand and loam, on the top rough, sand dominates; from a depth of 15.7 m the interbedding is thin (1–2 cm). Sand is yellow-grey up to white, fine-grained, well washed out and sorted. Lamination is horizontal. In the bottom of the layer, in interbeds of sand, lamination sometimes crosses. The loam dove-coloured grey, dark, plastic, weakly aleuritic. Contacts of interbeds of sand and loam are sharp.

In quality stratotype the section Kirias is studied and is published by S. A. Arkhipov (Архипов и др., 1973; 1976; 1980; Левина, 1979). Let's compare our layers to the strata summed up in (Архипов и др., 1980) from the quoted above publications. Our layers 1–3 correspond to the overlying strata, layers 4–12 to the middle fluvio-lacustrine strata, and layers 13–16 to the lower, Kazantsovian-Zirianian, strata (Архипов и др., 1980), i. e. to the socle of the terrace. In the 60s–70s, ^{14}C-dates of the middle strata (Fig. 2) were obtained: the top "whitish aleurites" (our layer 11) 27.5 to 36.3 thousand years, and the "lower peat bog" (our layer 12) underlying these aleurites 38.7 to 44.7 thousand years. The age of the interval of the section, which was dated back to 27.5–44.7 thousand years; what part it is in the stratotype of Kiriassian layers, in the publications (Архипов и др., 1973; 1976; 1980 и т. д.) is not indicated.

Employing a technique of dating, improved at the St. Petersburg State University (Арсланов, 1987), the following dates of our samples were obtained (Laukhin et al., 2006): layer 4 (depth 4.8 m) 27800 ± 210 years (LU-5095), layer 5 from the depth of 5 m 31880 ± 290 years (LU-5115) and from the depth of 6.1 m 32600 ± 200 years (LU-5094), layer 9 (depth 9.95 m) 46350 ± 1590 years (LU-5109) and from layer 12 (depth 11.95 m, ≥ 60700 years (LU-5119) (Fig. 3). Therefore, "the lower peat bog" in (Архипов и др., 1980) and our layer 12 are more ancient than the Karganian horizon. It is confirmed also by the rich (many thousand residua) macroflora of this peat bog characteristic, according to F. Yu. Velichkevich, of the Zirianian (Early Würm) interstadial. This flora reflects a wood type of vegetation with prevalence of coniferous species (*Larix sibirica, Picea sect. Eupicea,* etc.).

DESCRIPTION OF PALYNOSPECTRA AND DISCUSSION

Seventy-one samples were studied by palynological analysis. Layers 13 and 14 were certainly more ancient than the Karganian, that's why their palynospectra were jointed into one palynocomplex (PC-1), which here not is discussed. Palynospectra of PC-2 from the peat bog of layer 12 are miscellaneous and reflect the development of spruce-birch open woodland vegetation, fur-tree and larch forests to open birch woodlands. During all phases of the PC-2, the climate was colder than of present. The accumulation of the buried peat bog of layer 12 ends in the interruption of sedimentation and formation of numerous (Fig. 2) and rather large (1–6 m) ice (ice-ground?) veins which, however, did not compose a polygonal net. Then the degradation wedge ices and sedimentation of "whitish aleurites" follows. Palynospectra from "whitish aleurites" (PC-3 beginning) reflect birch open woodlands. The degradation of open woodlands at the end of the PC-3 formation (layer 10) resulted in domination of woodless periglacial vegetation with spreading heaths, yerniks with *Rubus chamaemorus*. The completion of the Zirianian glaciation in the region of Kirias exposure was marked by sedimentation of layer 10 loams.

PC-4 (Fig. 4) was studied at the top of layer 10 and in the peat bog of layer 9. The content of pollen tree and shrub species is 21.5% up to 28% and pollen of grass and undershrub plants 45.5% to 49.5%. The role of tree-like and shrub-like birches and coniferous species (spruce, larch, *Pinus sibirica*) rises. There is a large quantity of *Bryales* (12–19.5%) and *Sphagnum* (5.6–10%) spores. Spores of wood species were noted: *Lycopodium annotinum* (up to 2.1%), *L. complanatum, L. selago*, and *Botrichium*. In equal quantities the pollen of *Gramineae, Chenopodiaceae*, forbs is found. Pollen of *Artemisia* is scarce. Among forbs there are meadow (*Caryophyllaceae, Polygonaceae, Ranunculaceae, Valerianaceae, Rosaceae, Leguminosae, Thalictrum*), steppe (*Asteraceae, Cichoriaceae*), swamp (*Polemoniaceae*), tundra (*Rubus chamaemorus, Draba, Armeria*), aquatic (*Typha, Sparganiaceae*) plants. Open woodlands with birch, larch, spruce extended. In lowerings, there were *Bryales* and *Sphagnales* swamps with aquatic plants. Open spaces were occupied by forbs–*Gramineae* meadows. The area of tundra with yerniks, heaths, xerophytes remained. With time, swamp-forming warming becomes clearer: palynospectra reflects a larch open woodland. For peat bog of layer 9 there is ^{14}C-date LU-5109: 46350 ± 1590 years, which by the whole confidence interval totally falls within the early warming of the Karganian time, as in the opinion of N. V. Kind (1974) and in complicate with V. S. Volkova and co-authors (2003). At present, the Kirias exposure is in a sub-zone of middle taiga, and the structure of palynospectra of surface samples strongly differs from spectra of the early warming Karganian. Judging by the macroflora structure, the peat bog accumulated in a small pool surrounded by forest-tundra and tundra landscapes. Among the three species of birches, undershrub (*Betula nana*) and shrub (*Betula humilis*) species dominates. Almost all species belong to the group of cold-resistant plants. It is important to note that the transition from Zirianian glacial to Karganian time took place within the limits of one layer (layer 10) and was not accompanied even by a short interruption of sedimentation. According to palynological data, this transition proceeded step-by-step, but very rapidly and was not accompanied by changes in sedimentation.

PC-5 (Fig. 4) was studied in layers from 8 to the lower part of layer 5. In PC-5, pollen of grass and undershrub plants prevails (47–71%). The portions of pollen of tree and shrub species (9.7–39%), and spores (11.5–33%) are almost equal. Among grass and undershrub plants, *Gramineae* (11.4–41%), *Artemisia* (2.1–21.5%, as a rule 7–19%) and forbs (98.7–28%) predominate. Forbs are greatly various, but *Caryophillaceae* (3.6–25%), *Asteraceae* (0.8–11.4%) and *Cichoriaceae* (0.6–3.3%) predominate; *Polygonaceae, Umbelliferae, Thalictrum, Rubiaceae, Ranunculaceae, Rosaceae, Spiraea, Scrophulariaceae* were noted. *Draba* is stable, and *Rubus chamaemorus* is sparse. Among pollen of tree and shrub species, *Pinus sibirica* (1.4–22%, as a rule 1–10%), *Picea* (0.4–10.8%) and *Pinus silvestris* (0.6–11%) predominates. Pollen *Betula* of tree-like (1.2–10.5%) and shrub-like (0.5–8.1%) *Betula* occurs almost equally. *Larix* (up to 1.3%) and *Alnus* (sparsely) are stable. Among spores, *Bryales* (9–28.3%) and *Sphagnum* (0.5–9%, as a rule 0.5–4%) predominate. *Lycopodium* is various: *L. alpinum* (0.4–3.2%), *L. pungens* (up to 1%), *L. appressum* (sparse), which are characteristic of tundra; while *L. annotinum* (up to 1.1%), *L. clavatum* and *L. complanatum* which are characteristic of wood, are sparse. Forbs-grass meadows dominated. Segments of tundra with yerniks, heaths, *Rubus chamaemorus* are presented on the slopes of the northern exposition. In valleys, small areas of birch open woodlands with spruce and larch could be preserved. The climate was much colder than at present. During a long time (46.3–27.8 BP) of the development of vegetation characterised by PC-5, insignificant oscillations of palaeoclimates and palaeolandscapes between north-taiga open woodlands and forest-tundra took place. Only at the beginning (palynospectra from layer 8) and in the end (palynospectra from the lower part of layer 5) of the PC-5 interval, vegetation was close to that of tundra. Let us discuss these oscillations in the character of vegetation of PC-5 by dividing it into five phases: PC-5a – PC-5e.

In phase PC-5a (palynospectra from layer 8) pollen of grass and undershrub plants prevails (47–60%), including *Gramineae* 17–25%, forbs 10–28%, *Artemisia* 17–12%. Forbs are presented by meadow (*Caryophillaceae, Polygonaceae, Ranunculaceae, Umbelliferae, Thalictrum, Rosaceae*), forest (*Onagraceae*), tundra (*Draba, Rubus chamaemorus*), steppe and aquatic plants. Spores of *Bryales* are abundant; spores of cold-resistant *Lycopodium* (*L. alpinum, L. pungens, L. appressum*) are various. Pollen of tree and shrub species is represented by *Betula albae, B. sect. nanae, B. sect. fruticosae*; coniferous are single. Forbs–*Gramineae* meadows and green-moss swamps predominated. Birch forest-tundra with *Ericales* occupied small areas. Deposits were formed in conditions of transition from forest-tundra to tundra.

In phase PC-5b (palynospectra from the lower part of layer 7), the quantity of tree and shrub species rises to 31%. The role of *Pinus sibirica* (4–10%), *Picea* (5–10%) increases. Forest plants of *Lycopodium* (*L. annotinum, L. complanatum, L. selago*) appear. Among forbs, pollen of *Veratrum* and *Onagraceae* characteristic of forest meadows and edges, is present. Side by side with forbs–*Gramineae* meadows, northern taiga open woodlands with *Pinus sibirica, Picea, Betula,* *Larix* appear. Vegetation was close to that of northern taiga open woodlands.

In phase PC-5c (palynospectra from the upper part of layer 7), pollen of *Gramineae* 21–34%, forbs 8–18%, *Artemisia* 10–17%, *Chenopodiaceae* 3–8%, shrub-like *Betula* 7% and spores of *Bryales* 9–14% were abundant. Cold-resistant *Lycopodium* (*L. alpinum, L. pungens, L. appressum*) was present. Gramineae–forbs meadows, yernik forest-tundras, larch open woodlands, green mosses, *Artemisia–Chenopodiaceae* associations were widespread. Landscapes were close to forest-tundra.

In phase PC-5d (palynospectra from layer 6), the portion of tree and shrub species increases to 39%. In them, the role of *Picea* (4–7%), *Pinus sibirica* (4–22%), *Larix* (0,6–2%) increases. *Gramineae* pollen is abundant (24–33%). The *Artemisia, Chenopodiaceae,* forb pollen decreases. Among *Lycopodium* forest species, *L. annotinum, L. complanatum, L. selago* are present. Side by side with forbs–*Gramineae* meadows, northern taiga open woodlands with *Pinus sibirica, Picea, Larix, Ericales, Filicales* appear.

In phase PC-5e (palynospectra from the lower part of layer 5), pollen of grass and undershrub plants predominates (62–71%). Pollen of *Gramineae* (21–41%), forbs (14–23%) and *Artemisia* (11–19%) prevails. Forb is presented by meadow (*Caryophillaceae, Primulaceae, Valerianaceae, Polygonaceae, Thalictrum, Ranunculaceae, Sanguisorba, Rosaceae, Scrophulariaceae*), steppe (*Asteraceae, Cichoriaceae*), tundra (*Draba*) and aquatic (*Myriophillum*) plants. *Bryales* spores are abundant (15–21%). Spores of cold-resistant *Lycopodium (L. alpinum, L. pungens, L. appressum*) are present. *Selaginella selaginoides* appears. Areas under grass and moss swamps, forb–*Gramineae* meadows, yerniks expand. The landscape approaches that of tundra.

PC-6 was studied in the upper part of layer 5. In PC-6, pollen of grass and undershrub plants comprises 66–80%. Pollen of *Gramineae, Artemisia* and *Caryophillacea* predominates. Pollen of *Chenopodiaceae, Cyperaceae, Ephedra, Ericaceae*, forb is sparce. Forb are represented by meadow, steppe and tundra plants. *Bryales* spores (1.5–18.6%) predominate; *Sphagnum* and *Lycopodium* are sparce. *Lycopodium* as *L. alpinum, L. appressum* and *L. annotinum, L. clavatum* are present. Spores of *Selaginella boreales* appear. Tree and shrub pollen reaches 8.8–15.4%. Pollen of tree-like and shrub-like *Betula*, *Alnus, Pinus sibirica, Picea* and *Larix* is sparce. Open space with forbs–*Gramineae* meadows and *Chenopodiaceae–Artemisia* associations with *Ephedra* prevail. There are green-moss swamps in the lowerings. On slopes of the northern exposition there were areas of tundra with arctic species of *Lycopodium, Draba, Ericales*, yerniks. In the valleys, small areas of open woodlands with birch, larch and spruce could remain.

PC-7 was studied from layer 4. In PC-7, pollen of grass and undershrub plants comprises 55–65%. In the abundance of *Gramineae* and *Artemisia*, the quantity and various forbs declined. The pollen of tree and shrub species (13–20%) almost totally belongs to coniferous: *Larix, Picea, Pinus sibirica*. Pollen of tree-like and shrub-like *Betula* is scanty. Spores of *Bryales* are abundant and of *Spahgnum* and *Lycopodium pungens* sparce. Widespread were forbs–*Gramineae*, in valleys larch, birch and spruce open woodlands, reflecting a minor warming about 27.8 thousand years ago (LU-5095). The peat of layer 4 was formed in the late Karganian time.

PC-8 was studied in the lower part of layer 3. Pollen of *Gramineae* is abundant, of *Caryophillaceae* and sometimes *Cichoriaceae* is also rich. Pollen of tundra plants and *Chenopodiaceae album* characteristic of unstable grounds occurs. Spores of *Bryales* are abundant. Arctic *Lycopodium* flora *(L. pungens, L. alpinum, L. appressum*) is constantly present. Spores of *Selaginella sibirica* appear. Palynospectra reflect tundra vegetation of the Sartanian glacial time.

PC-9 (Fig. 4) was studied in the upper part of layer 3 and the lower part of layer 2. Beside abundant *Gramineae*, there is a large quantity of *Cichoriaceae* pollen which is characteristic of unstable. Open spaces were occupied by tundra vegetation with arctic club mosses, heath, *Chenopodiaceae, Ephedra, Artemisia, Draba, Selaginella*, yernics. Deposits of this part of the section were formed in the conditions of cold and dry climate of the Sartanian time.

Thus, in the interval of 48–27 thousand years BP (LU-5109–LU-5095), which encompasses almost all the Karganian time, in the Kirias section, palynological data indicate three warmings (palynospectra of layers 9.7–6. 4) and two coolings – in layers 8 and 5. In the time of coolings, up to Surgut Priobye grass and yernic tundras spread. The displacement of vegetative zones to the south could exceed 800 km in coolings and reach 600–300 km during warmings. The climate in Surgut Priobye in the Karganian time did not reach the modern parameters, since among palynospectra of the Kirias section there are no ones at least distantly similar to middle taiga palynospectra studied in subrecent surface samples and in Holocene depositions. Neither the earlier published palaeobotanical data on the Kirias section (Архипов и др., 1973; 1976; Левина, 1979) found traces of a climate close to the modern, but showed the development of a permanently colder climate. Besides, no traces of essential washout and / or sedimentation interruptions in the middle strata (layers 9–5 of our description) of the section were revealed, either, leaving no hope for detecting layers of the Karganian horizon that were formed in conditions of a climate close to modern or softer, but saw an interruption in sedimentation and consequently cannot be detected in the Kirias section. As we see, in the Kirias section all ^{14}C-dates of the 60s–70s, but not part of them as shown by (Архипов и др. (1980), are pseudoterminal. But even if it would be possible to recognize valid dates from "the lower peat bog" (our layer 12), all the same it lacks palynospectra close to those of the modern middle subzone of taiga, in the southern part of which the Kirias section is located at present.

Now it is well known (Астахов и др., 2005; Лаухин, 2005; Laukhin et al., 2006, etc.) that stratotypes of Shurishkarian, Kiriasian, Zolotomisskian layers and the key section of Lokhpodgornian layers are not valid, in spite of the fact that in all these sections it is possible to reveal tracks of three warming intervals and two cooling intervals. However, the warming did not reach the modern climatic parameters in the regions of these sections, and consequently the Karganian time on the West-Siberian Plain cannot have the status of an Interglacial, but has all indications of an Interstadial, continuous and composite both in the spatial and the temporary aspects. The Karganian horizon preserves its stratigraphic significance, but the stratotypes of his layers have lost such significance and thus the horizon has no areal stratotype, either, to which the unified stratigraphic schemes of the last decades refer (Архипов, 1990; Унифицированная..., 2000; Волкова и др., 2003; 2005 и др.).

Interesting is the discovery of a short cooling in the middle of the middle warming (layers 6 and 7) of the Kirias section in Surgut Priobye (Fig. 3). If to recall the data of S. S. Sukhorukova (Сухорукова, 1998) on the tracks of cooling about 27 thousand years BP in the late warming of the Karganian time in the north of the Prienysey and Pryob parts of Western Siberia, we will be able to guess, alongside the recognized five-member division of the Karganian time, the existence of a more fractional, nine-member division of the Karganian time. Attention is attracted by the fact that, despite all oscillations in the backdating of the "warm" and "cold" stages of the Karganian time in the last 30 years (from Кинд, 1974 up to Волкова и др., 2005), the duration of "warm" stages always remained approximately 2–3 times longer than of "cold" stages. Not surprisingly, the "triplicity" of the last warming was noted almost 10 years earlier than the "triplicity" of the middle warming, and the history of vegetation and palaeoclimate of the early warming, where ^{14}C-dates are at the limits of the method (50–45 thousand years) and consequently are not numerous, has been studied not enough to reveal three (more? or less?) of palaeoclimatic events or to demonstrate the monotony of this warming, i. e. absence of climate oscillations in it. Of course, data for a "triple" division of the late and the middle warmings of the Karganian time are still not enough. However, these data already give a direction for studying the possibility of detailing the scope of events of the Karganian time and the climato-stratigraphical scheme of this horizon.

The natural environments of the West-Siberian Plain in the Karganian time were monotonous unfavorable, everywhere less favourable than at present. At the same time, in the highlands of Eastern Siberia and North-eastern Asia, in variegated mountainous landscapes separate refuges could occur. Therefore it is hardly possible to extrapolate the results obtained on the West-Siberian Plain to all Northern Asia, as V. I. Astakhov and J. Mangerud do (Астахов и Мангеруд, 2005). Interestingly, like before (Laukhin et al., 1996), traces of a Karganian climate warmer than modern are found also at present in mountainous regions of both the Southern mountain belt of Siberia (Derevianko et al., 1995; Деревянко и др., 2000; Русанов, 2005; Калмыков, 2005; Покатилов, 2005, etc.), and northward from it (Laukhin, Rybakova, 1986; Лаухин, 2001; Пушкарь, Черепанова, 2001; Шило и др., 2005, etc.).

CONCLUSIONS

Palynological studies and modern ^{14}C-dating of the Kirias section have shown the non-valid ^{14}C-dating of the 60s–70s of this section and that this section characterizes practically all the Karganian horizon and has allowed to update essentially the evolution of natural changes of aircraft attitude of environment of the West-Siberian Plain in the Karganian time. The scale of this time, which includes five palaeoclimatic events, is confirmed and the possibility of its essential detailing is shown.

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SURGUTO PRIE OBĖS KARGINIO NUOGULŲ PALINOLOGINĖ CHARAKTERISTIKA (VAKARŲ SIBIRO LYGUMOS VĖLYVASIS PLEISTOCENAS)

Santrauka

Kirjaso stratotipinio pjūvio (Obės vidurupis) Karginio horizonto Kirjaso sluoksnių radiokarboninių (^{14}C) datavimų ir palinologinių tyrimų duomenimis, apatinė pjūvio dalis, kuri anksčiau buvo priskiriama Karginio horizonto apatiniams sluoksniams, slūgso kur kas aukščiau. Kirjaso pjūvio Karginio nuogulų palinologiniai tyrimai leido išskirti devynis palinologinius kompleksus, iš jų du priklauso iki Karginio buvusiam laikotarpiui ir du pro Karginio (Sartaniui). Palinologiniais duomenimis, Karginio metu Kirjaso apylinkių augmenija šiltais laikotarpiais keitėsi nuo šiaurės taigos retmiškio, iki tundros retmiškio, o atšalus įsivyraudavo tundros sąlygos (arba perėjimas iš miško tundros į tundrą). Zyrianio pabaigoje ir Sartanio pradžioje tundros augmeniją pakeitė tundros stepių augmenija. Karginio metu augmenijos zonos galėjo pasistumti į pietus daugiau kaip 800 km atšalimo ir 300–600 km atšilimo laikotarpiais.

Станислав Лаухин, Галина Шилова

ПАЛИНОЛОГИЧЕСКАЯ ХАРАКТЕРИСТИКА КАРГИНСКИХ ОТЛОЖЕНИЙ В СУРГУТСКОМ ПРИОБЬЕ (ПОЗДНИЙ ПЛЕЙСТОЦЕН ЗАПАДНО-СИБИРСКОЙ РАВНИНЫ)

Резюме

Повторное 14С-датирование и палинологическое изучение разреза Кирьяс (среднее течение Оби), стратотипа кирьясских слоев каргинского горизонта показали, что нижняя часть этого разреза, которая ранее была отнесена к каргинскому горизонту, на самом деле имеет зырянский возраст. Нижние слои каргинского горизонта залегают значительно выше. Палинологическое изучение каргинских отложений в разрезе Кирьяс позволило выделить девять палинокомплексов, в том числе два докаргинских и два посткаргинских (сартанских). Палинологические данные показали, что в течение каргинского времени растительность района Кирьяса во время теплых этапов каргинского времени менялась от редколесий северной тайги до редколесий лесотундры и достигала параметров тундры (или перехода от лесотундры к тундре) во время похолоданий. В конце зырянского и в начале сартанского времени растительность менялась от тундры до тундростепи. В каргинское время смещение растительных зон к югу могло превышать 800 км во время похолоданий и достигать 600–300 км во время потеплений.