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The first early interstadial of Zirianian traces (Early Würm) glaciation in Siberia: U / Th date and palaeobotanical data

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The application of the U / Th method allowed to reveal traces of an interstadial, which is coeval with the Brørup in the middle stream of the Ob' River in the well-known Kirias outcrop. Description of a buried peat bog which is coeval with the Brørup interstadial, layers underlying and overlapping the Kirias section are discussed. The U / Th date was obtained from the peat bog by the methods: leachate alone (L / L) and total sample dissolution (TDS) – 105.5 + 3.6 / –3.3 Ka (L / L) and 104.4 + 4.4 / 3.9 Ka (TSD). The abundant flora (thousands of fruits, seeds, etc.) characteristic of north taiga shows the time of peat bog formation. This flora reflected the local vegetation near the swamp. Palynospectra reflect the zonality in vegetation changes. It characteristics in the beginning of peat bog formation show the development other sub-zones of taiga, followed by forest-tundra. In the layers of loam underlying and overlapping the buried peat bog, palynospectra of the non-forest periglacial vegetation of Zirianian (Early Würm) glacial time were studied.

Key words: Pleistocene, uranium–thorium dating, macroflora, palynospectra, Western Siberia, Zirianian Glaciation, Interglacial, Brørup

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INTRODUCTION

The interstadials of the Early Weichselian (Early Valday, Early Würm) glaciation have been known in Western Europe for a long time. Three interstadials of this glaciation have been revealed in the Russian Plain (Арсланов, 1992). L. N. Voznyachuk (Вознячук, 1971) guessed the development of three interstadials during this glaciation in Belarus; now they have titles of the Cerikovskiy, Surozskiy, Polotskiy interstadials and are compared with the Amersfoort, Brørup and Odderade ones of Western Europe, correspondingly (Санько, 1999). Unfortunately, there are no sufficiently reliable correlations of these interstadials neither with the MOIS or with the absolute chronology of the North of Western Europe in these publications. So, the interstadials from Western Europe known in the 60s were dated to 57–59 Ka for the Brørup and 64–67 Ka for the Amersfoort (Woldshted, 1960; Gross, 1960; Dansgaard et al., 1969, etc.). The sequence and chronology of these interstadials were changed in the 90s (Dansgaard et al., 1993). Their age became about 105–100 Ka for the Brørup, 90–80 Ka for the Odderade, 70–60 Ka for the Oerel, 55–50 Ka for the Glinde. This sequence is adopted now in Western and Central Europe, in particular in Poland (Комар, 2005).

The history of the Early Würm (Zirianian) glaciation interstadials of Western Siberia is dramatic. They were revealed and determined (studied) by the palynological method at the end of the 80s (Архипов и др., 1987; Архипов, Вотах, 1989; Архипов, Волкова, 1994 и др.). S. A. Arkhipov (Архипов, 1997) in 1997 described the Bogdashkinskye layers from the Bogdashkiny Mountainous key section (Fig. 1). They consisted of a lower peat bog, an upper peat bog and loams separating them (Fig. 2). The clays directly underlie the lower peat bog and contain the palynospectra of coniferous-birch forests. The palynospectra of spruce–birch–pine forests are studied in the lower peat bog. The diatoms characteristic of glaciofluvial conditions (environment) are marked in the loams located between the peat bogs. The palynospectra from the upper peat bog are typical of the spruce–birch forests. As a whole, the palynospectra of the upper and lower peat bogs are characteristic (typical) of the middle sub-zone of taiga (Архипов, Волкова, 1994). The upper peat bog has the TL-date 65 ± 8 Ka and the lower one TL-date 80 ± 11 Ka (Fig. 2). The dates were compared by S. A. Arkhipov (Архипов, 1997) with the Brørup and Amersfoord. In general, the chronology of the Bogdashkinskye layers showed a rather poor agreement with the interstadials of Western Europe both according to schemes of the 60s and the scheme of the 90s. These disagreements were considerable, therefore researches in the 21st century began to recognize only one interstadial on the basis of the Bogashkinskye layers, with the duration from 80 ± 11(13) to 65 ± 8 Ka (Волкова, Архипов и др., 2003). Later, this interstadial was excluded from the Zirianian glaciation (Волкова и др., 2005).

Almost fully absence of ^{14}C-dates 50 Ka and more ancient; the paucity and big confiding intervals of TL-dates not only made for the success of interstadial selection in the Zirianian glaciation, but also till now are the reason for not a fully clear chronological position of the lower and upper boundaries of the Zirianian time. So, in most complete publications (Архипов, Волкова, 1994; Архипов, 1997; Волкова и др., 2003) a boundary of the Karganian and Zirianian times was marked, respectively, at 51 Ka, 60–65 Ka and 50(60–65?) Ka, and the boundary of the Zirianian and Kazantsovian time at 115 [100(110)–17(27)] Ka, 110(100) Ka and 110 Ka. Numerous OSL-TL dates have recently appeared (Астахов, Мангеруд, 2005). Possibly, they will help to adjust the age of the mentioned boundaries, but these dates till now are not introduced into practice of Pleistocene investigations of Western Siberia. The more so as these dates do not assist in selecting interstadial intervals during the Zirianian glacial time.

Meanwhile, the MOIS 5d–5a and the interstadial about 82–64 Ka are recognized well in the Northern Atlantic, Barents and Kara seas (Mangerud et al., 2001; Oppo et al., 2001; Svensen et al., 2004 etc.). The interstadials with time frames of 90–75 Ka, 70–65 Ka, 65–55 Ka have been revealed by I. N. Demidov et al. (2006) in the North-West of the European part of Russia. The Odderade interstadial (MOIS 5a) in the Kola region (Peninsula) (Yevzerov, 2006) is also recognized. The evidence of Heinrich events studied in the Northern Atlantic has been revealed even in Lake Baikal (Kuimova, Sherstiankin, 1999). It allowed A. K. Vasilchuk (Васильчук, 2007) to write about the relationship between the Late Pleistocene climatic events in the North Atlantic and in Eastern Siberia. There is a good reason to believe in a possibility to detect the Early Valday interstadial traces in Western Siberia. These traces are known in the Arkhangelsk district (Demidov et al., 2006; Jensen et al., 2006) separated from the northern part of Western Siberia by a narrow bandwidth (line) of the Urals. The wide confidence intervals of the TL-dates of the Bogdashkinskye interstadials allow to compare them with the Odderade and Oerel interstadials of Western Europe. However, refinement of the geochronology of layers corresponding to these events is needed in connection with renovation of climate for both Lower- and Upper-Bogdashkinskye stages close to recent one (Архипов, Волкова, 1994). The application of the U / Th method allowed us to reveal traces of an interstadial which is coeval with the Brørup at the middle stream of the Ob' River in the well-known Kirias outcrop (Fig. 1).

DESCRIPTION OF THE ZIRIANIAN PART OF THE KIRIAS SECTION AND THE AGE OF THE DEPOSITS

The Kirias outcrop is located on the left-hand coast of the Ob' River in its middle stream ($60^0 51'$ N. L. and $75^0 45'$ EL), on the Ob' River branch. It uncovers a section of III fluvial terrace above the flood plain of the Ob' River (Архипов и др., 1976; Левина, 1979 и др.). The outcrop has the submeridianal and sublatitudi-

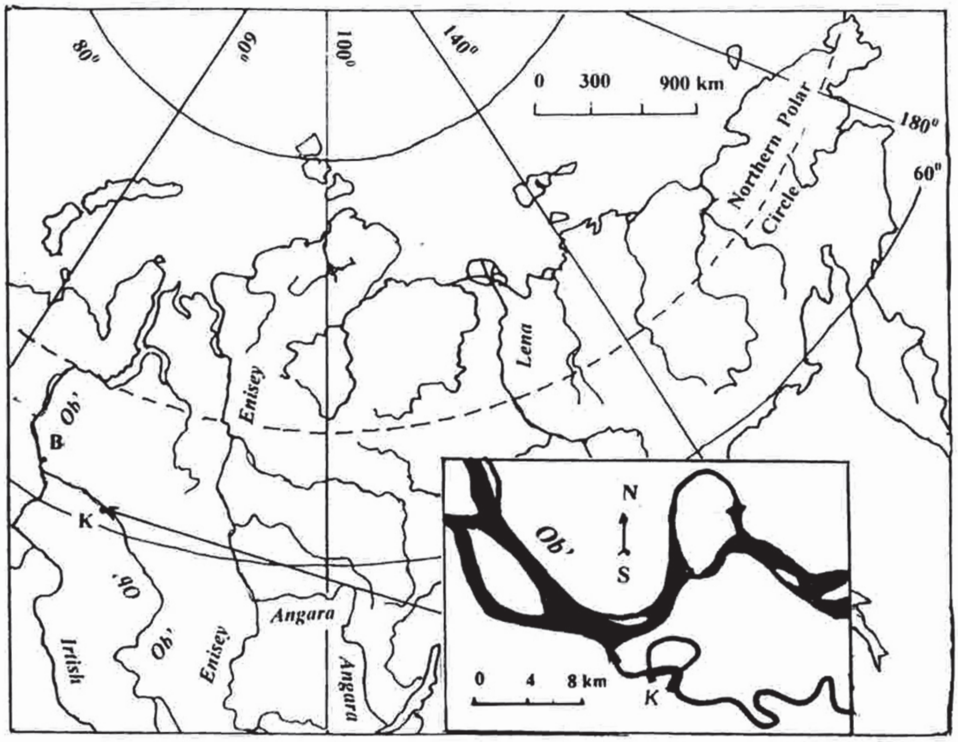

Fig. 1. Location of Bogdashkiny Gory sections (Bogdashkin Mountain) (*B*) and Kirias (*K*)
1 pav. Bogdaškino kalvos (*B*) ir Kirjaso (*K*) pjūvių lokalizacija

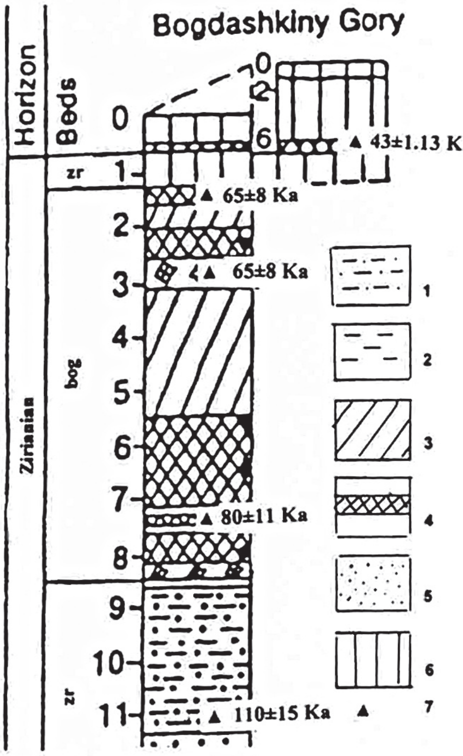

Fig. 2. Bogdashkinsky layers section (see Fig. 1) according to S. A. Arkhipov (1997). Bog – Bogdashkinsky layers, zr – other layers of Zirianian horizon. *1* – silt, silty clays, *2* – clays, *3* – loams, *4* – peat bogs, *5* – sands, *6* – loess-like loams, *7* – TL-dates

2 pav. Bogdaškino sluoksnių pjūvis (žr. 1 pav.) pagal S. A. Arhipovą (1997). Bog – Bogdaškino sluoksniai, zr – kiti Zirianio horizonto sluoksniai. *1* – dumblas, priesmėlis, *2* – molis, *3* – priemolis, *4* – durpės, *5* – smėlis, *6* – liosių priemolis, *7* – TL datos

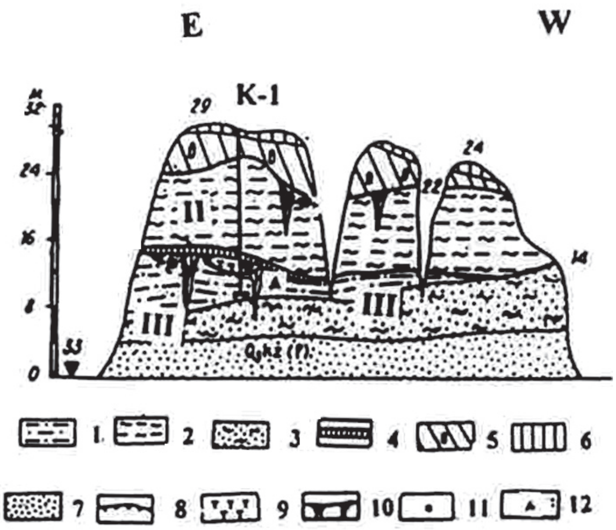

Fig. 3. Sub-latitudinal part of Kirias outcrop according to S. A. Arkhipov et al. (Архипов и др., 1980). I–III – strata: I – upper, covering; II – middle; III – lower (socle). K-1 – stripping, which is discussed in this paper. ^{33}▼ normal water level of the Ob' River near Kirias section (elevation), other marks are above the normal level of the Ob' River. *1* – clays and aleurites, *2* – interbeds of clay and sandy loams, *3* – interbeds of clays, sands and sandy loams, *4* – white sandy loams ("white aleurites"), *5* – greenish-gray loams, *6* – loess-like loams, *7* – sands, *8* – buried soils, *9* – peat bogs, *10* – pseudomorphs after ice wedges, *11* – ^{14}C-dates of the 70s (Архипов и др. 1980), *12* – TL-date 120 ± 36 Ka according to S. A. Arkhipov et al. (Архипов и др., 1980)

3 pav. Kirjaso atodangos subplatuminė dalis pagal S. A. Archipovą ir kt. (1980). I–III – pluoštai: I – viršutinis, dengiantis, II – vidurinis, III – apatinis (cokolis). K-1 – šiame straipsnyje aptariama prakasa. ^{33}▼ Obės upės žemiausias vandens lygis prie Kirjaso atodangos (absoliuti atžyma), kitos atžymos santykinės (aukščiau žemiausio vandens lygio Obėje). *1* – molis ir aleuritas, *2* – molio ir priesmėlio persisluoksniavimas, *3* – molio, smėlio ir priesmėlio persisluoksniavimas, *4* – šviesus priesmėlis („šviesus aleuritas"), *5* – žalsvai pilkas priemolis, *6* – liosių priemolis, *7* – smėlis, *8* – palaidoti dirvožemiai, *9* – durpės, *10* – ledo gyslų pseudomorfozės, *11* – ^{14}C datos, 1970 m. (Архипов и др., 1980), *12* – TL data 120 ± 36 tūkst. metų (Архипов и др. 1980).

nal segments (Fig. 1). The sublatitudinal segment of the outcrop (Fig. 3) is considered here. Ten ^{14}C dates (27.5–44.7 Ka) were obtained in the 60s for both segments of the outcrop. Some of these dates were doubted by S. A. Arkhipov (Архипов и др., 1980) who studied the Kirias section later. S. A. Arkhipov (Архипов, 1997) called such dates pseudo terminal. However, the main massif of the ^{14}C dates was recognized as valid. The section consists of three strata (Fig. 3): upper – the covering stratum, middle – the lacustrine-alluvial stratum, and the lowest – the socle (basement) of the terrace (Архипов и др., 1976; 1980; Левина, 1979 и др.). All ^{14}C dates correspond to the "upper" and "lower" peat bogs occurring in the middle stratum. The stratotype of the Kiriassian layers also corresponds to the middle stratum. The upper peat bog (within the limits of the middle stratum) is carved out from the lower one by "whitish aleurites". They are the key horizons that are traced along the outcrop and go beyond its limits (Архипов и др., 1980). The ^{14}C dates 36.3–27.5 Ka and 38.7–44.7 Ka were obtained for the upper and for the lower peat bogs, respectively. For a stratotype of the Kiriassian layers of the Karganian (Middle Wurm, Middle Valday) horizon, A. Arkhipov (Архипов и др., 1976; 1980 и т.д.) studied and described the Kirias section.

Thus, the Kirias section as a stratotype is included in the current scheme "The Unified Regional Stratigraphic Scheme of Quaternary Sediments of the Western-Siberian Plain" (2000) and in the latest large report on the Pleistocene of Western Siberia (Волкова и др., 2003). Only in the latest time, data on an inconsistency of stratotype series of layers of the Karganian horizon, including and Kirias section (Laukhin et al., 2006), have appeared.

As the Kirias section is a stratotype, its description has been repeatedly published (Архипов и др., 1973; 1976; 1980; Левина, 1979; Laukhin et al., 2006; Laukhin, Shilova, 2007 и т.д.), and it is not necessary to show it in full here, the more so as a description made by authors (Laukhin, Shilova, 2007) has been published recently. Our description is made according to K-1 stripping (Fig. 3). The covering stratum with layers 1–3 consists of loams laminated above and not laminated below. Below, at the depth 4.68–10.0 m, there occur layers 4–9 folded by interbedding of loams with infrequent low-powered (5–10 cm) hardpans of peat (Laukhin et al., 2006; Laukhin, Shilova, 2007). According to the method of dating improved (at the St. Petersburg State University (Арсланов, 1987)) we obtained a set of ^{14}C dates (Laukhin et al., 2006) from 27800 ± 210 years (LU-5095) for the peat bog from layer 4 and to 46350 ± 1590 years (LU-5109) for the peat bog from layer 9. Thus, we have established that only

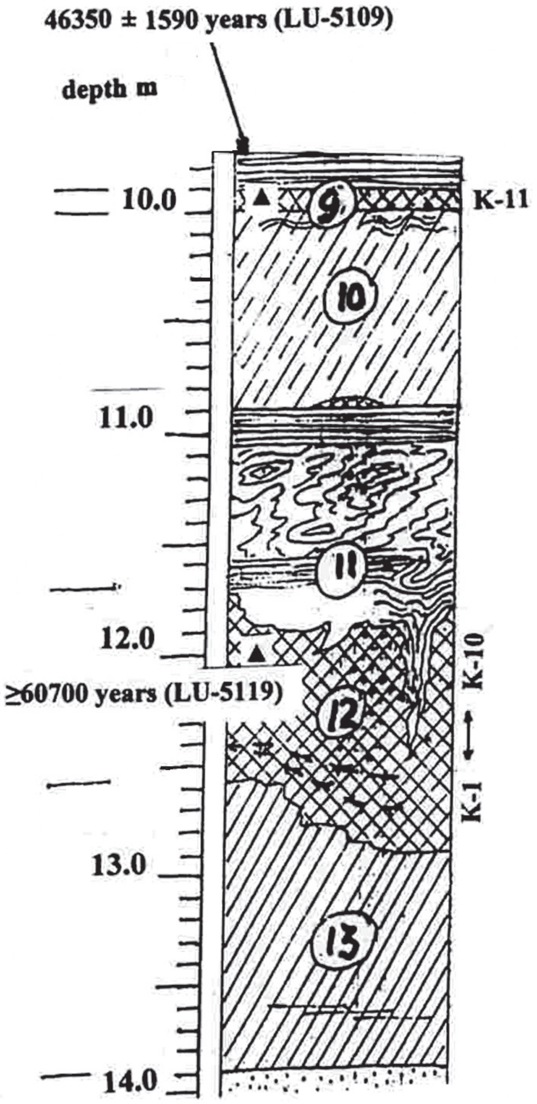

Fig. 4. Lower part of stripping K-1 (see Fig. 3) of Kirias section, studied by authors of the paper. In circles are shown layers (description in the text). Triangles are places of ^{14}C sample collecting. K-1 – K-10 and K-11 are places of macroflora sampling (see Table 3)

4 pav. Kirjaso pjūvio K-1 prakasos (žr. 1 pav.) apatinė dalis, tyrinėta šio straipsnio autorių. Apskritimu apvesti sluoksnių numeriai (aprašymą žr. tekste). Trikampiai – ^{14}C ėminių vietos. K-1 – K-10 ir K-11 – ėminių mikrofloros tyrimams vietos (žr. 3 lentelę)

part of the middle stratum is of the Karganian (Middle Würm) age, and the underlying layers were formed during the Zirianian (Early Würm, Early Valday) glacial time. They are of special interest to us. Therefore, their detailed description has been recently published (Laukhin, Shilova, 2007) (Fig. 4).

Layer 10. 10.0–10.9 m. Loam dove grey colored, aleuritic, with a rough fragmentary texture, very gentle lamination, crumpled. The crumpling is especially well visible in the top of the layer. In the base surface, lenses (up to 5 cm) of dark loam, weakly peaty, with a weak swamp odor occur. In the top of lenses thin (up to 1.5 cm) lenses of forest floor, practically not decomposed, occur. The loam gradually gains a grey tint in the upper half of the layer.

Layer 11. 10.9–11.9 m. Loam, light grey sandy up to sandy loam, almost white. Above and in the bottom of the layer, interbeds (10–15 cm) of loam grey and sandy loam light, almost white occur. In these interbeds lamination is very thin, horizontal and lenticular. The upper interbed is horizontal, the lower is almost horizontal, in places its roof is grasped by deformations conformable to the middle part of the layer, and the base surface is distorted according to the roof of layer 12. The deposits of the lower thin laminated packet also fill in a wedge which penetrates into a layer of peat. Between the interbeds of thin laminated and sandy loams, grey loam (50–70 cm), light, very intensively distorted (sintered deformations) occurs. The sintered deformations are apparently connected with permafrost processes. In the description of S. A. Arkhipov (Архипов и др., 1980) it is "whitish aleurites". Notably, the upper part of layer 11 is not distorted, and the lower part is not distorted together with the middle part of layer 11, but is involved in the filling of a pseudo morph on ice veins, which breach the underlying peat bog of layer 12. At the same stratigraphical level, in the roof of "the lower peat bog" on the whole outcrop, a series of pseudo morph on ice veins are implanted, their length reaching 5–6 m.

Layer 12. 11.9–12.9 m. Peat bog, strongly distorted, in places faulted and is 50 cm thick, and places with pinches up to 1 m and more. Above peat there is loose, saturated vegetative debris; below the peat the content of clay is augmented. 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 base surface of the layer is very rough. From above in the peat bog, folded deposits of layer 11 are injected. The peat bog does not form an integral layer and occurs as lenses in the base of the "whitish aleurite" layer according to S. A. Arkhipov et al. (Архипов и др., 1980) or layer 11 of our description. In the top of the peat bog studied by us, ^{14}C date ≥60700 years (LU-5119) confirmed the pre-Karganian (older than the Middle Würm-Valday) age of the peat bog.

Layer 13. 12.9–13.9 m. Grey loam with a weak greenish tint, clay loam, almost clay, is weakly aleuritic, from above not laminated. Downwards in the layer, the content of aleurite increases. At the depth 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, from above rough, sand dominates; from the depth 15.7 m the interbedding is thin (1–2 cm). Sand is yellow-grey up to white, fine-grained, well washed out and sorted. The lamination is horizontal. In the bottom of the layer, interbeds of sand lamination sometimes cross in. The loam is dove-colored.

The peat from layer 12 with the depth 30–65 cm from the peat bog roof (Fig. 4) is dated by the ^{230}Th / U isochron-corrected method. Two analytical techniques, "leachate alone" (L / L) and "total sample dissolution" (TSD), were applied (Maksimov et al., 2006). We proposed a parallel application of both techniques (L / L and TSD) for each peat sample to find the actual age. Uranium and thorium were radiochemically extracted from the peat samples taken from each 5 cm sublayer along the peat profile. Our previous analyses of the peat bog from the Russian Plain (Kuznetsov et al., 2002; Кузнецов и др., 2003) showed that the top and bottom of peat layer acted usually as geochemical barriers with respect to uranium (and thorium). Hence, we consider that the inner part of the peat layer (with the depth of 30–65 cm) under study behaves as a more or less closed system with regard to U and Th.

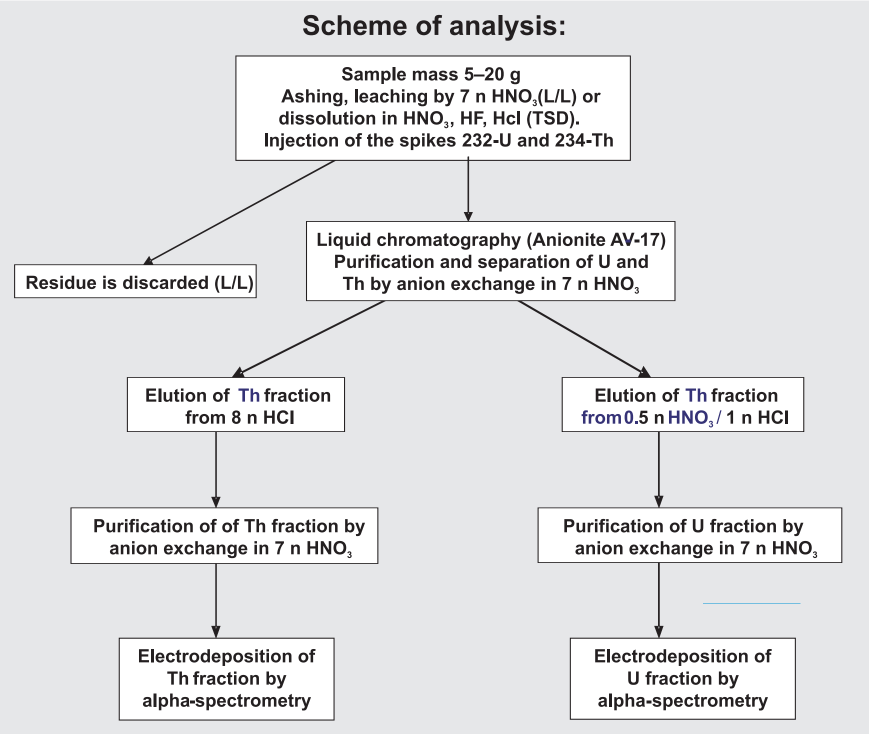

Table 1. **Results of radiochemical analysis of peat samples from the Kirias section (leachate alone method)**
Lentelė 1. **Kirjaso pjūvio durpių pavyzdžių radiocheminės analizės duomenys (visiškai išplovus ėminį)**

Depth cm	Ash %	^{238}U decay / min g–dpm	^{234}U decay / min g–dpm	^{230}Th decay / min g–dpm	^{232}Th decay / min g–dpm	^{230}Th / ^{234}U	^{234}U / ^{238}U
30–35	13.56	0.184 ± 0.006	0.211 ± 0.007	0.149 ± 0.004	0.091 ± 0.003	0.707 ± 0.030	1.143 ± 0.047
35–40	12.94	0.172 ± 0.006	0.165 ± 0.006	0.129 ± 0.003	0.076 ± 0.002	0.661 ± 0.026	1.136 ± 0.049
40–45	11.95	0.165 ± 0.004	0.193 ± 0.005	0.137 ± 0.003	0.083 ± 0.002	0.710 ± 0.022	1.170 ± 0.038
45–50	11.98	0.375 ± 0.010	0.406 ± 0.011	0.257 ± 0.006	0.079 ± 0.003	0.632 ± 0.023	1.084 ± 0.034
50–55	11.85	0.625 ± 0.013	0.678 ± 0.014	0.482 ± 0.007	0.075 ± 0.002	0.711 ± 0.018	1.084 ± 0.023
55–60	12.40	1.074 ± 0.025	1.196 ± 0.027	0.769 ± 0.009	0.081 ± 0.002	0.643 ± 0.016	1.114 ± 0.023
60–65	13.47	1.838 ± 0.048	3.186 ± 0.054	2.308 ± 0.028	0.106 ± 0.004	0.724 ± 0.015	1.123 ± 0.012

The protocol of radiochemical procedures to extract the U and Th isotopes from the peat samples is shown in Scheme.

The isochron-corrected ages were determined using a model proposed by Prof. M. Geyh (2001). We used only the data sets of samples the isotopic composition of which yielded an agreement with the isochron-corrected ^{230}Th / U age for the L / L and TSD techniques. The main steps were:

1. Estimation of the present thorium index with standard deviation ($a = f \pm \sigma f$) using the method of least squares by York (1966).

2. Calculation of the isochron-corrected $(^{230}\mathrm{Th} / ^{234}\mathrm{U})_i$ age A_i for each sublayer is obtained by using the $(^{230}\mathrm{Th} / ^{234}\mathrm{U})_{i,\ corrected}$ AR and $(^{234}\mathrm{U} / ^{238}\mathrm{U})_{i,\ anal.\ data}$ AR (Kaufman and Broecker, 1965):

$$1 - e^{-\lambda_{230} A_i}$$
$$(^{230}\mathrm{Th} / ^{234}\mathrm{U})_{i,\ corr} = \pm\ (1)$$
$$(^{234}\mathrm{U} / ^{238}\mathrm{U})_{i,\ anal.\ data}$$

$$1 \qquad \lambda_{230}$$
$$+ \left[1 - \text{----------------}\right] \left(\text{----------------} \right) \left[1 - e^{-(\lambda_{230} - \lambda_{234})\,Ai}\right],$$
$$(^{234}\mathrm{U} / ^{238}\mathrm{U})_{i,\ anal.\ data} \qquad \lambda_{230} - \lambda_{234}$$

where λ_{230} and λ_{234} are decay constants for ^{230}Th and ^{234}U;

^{230}Th, ^{234}U and ^{238}U are specific activities of the isotopes,

A_i is the age of a sample.

3. Calculation of the weighted mean of the isochron-derived detritally corrected age and its standard deviation if the dates (with errors) fit the χ^2 test.

Thus, the isochron-derived detritally corrected ^{230}Th / U age for the five inner sublayers (from the depth of 30–60 cm) of the Kirias section was estimated to be 105.5 ± 3.6 / 3.3 kyr by the L / L and 104.5 ± 4.4 / 3.9 kyr by the TSD techniques.

The method and techniques of U / Th-dating and the methods of age calculation were published elsewhere (Geyh, 2001; Кузнецов и др., 2003; Maksimov et al., 2006).

Note here that the U / Th dates obtained for the Zirianian interstadial from the Kirias section correlate well with the chronology of MOIS 5c (102–92 Ka), of oceanic transgression (105–100 Ka) and of the Brørup interstadial on the base of the Greenland glacier core (Dansgaard et al., 1993). Moreover, quite an accurate radioisotope date of the terrestrial section of the Early Würm interstadial of Siberia was obtained and this interstadial showed a close correlation with the climatic events in oceanic sediments.

Table 2. **Results of radiochemical analysis of peat samples from the Kirjas section (total sample dissolution method)**
2 lentelė. **Kirjaso pjūvio durpių pavyzdžių radiocheminės analizės duomenys (visiškai ištirpintų ėminių)**

Depth cm	Ash %	^{238}U decay / min g–dpm	^{234}U decay / min g–dpm	^{230Th} decay / min g–dpm	^{232}Th decay / min g–dpm	^{230}Th / ^{234}U	^{234}U / ^{238}U
30–35	13.56	0.208 ± 0.009	0.257 ± 0.011	0.169 ± 0.006	0.094 ± 0.004	0.656 ± 0.036	1.234 ± 0.069
35–40	12.94	0.186 ± 0.007	0.205 ± 0.007	0.138 ± 0.004	0.088 ± 0.003	0.674 ± 0.031	1.090 ± 0.048
40–45	11.95	0.219 ± 0.011	0.253 ± 0.012	0.161 ± 0.006	0.090 ± 0.004	0.637 ± 0.039	1.155 ± 0.079
45–50	11.98	0.390 ± 0.016	0.437 ± 0.017	0.287 ± 0.006	0.093 ± 0.003	0.658 ± 0.029	1.120 ± 0.049
50–55	11.85	0.657 ± 0.027	0.736 ± 0.029	0.484 ± 0.010	0.087 ± 0.004	0.658 ± 0.029	1.120 ± 0.047
55–60	12.40	1.155 ± 0.031	1.266 ± 0.034	0.805 ± 0.015	0.111 ± 0.004	0.636 ± 0.021	1.096 ± 0.027
60–65	13.47	3.021 ± 0.071	3.420 ± 0.079	2.315 ± 0.034	0.130 ± 0.006	0.677 ± 0.018	1.132 ± 0.021

Table 3. **List of macroscopic plant remains from buried peat bog of Kirias section. Identification of F. Yu. Velichkevich**
3 lentelė. **Makroaugalų liekanų iš palaidotų Kirjaso pjūvio durpių sąrašas (apibūdino F. Yu. Velichkevich)**

Taxon	K*	1	2	3	4	5	6	7	8	9	10	11
Salvinia natans (L) All.	m	–	2	–	–	–	–	–	–	–	–	–
Larix sibirica Ldb.	s / ds	16 / 5	26 / 2	82 / 1	110 / 36	62 / 1	10 / –	4 / –	5 / –	–	1 / –	–
Picea sect. Picea Willk.	s / n	10 / –	3/ ∞	23 / –	15 / –	7 / 15	1 / 14	– / 10	–	–	–	–
Pinus silvestris L.	ds	–	–	–	–	1	–	–	–	–	–	–
Typha sp.	t	∞	∞	∞	∞	∞	–	–	–	–	–	–
Potamogeton alpinus Balb	e	–	–	–	–	–	–	–	–	–	–	4
P. filifirmis Pers.	e	–	–	–	–	–	–	–	–	–	–	26
P. pectinatus L.	e	–	–	–	–	–	–	–	–	–	–	2
P. pussilus L.	e	–	–	–	–	–	–	–	–	–	–	5
P. sibiricus A.Benn.	e	–	–	–	–	–	–	–	–	–	–	7
Potamogeton sp.	e	–	–	–	–	–	–	–	–	–	–	9
Sparganium minimum Wallr.	e	–	–	–	–	–	–	1	–	–	–	–
S. hyperboreum Laest.	e	–	–	–	–	–	–	–	–	–	–	2
Carex cf. diandra Schrank.	f	1	47	35	66	41	15	16	8	–	–	–
C. pseudocyperus L.	f	7	∞	∞	∞	∞	83	26	∞	–	–	–
C. riparia Curt.	f	24	9	10	2	∞	∞	∞	∞	∞	∞	–
C. cf. rostrata Stokes	f	–	–	5	68	–	–	–	–	–	–	–
C. s/g Vignea (Beauv.) Kirschl.	f	–	52	75	–	–	–	–	–	–	–	∞
Carex sp.	f	43	32	18	∞	∞	∞	∞	∞	–	–	8
Shoeplectus tabernaemontani (C. C. Gmel.) Palla	f	–	–	–	1	–	–	–	–	–	–	1
Eriophorum vaginatus L.	f	–	–	–	–	–	–	–	–	11	176	2
Calla palustris L.	s	–	–	4	47	76	10	6	12	55	83	4
Lemna trisulcata L.	s	–	2	–	10	12	–	–	–	–	–	–
Betula fruticosa Pall.	f / sc	58 / 4	60 / 3	34 / 4	52 / 1	10 / 1	–	–	–	–	–	–
B. humilus Schrank	f / sc	–	–	–	–	–	–	–	–	–	–	54 / 21
B. nana L.	f / sc	–	–	–	–	–	–	–	–	–	–	85 / 3
B. sect. Albae Reg.	f / sc	1 / –	6 / 1	1 / –	7 / 1	–	3 / –	1 / –	3 / –	–	14 / –	23 / –
Caltha palustris L.	s	–	–	–	–	–	–	–	–	–	–	4
Urtica dioica L.	f	–	–	38	2	2	–	–	–	–	–	–
Atriplex cf. paluta L.	s	4	11	2	–	–	–	–	–	–	–	–
Rumex sp.	f	–	–	1	–	–	–	–	–	–	–	–
Silene cf. acaulis (L.) Jacq.	s	–	–	–	–	–	–	–	–	–	–	3
Batrachium sp.	f	–	–	–	–	–	–	–	–	–	–	8
Ranunculus flammula L.	f	–	–	–	–	1	–	–	–	–	–	–
R. lingua L.	f	–	–	10	61	164	40	38	3	14	–	–
R. repens L.	f	–	–	–	–	–	–	–	1	–	–	6
R. gmelinii DC.	f	–	–	–	–	–	–	–	–	–	–	1
R. scelleratus L.	f	–	–	–	–	–	–	–	–	–	–	3
Thalictrum lucidum L.	f	1	–	–	–	–	–	–	–	–	–	–
Rubus idaeus L.	f	–	–	–	–	–	–	–	–	–	1	–
Rubus sp.	f	–	–	–	–	–	1	–	–	–	–	–

Table 3 continued
3 lentelės tęsinys

Comarum palustre L.	f	–	–	–	–	44	23	13	32	9	18	–
Viola palustris L.	s	3	3	–	–	–	–	–	–	–	–	–
Cicuta virosa L.	f	–	1	–	–	1	–	–	–	–	–	–
Hippuris vulgaris L.	f	–	–	1	–	–	–	–	–	–	–	1
Myriophyllum spectrum L.	f	–	–	–	–	–	–	–	1	–	–	9
Patentilla sp.	f	–	–	–	–	–	–	–	–	–	–	2
Ledum palustre L.	l	–	–	–	–	–	–	–	–	–	1	–
Chamaedaphne calyculata (L.) Moench.	s	–	–	–	–	–	–	–		36	14	147
Lusimachia thyrsiflora L.	s	–	–	–	–	4	23	22	18	20	27	–
Menyanthes trifoliate L.	s	2	∞	∞	∞	∞	∞	∞	∞	–	1	–
Lycopus europaeus L.	f	–	3	7	∞	89	25	11	4	–	–	–
Stachys palustris L.	f	–	–	–	–	1	–	–	2	–	–	–
Galeopsis bifida Boenn.	f	–	–	–	2	–	–	–	–	–	–	–
Laminaceae gen.	f	–	–	2	–	–	–	–	–	–	–	–
Scutellaria galericulata L.	s	–	–	–	6	–	–	–	1	–	1	–
Bidens tripartite L.	s	–	–	–	4	–	–	–	–	–	–	–
Cirsium palustre (L.) Scop.	s	–	–	5	1	–	–	–	–	–	–	–
Carduus sp.	s	2	2	–	–	–	–	–	–	–	–	–
Asteraceae gen.	s	–	–	–	–	1	–	–	–	–	–	–
Cennococcum graniformae (Sow.) Ferd. et Winge	st	∞	∞	∞	∞	–	–	–	–	–	–	–

Abbreviations (K*): e – endocarp, ds – dwarf shoot, f – fruit, l – leaf, m – megaspore, n – needle, s – seed, sc – scale, st – sclerotium, t – tegmen, ∞ – some hundreds of speci-

PALAEOBOTANIC DATA AND DISCUSSION

An abundant flora (many thousands of fruits, seeds, scales, tegments, etc.) is characteristic of the forest type of vegetation during all the time of peat bog (layer 12) formation (Table 3, Fig. 4). Some species (*Carex, Menyanthes trifoliate, Typha* sp., *Picea sect Picea, Lycopus europaeus, Cenococcum graniformae,* etc.) are presented by hundreds and thousands of fruits, seeds, fragments of needles. Forest vegetation was similar to coniferous taiga with the domination of *Larix sibirica* and *Picea sect. Eupicea* and with *Betula sect. Albae* and shrub *Betula fruticosa* admixture. Herbal plant are not very various and belong to a swamp taphocenosis. Cold-resistant and typical thermophilic species are absent. Change of flora composition from bottom to top of layer 12 reflects the progress of swamping of the primary pond and its transformation to an oligotrophic swamp with a typical limited composition of species (*Carex* sp. *div., Eriophorum vaginatum, Chamaedaphne calyculata, Ledum palustre,* etc.). Some scarcity of flora is observed at the end of the peat bog formation. According to F. Yu. Velichkevich, who studied this flora, it is typical of the Zirianian (Early Würm) interstadials: Amersfoort, Brørup or Odderade (Laukhin et al., 2006).

Changes of vegetation and palaeoclimate in the Brørup interstadial in the Surgutskoye Priobye (Kirias section region) have been reconstructed on the palynological data from the buried peat bog (Fig. 5).

The high-gravity loam (layer 13), underlying the peat bog, was formed in conditions of non-forest periglacial vegetation (Левина, 1979). Below the peat bog we collected sparse samples. That's why we made use of T. P. Levina's (1979) data. At the end of loam sedimentation, in our data (Fig. 5), open woodlands were spread. Pollen of tree and shrub species reached up to 53%: *Pinus sibirica* (probably, elfin wood), *Picea* up to 13% and *Betula* up to 5.3% (almost 50% of Betula pollen comes from *Betula Nanae + B. Fruticosae*). The Bryales mire spread very widely. The abundance (up to 2%) of cold-resistante *Lycopodium alpinum* is significant. Spreading of forest-tundra in the Kirias region is possible in this time.

In the process of the peat bog formation, three phases of vegetation development (Fig. 5) were distinguished.

In the initial phase *a* the portion of pollen of grassy plants sharply reduced to 8–14%. Palynospectra, as well as macroflora, revealed a taiga type of a fur-larch forest. In the macroflora composition seeds and small-size escapes of larch are 2–9 times more abundant than those of fur. It is possible to guess that all the forests were larch forests. However, the sharp prevalence of fur pollen over pollen of other wood species testifies to its great role in forests of the Surgutskoye Priobye at that time and also to a vast tabetisoil zone in the valley of the middle-stream Ob' River. It is indicative that in the macroflora *Betula fruticosa* dominates over *Betula Albae*. In the second half of phase *a* sharply augments (up to 60%) the role of *Polypodiaceae* spores which are characteristic of dark coniferous forests. As a whole, the paleobotanical data allow to guess development at that time of the northern sub-zone of taiga. At present, the Kirias section lies in the middle sub-zone of taiga 400–450 km from the southern boundary of the northern subzone of taiga.

In palynospectra of phase *b*, the role of grassy plants, among them of *Gramineae* and forbs increases. Pollen of tree species makes 30–43%; there is a lot of fur pollen, but the role of birch, both shrub and tree-like, increases. *Bryales* spores are single, together with miscellaneous spores of cold-resistant *Lycopodium*

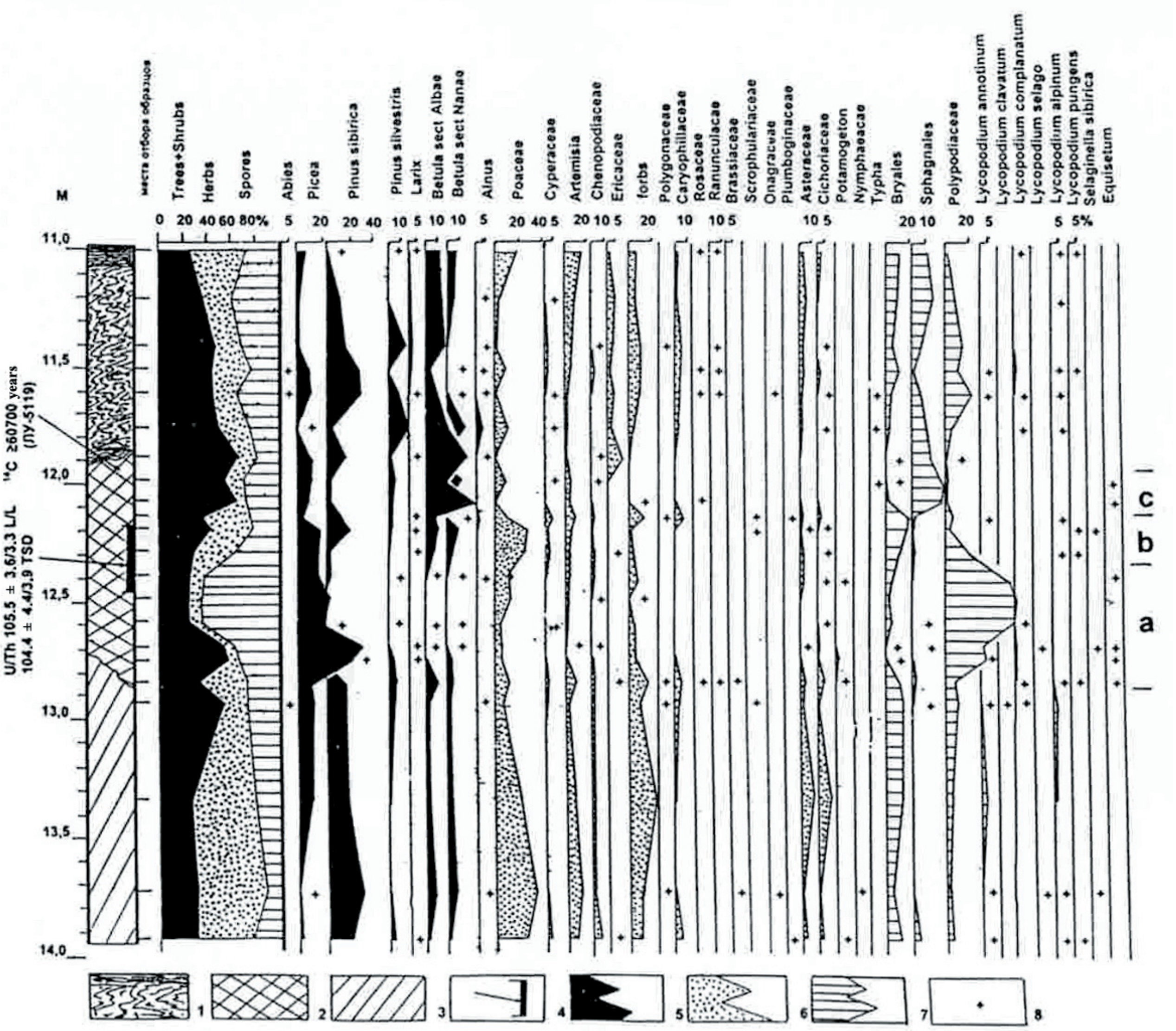

Fig. 5. Spore-and-pollen diagram of lower buried peat bog of Kirias section. *1* – layer 11 of "whitish aleurites", *2* – layer 12, peat bog, *3* – loam of layer 13, *4* – interval of collecting samples for U / Th-dating and date, *5* – pollen of tree and shrub species, sum, *6* – pollen of grass and undershrub plants, sum, *7* – spore sum, *8* – content of spores or pollen less than 1%

5 pav. Palaidotų Kirjaso pjūvio durpių apatinio sluoksnio sporų ir žiedadulkių diagrama. *1* – 11 sluoksnis („šviesus aleuritas"), *2* – 12 sluoksnis (durpės), *3* – 13-o sluoksnio priemolis, *4* – ėminių U / Th datavimui intervalas ir data, *5* – medžių ir krūmų žiedadulkių suma, *6* – žolinių ir krūminių augalų žiedadulkių suma, *7* – sporų suma, *8* – žiedadulkių arba sporų kiekis, mažesnis negu 1%

alpinum, L. pungens, Selaginella sibirica, etc. Open woodlands with larch, fur and birch dominated. A lowering near the Bryales mire and open places were occupied by *Gramineae* and xerophytes. The cooling was limited.

In palynospectra of phase *c* again increases the role of pollen of tree species (up to 55–66%), this time at the expense of birch (up to 34–49%), mostly tree-like. Open woodlands of birch with peat moss bogs were spread.

During the whole time of peat bog (layer 12) formation, the climate was colder than at present.

Peat bog formation concluded by interruption of sedimentation and formation of numerous rather large (1–6 m) ice (and ice-ground?) wedges which, however, did not form a system of polygonal networks. Then followed the degradation of ice-wedges (tracks of one more interstadial) and formation of "whitish aleurites" with a strongly distorted sintering lamination of layer 11. The beginning of the formation "whitish aleurites" coincides with the reference interstadial, since the aleurites from the bottom of this layer participate in the filling of pseudomorphs on ice-wedges. In the composition of "whitish aleurites" (layer 11), the palynospectra pollen of tree species comprises 25–52%; birch prevails (Fig. 5). In the group of grass and undershrub plants (20–46%) *Ericales* prevail, dominates, followed by *Gramineae* and *Artemisia*. Forest-tundra (birch open woodland) during loam sedimentation of layer 10 became degraded to non-forest periglacial vegetation (Fig. 5) with the spreading of heaths, yerniks with *Rubus hamaemorus, Draba,* cold-resistant *Lycopodium* and *Selaginella*. Sedimentation of Zirianian (Early Würm-Weichselian) deposits was concluded by loams of layer 10, because higher a thin peat bog of layer 9 occurs.

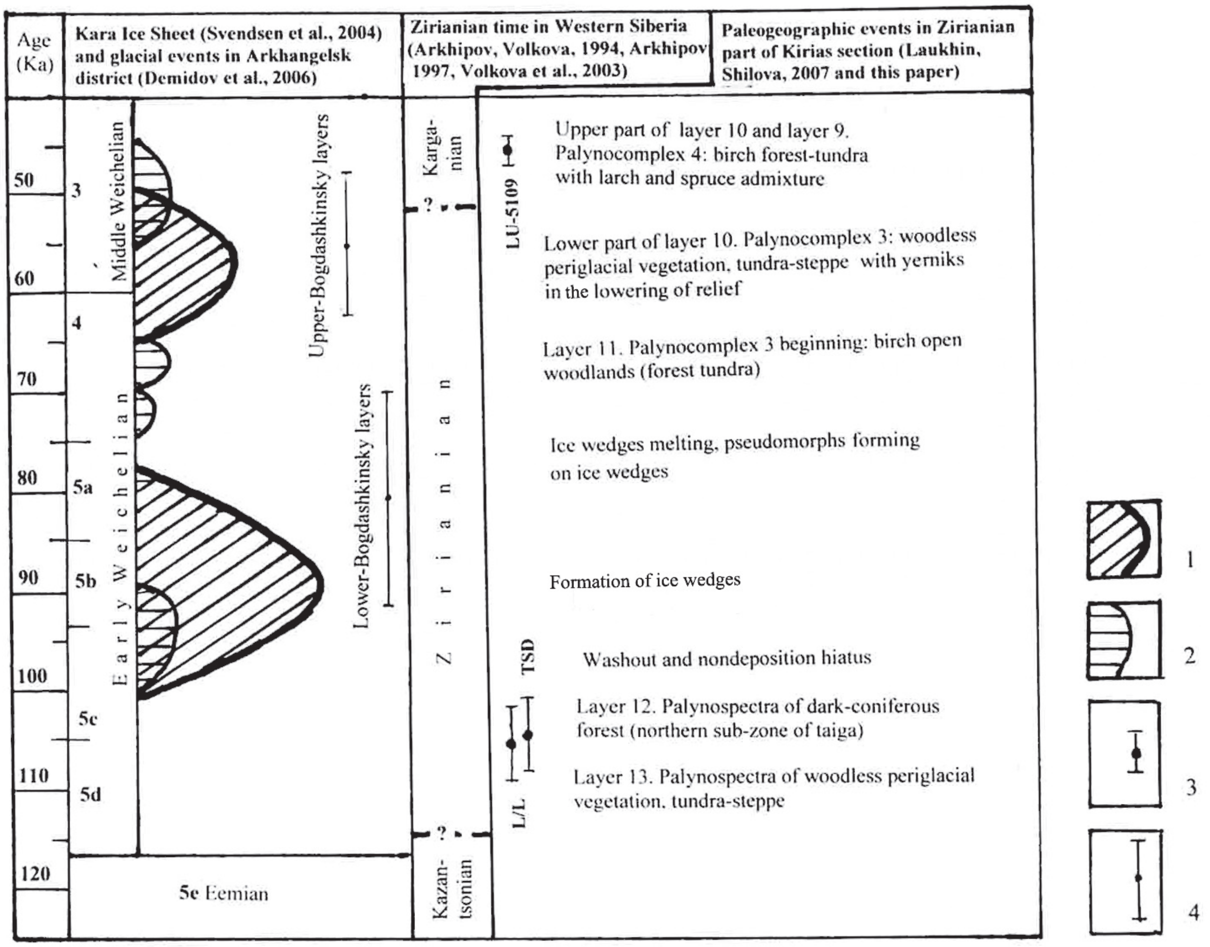

Fig. 6. Correlation of Barents–Kara Ice Sheet fluctuations in northern Russia (Svensen et al., 2004), and in Arkhangelsk district in particular (Demidov et al., 2006) with Western Siberia stratigraphical scheme of the Quaternary according to S. A. Arkhipov, (Архипов, Волкова, 1994), S. A. Arkhipov (1997) and V. S. Volkova et al. (Волкова и др., 2003) and paleogeographical events whose traces were studied in the Zirianian part of Kirias section. *1* – glacial events of Siberia according to J. I. Svendsen et al. (2004), *2* – glacial events of Arkhangelsk district to according I. N. Demidov et al. (2006), *3* – ^{14}C (LU-5109) and U / Th dates reported in the present paper, *4* – TL-dates of Bogdashkinsky layers according to S. A. Artkhipov (1997)

6 pav. Barenco-Karos ledyno dangos Rusijos Šiaurėje (Svensen et al., 2004) ir Archangelsko srityje (pagal S. A. Archipovą ir V. S. Volkovą (1994), S. A. Archipovą (1997), V. S. Volkovą ir kt. (2003)) palyginimas ir paleogeografinių įvykių pėdsakai Kirjaso pjūvio Zirianio dalyje. *1* – ledyno pėdsakai Rusijos šiaurėje (pagal J. I. Svensen ir kt. (2004)), *2* – ledyno pėdsakai Archangelko srityje (pagal Demidovą ir kt. (2006)), *3* – ^{14}C (ЛУ-5109) ir U / Th datos, *4* – Bogdaškino sluoksnių TL datos (pagal S. A. Archipovą (1997))

This peat bog has the ^{14}C-date of 46350 ± 1590 years (LU-5109). Layer 9 begins the Karganian horizon of the Middle Würm-Wisconsin (Fig. 4).

Thus, at least three stages of sharp cooling are reflected in layers 13–10 of the Kirias section development of non-forest periglacial vegetation in palynospectra of layers 13, 10, and a stage of big wedges formed after peat bog of layer 12 sedimentation (Fig. 6). Such ice wedges now form on the north of Western Siberia 100–150 km from the Northern Polar Circle (Brown et al., 1997) or 750 km north from the Kirias section. It confirmed very well the data about the maximal spreading of the Zirianian (Early Würm) glaciers in the Barents and Kara seas about 95–85 Ka (Mangerud et al., 2001) or 78–100 Ka (Svensen et al., 2004).

As to the warming during the Zirianian (Early Würm) interstadials, the macroflora and palynospectra of layer 12 in the Kirias section indicate that during the optimum of the Brørup interstadial, displacement of vegetation zones to the south in the Western-Siberian Plain could exceed 450 km. According to data on macroflora, almost all the peat bog was formed in taiga conditions. According to palynological data, considerable part of the peat bog was formed in forest-tundra conditions. This is an apparent contradiction. Palynospectra reflected the zonal type of vegetation, but macroflora reflected local conditions in the neighbourhood of the swamp which was located in a table soil zone (abundance of fir fossil remains testifies to it) near the channel of a big river (Ob') which flew from the south. The Brørop interstadial was not optimal for the northern half of the Western-Siberian Plain, because the maximal Early Würm (Zirianian) transgression of the sea was connected with a younger interstadial – 65–55 Ka (Demidov et al., 2006). The climate of that interstadial was colder than at present (Jensen et al., 2006). This seems strange, because at 65–55 Ka, according to models of M. Sigert (Sigert et al., 2001), the volume of the Weichselian Ice Sheet was maximal exactly within the interval 120–45 Ka. It inspires special interest to dating of the Bogashkinskye layers (Fig. 1, 2) where palynospectra of vegetation were studied.

CONCLUSIONS

At first, the U / Th-date was received for continental deposits of the Early Würm (Zirianian for Siberia) glaciation of Siberia: 105.5 + 3.6 / −3.3 (L / L) and 104.4 + 4.4 / −3.9 (TSD) thousand years.

This date very well conforms to the interstadial Brørup time of North-Western Europe and MOIS 5c. This U/ Th date was received from a buried peat bog in the well known Kirias section which was studied by different researchers for more 35 years.

The new macroflora and palynological collections allowed us to reconstruct more precisely the character of paleoclimate and paleovegetation during the peat bog formation and for this interglacial of the Zirianian (Early Würm) glaciation in the middle stream of the Ob' River – central part of the boreal zone of Western Siberia.

New collections of macro flora and palynological researches allowed the authors define much more precisely the character of the paleoclimate and paleovegetation in the period of peat bog formation and also to reconstruct them for this interglacial of the Zirianian (Early Würm) glaciation in the middle-stream Ob' River – central part of the boreal zone of Western Siberia.

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References

1. Arkhipov S. A. 1997. Record of Late Pleistocene geological events in West Siberia. *Russian Geology and Geophysics*. ***38***(*12*). 1891–1911.
2. Архипов С. А., Фирсов Л. В., Панычев В. А., Орлова Л. А. 1973. Новые данные по стратиграфии и геохронологии террас среднего течения бассейна р. Оби. *Плейстоцен Сибири и сопредельных регионов*. Москва: Наука. 21–33.
3. Архипов С. А., Довгаль Л. А., Левина Т. П., Липагина В. Я., Сухорукова С. С. 1976. Литологическая, палинологическая характеристика, диатомовая флора и остракоды из разреза третьей надпойменной террасы реки Оби (Сургутское Приобье). *Этюды по палеофитологии Сибири*. М.: Наука. 83–101.
4. Архипов С. А., Астахов В. И., Волков И. А., Панычев В. А. 1980 Палеогеография Западно-Сибирской равнины в максимум позднезырянского оледенения. Новосибирск: Наука. 110 с.
5. Архипов С. А., Панычев В. А., Шелкопляс В. Н. 1987. Геохронология верхнего плейстоцена Белогорского Приобья (Западно-Сибирская равнина). *Региональная геохронология Сибири и Дальнего Востока*. Новосибирск: Наука.110–125.
6. Архипов С. А., Вотах М. Р. 1989. К проблеме выделения зырянских интерстадиалов в Западной Сибири. *Кайнозой Сибири и Северо-Востока СССР.* Новосибирск: Наука. 138–141.
7. Архипов С. А., Волкова В. С. 1994. Геологическая история, ландшафты и климаты плейстоцена Западной Сибири. Новосибирск: ИГГиМ СО РАН. 106 с.
8. Арсланов Х. А. 1987. Радиоуглерод: геохимия и геохронология. Л.: ЛГУ. 298 с.
9. Арсланов Х. А. 1992. Геохронологическая шкала верхнего плейстоцена Русской равнины. *Геохронология четвертичного периода*. Москва: Наука. 10–19.
10. Астахов В. И., Мангеруд Я. 2005. Возраст каргинских слоев и климат OIS-3 на севере Сибири. *Квартер – 2005*. Сыктывкар: Геопринт. 24–25.
11. Васильчук А. К. 2007. Палинология и хронология полигонально-жильных комплексов в криолитозоне России. М.: МГУ. 385 с.
12. Вознячук Л. Н 1971. Основные особенности палеогеографии вадлайской эпохи и возраст краевых формаций максимальной стадии последнего оледенения на северо-западе Русской равнины. *Антропоген Белоруссии*. Минск. 8–23.
13. Волкова В. С., Архипов С. А., Бабушкин А. Е., Кулькова И. А., Гуськов С. А., Кузьмина О. Б., Левчук Л. К., Михаилова И. В., Сухорукова С. С. 2003. Стратиграфия нефтегазоносных бассейнов Сибири. *Кайнозой Западной Сибири*. Новосибирск: Гео. 247 с.
14. Волкова В. С., Хазина А. Е., Бабушкин А. Е. 2005. Стратиграфия плейстоцена Западной Сибири и палеоклиматическая шкала. *Квартер – 2005*. Сыктывкар: Геопринт. 77–78.
15. Bassinot F. C., Laberie L. D., Vincent E., Quidelleur Q., Shackleton N. J., Lancelot Y. 1994. The astronomical theory of climate and the age of the Brunhes-Matuyama magnetic reversal. *Earth Planet Sci. Lett*. ***126***. 91–108.
16. Brown J., Ferrians O. J., Heginbottom J. A., Melnikov E. S. 1997. Circum-Arctic map of Permafrost and Ground Ice Conditions. Denver.
17. Dansgaard W., Johnsen S. J., Moller J., Langway C. C. J. 1969. One thousand centuries of climatic record from Camp Century on the Greenland Ice Sheet. *Science.* ***166***(*3903*). 377–381.
18. Dansgaard W., Johnsen S. J., Clausen H. B., Dahl-Jensen D. et al. 1993. Evidence for general instability of past climate from a 250-kyr ice core record. *Nature.* ***364***(*6434*). 218–220.
19. Demidov I. N., Larsen E., Kjær K. H., Funder S., Houmark-Nielson M., Grosfjeld K., Jensen M., Linge H., Lyså A., Murray A. 2006. The Late Pleistocene stratigraphy and paleogeography of the Arkhangelsk District. *Correlation of Pleistocene Events in the Russian North*. Abstracts. St. Petersburg. 24–25.
20. Geyh M. A. 2001. Reflections on the 230-Th / U dating of dirty material. *Geochronometria.* ***20***. 9–14.
21. Jensen M., Demidov I. N., Larsen E., Lyså A. 2006**.** Weichselian glacers, lakes and sea level in the Arkhangelsk region: correlation potential and challenges. *Correlation of Pleistocene Events in the Russian North.* Abstracts. St. Petersburg. 44–45.
22. Комар М. С. 2005. Палинофлора как индикатор палеогеографических условий территории Польши в позднем плейстоцене. *Современные проблемы палеофлористики, палео-*

фитогеографии и фитостратиграфии. Вып. 1. Москва: ГЕОС. 173–177.

23. Kuimova L. N., Sherstiankin P. P. 1999. The peculiarities thermohalinic regime of Baikal lake at Heinrich events in Upper and Middle Pleistocene. *Doklady Earth Sciences*. ***368***(*5*). 313–327.
24. Kuznetsov V. Yu., Arslanov Kh. A., Alekseev M. N., Pisareva V. V., Chernov S. B., Maksimov F. E., Baranova N. G. 2002. New age data of buried peat deposits from the Site "Fili Park" (Moscow, Russia) by the uranium-thorium dating and palynological analysis and its stratigraphic significance. *Geochronometria*. ***21***. 41–48.
25. Кузнецов В. Ю., Арсланов Х. А., Козлов В. Б., Максимов Ф. Е., Савельева Л. А., Чернов С. Б., Баранова Н. Г. 2003. Перспективы применения уран-ториевого метода неравновесной геохронологии для датирования межледниковых континентальных отложений. *Вестник СпбГУ. Сер. 7. Вып.* ***2***(*15*). 40–51.
26. Laukhin S. A., Arslanov Kh. A., Shilova G. N., Velichkevich F. Yu et al. 2006. Paleoclimates and Chronology of the Middle Würm Megainterstadial on the West Siberian Plain. *Doklady Earth Sciences.* ***411A***(*9*). 1457–1461.
27. Laukhin S. A., Shilova G. N. 2007. Palynological characteristics of Karganian deposits in Surgut Priobye (Late Pleistocene of West-Siberian Plain). *Geologija.* ***58.*** 25–33.
28. Левина Т. П. 1979. Палинологическая характеристика отложений позднечетвертичной ледниковой эпохи в долине Средней Оби. *Стратиграфия и палинология мезозоя и кайнозоя Сибири.* Новосибирск: Наука. 74–98.
29. Maksimov F., Arslanov Kh., Kuznetsov V., Chernov S. 2006. ^{230}Th / U and ^{14}C dating of Upper and Middle Pleistocene Interglacial and Interstadial organic deposits from the East-Europe Plain and Siberia. *Pleistocene Environments in Eurasia. Chronology, Palaeoclimate, and Teleconnection*. Hannover. 1–5.
30. Mangerud J., Astakhov V. I., Murray A., Svendsen J. I. 2001. The chronology of a large ice-dammed lake and the Barents-Kara Ice Sheet advances, Northern Russia. *Global and Planetary Change.* ***31***. 321–336.
31. Oppo D. W., Keigwin L. D., McManus J. F., Cullen J. L. 2001. Persistent suborbital climate variability in marine isotope stage 5 and Termination II. *Paleoceanography.* ***16***(*3*). 280-292.
32. Санько А. Ф. 1999. Фауна моллюсков гляциоплейстоцена и голоцена Беларуси. Минск: Наука и техника. 103 с.
33. Siegert M. J., Dowdeswell J. A., Hald M., Svendsen J. I. 2001. Modelling the Eurasian Ice Sheet through a full (Weichselian) glacial cycle. *Global and Planetary Change*. ***31***. 367–385.
34. Svensen J. I., Alexsanderson H., Astakhov V. I. Demidov I. et al. 2004**.** Late Quaternary ice sheet history of northern Eurasia. *Quaternary Science Reviews*. ***23***. 1229–1271.
35. Унифицированная региональная стратиграфическая схема четвертичных отложений Западно-Сибирской равнины. 2000. Новосибирск: СНИИГГИМС. 64 с.
36. Yevzerov V. Ya. 2006**.** Late Pleistocene marine transgressions in the Kola region. *Correlation of Pleistocene Events in the Russian North*. Abstracts. St. Petersburg. 108–109.

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SIBIRO ZIRIANIO (ANKSTYVOJO VIURMO) APLEDĖJIMO ANKSTYVOJO TARPSTADIALO PĖDSAKAI: U / Th DATA IR PALEOBOTANINIAI DUOMENYS

Santrauka

Europoje ankstyvojo Vyslio (ankstyvojo Valdajaus, ankstyvojo Viurmo) apledėjimo tarpstadialai seniai yra surasti. Jų amžius ir apimtis nuolat tikslinama. Vakarų Sibire 1980 m. buvo išskirti du, XX a. pradžioje – vienas, dabar (Волкова и др., 2005) – nei vieno tarpstadialo. Beje, jų pėdsakai yra ryškūs Karos jūroje ir Europos šiaurės vakarinėje dalyje. 1980–1990 m. Vakarų Sibiro Zirianio (ankstyvojo Viurmo) apledėjimo tarpstadialai buvo išskirti MOIS-4 ribose (arba šiek tiek anksčiau, arba vėliau tos stadijos). Datavimas U / Th metodu (pirmą kartą panaudotas Sibiro sąlygomis) atskleidė, kad Obės vidurupyje žinomos Kirjaso atodangos apatinis durpių sluoksnis formavosi Zirianio apledėjimo ankstyvojo tarpstadialo metu. Straipsnyje aprašoma Kirjaso pjūvio sandara – apatinis durpių sluoksnis ir jį perdengiantys bei apačioje slūgsantys Zirianio horizonto sluoksniai. U / Th data, kuri gauta iš durpių pašalinus karbonatus, yra 105,3 + 3,6 / –3,3 tūkst. metų, o visiškai ištirpinus – 104,4 + 4,4 / –3,9 tūkst. metų. Ši data atitinka Vakarų Europos Briorupo tarpstadialą ir MOIS-5c stadiją. Pateikti paleobotaniniai (makrofloros ir palinologiniai) duomenys. Nustatyta, kad Zirianio ankstyvojo tarpstadialo metu Obės vidurupyje augo taigos šiaurinės pazonės miškai. Tuomet augalijos zonos galėjo pasistūmėti į pietus daugiau negu 450 km. Virš durpių ir po jomis nustatyti tundros palinologiniai spektrai, vėliau – tundros ir tundros-stepių. Durpėms susiklojus įsivyravo sedimentacijos pertrauka ir formavosi didelės (iki 6 m) ledo gyslos, kurios buvo susijusios su dar vienu (neskaitant durpės dengiančiuose sluoksniuose ir po jomis) stipriu atšalimu. Dar vieno atšilimo metu ledo gyslos ištirpo ir susidarė jų pseudomorfozės. Taigi Kirjaso pjūvio apatinėje (Zirianio) dalyje surandame trijų atšalimų ir dviejų atšilimų pėdsakų. Pirmasis atšilimas laiko atžvilgiu atitinka MOIS-5c ir Vakarų Europos Briorupo tarpstadialą.

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ПЕРВЫЕ СЛЕДЫ РАННЕГО ИНТЕРСТАДИАЛА ЗЫРЯНСКОГО (РАННЕВЮРМСКОГО) ОЛЕДЕНЕНИЯ В СИБИРИ: U / Th ДАТА И ДАННЫЕ ПАЛЕОБОТАНИКИ

Резюме

Межстадиалы ранневислинского (ранневалдайского, ранневюрмского) оледенения Европы известны давно, возраст и масштабы их постоянно уточняются. В Западной Сибири возникла обратная ситуация: в 80-е годы выделялось два, в начале XXI в. – одно, теперь (Волкова и др., 2005) – ни одного межстадиала. Между тем на шельфе Карского моря и на северо-востоке Европейской части России следы их проявлены очень четко. В 80–90-е годы интерстадиалы зырянского (ранневюрмского) оледенения Западной Сибири выделялись в пределах MOIS-4 (или немного раньше и позже этой стадии). Применение U / Th метода датирования, впервые использованного для зырянского (ранневюрмского) времени Сибири, показало, что нижний торфяник известного обнажения Кирьяс в среднем течении Оби относится к самому раннему интерстадиалу зырянского оледенения. Обсуждается строение нижней части разреза Кирьяс: нижний торфяник и слои зырянского горизонта, подстилающие и перекрывающие его. U / Th дата получена из торфяника методом выщелачивания – 105,5 + 3,6 / –3,3 тыс. лет, а методом полного растворения – 104,4 + 4,4 / –3,9 тыс. лет. Описана методика получения U/ Th даты. Эта дата соответствует интерстадиалу Бреруп Западной Европы и MOIS-5c. Приведены палеоботанические (макрофлора и палинология) данные. Показано, что во время самого раннего интерстадиала зырянского времени в среднем течении Оби распространялась северная подзона тайги, т. е. смещение растительных зон к югу могло превышать 450 км. Выше и ниже торфяника изучены палиноспектры сначала лесотундр, а затем – тундры и тундро-степи. После накопления торфяника произошли перерыв осадконакопления и формирование мощных (до 6 м) ледяных жил, которые отражают еще один (кроме выявленных в слоях, подстилающих и перекрывающих торфяник) этап сильного похолодания. Последующее вытаивание этих жил и образование псевдоморфоз по ним фиксируют еще один этап потепления. Таким образом, в нижней (зырянской) части разреза Кирьяс отражены три этапа похолодания и два – потепления, причем первое из потеплений соответствует по времени MOIS-5c и этапу Бреруп в Западной Европе.