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Palaeobotanical and palaeomalacological characteristics of Middle Siberia Kazantsovian Interglacial according to Bedoba section data

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An outcropping near the Bedoba settling (Northern Priangarye) uncovers a constrative series of alluvium, which is made up in lower stream, oxbow lake (with buried peat bog) and floodplain facies. These facies are overlapped by constrative alluvium (sands with clay of second pond facies) and covering strata. The U/Th-date 120 ± 13 ka BP was obtained for the peat bog of oxbow lake facies. It allows to attribute the stream and oxbow lake facies to the Kazantsovian horizon. In the peat-forming end, cooling began. The malacofauna of Interglacial type with *Unionidae* in single stream facies and the predominance *Gyraulus albus* above *G. laevis* was collected in the middle of the oxbow lake sediments. Palynospectra from the upper part of the stream facies to the top of the second pond facies lens, which occurs in the constrative alluvium top, reflect 8 stages of the vegetation development from the middle of the Kazantsovian Interglacial to the second half of the Zirianian glacial time. ^{14}C-date of 52100 ± 1680 years (ЛУ-5044) was obtained for clay of second pond facies. In the stream and oxbow lake sediments palynospectra are typical of a forest vegetation with admixture of broad-leaved species (*Corylus, Tilia* and *Quercus* in sum 3–4.9% from sum of tree and shrub species pollen). In sands of the constrative alluvium and clay of the second pond facies palynospectra are typical of open periglacial spaces.

Key words: Siberia, Irkineeva River, Bedoba section, palaeocarpology, molluscs, alluvium, palynology

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INTRODUCTION

One of the fundamental tasks related to the Quaternary is palaeoclimatic reconstructions of warm stages of the Late Pleistocene; for Siberia it is the Karganian (Middle Würm) and the Kazantsovian (Riss-Würm) time. It is known that an exceptionally important information on fine oscillations of climate can be deriv-

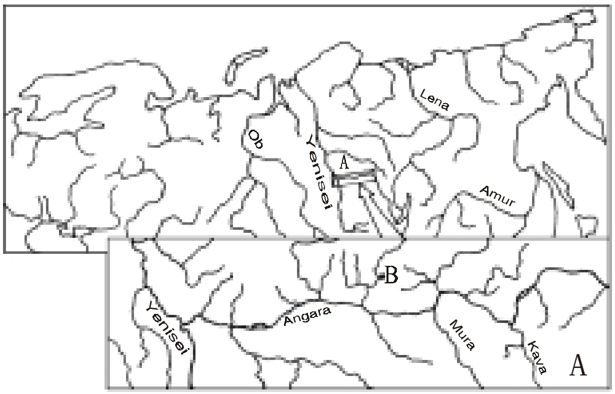

Fig. 1. Disposition of Bedoba section (*B*) in Northern Eurasia and in Northern Priangarye (*A*)
1 pav. Bedobos (*B*) pjūvio padėtis Šiaurės Eurazijoje ir Angaros žemupio rajone (*A*)

ed from vegetation (Кинд, 1974, c. 5). Therefore palaeoclimatic reconstructions were produced by authors mainly according to palaeobotanical data. Such reconstructions for the Late Pleistocene of Siberia were produced repeatedly (Лаухин, 1982, Архипов, Волкова, 1994, Архипов и др., 1999, Late Quaternary vegetation…, 2002 etc). The main drawback of these reconstructions as a rule was inadequate provision of absolute dates with palaeoclimatic events, especially in the Kazantsovian (Riss-Würm, Eem) time, because for Kazantsovian sediments there are only old TL-dates obtained in different years by different methods, which have so wide confidence intervals that it possible to ascribe the sediments dated by them both to the Kazantsovian and Zirianian (Early Würm, Early Valday) or Tazovian (Late Riss, Dnepr) horizons (Arkhipov, 1997). Therefore of particular significance for the Kazantsovian time is the U/Th method of dating. For the first time this method was used for peat bog dating in the Bedoba section (Fig. 1) in the Lower Irkineeva River (right tributary of the Lower Angara River) 2.5–3 km upstream from the Bedoba settlement (58° 48' 32" NL and 97° 15' 43" EL).

DESCRIPTION OF THE SECTION

The Bedoba outcropping extends for 450 m and uncovers constrative alluvial series of increased thickness (Fig. 2), made below by stream facies of alluvium (layer 5), by oxbow lake facies with thick lens of peat bog and floodplain facies (layer 4). The thickness of these facies (in total) is close to a normal thickness of the Irkineeva River alluvium under its recent stream-flow regime. Sands, which have signs of constrative alluvium, occur higher (layer 3 in Fig. 2). In total, layers 5–3 about twice exceed the normal alluvium thickness of the recent Irkineeva River. In the upper part of layer 3 a lens of secondary pond facies clay occurs (layer 3a in Fig. 2). Layers 2 and 1 relate to the cover series. A leaf-by-leaf description of a stripping is shown in Fig. 3 (stripping 1 in Fig. 2). Of course, the description of a concrete stripping was made in more detail and consisted of a greater number of layers. The conformity of layers in Figs. 2 and 3 is as follows: 1 – 1,2; 2 – 3; 3 – 4, 5, 7; 3a – 6; 4b – 8, 10; 4c – 9, 5–11. A more detailed description of the section was published (Лаухин, 1982, Лаухин, Метельцева, 1973). This description (Лаухин, Метельцева, 1973) was made in 1968. At that time for this section series the ^{14}C-dates showed from 47000 ± 1000 (KSM-41) in shingle of the stream facies to 24120 ± ± 1240 (SOAN-124) years in the clay of secondary pond facies lens. However, in 2003 for the peat

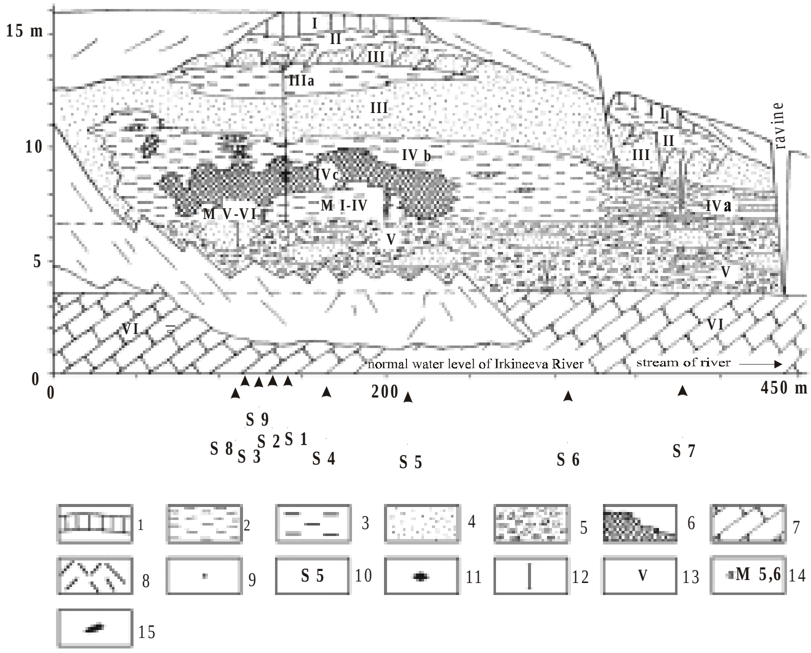

Fig. 2. Generalizing scheme of Bedoba section.
1 – loam grey, loess-like; *2* – loam and clay cherry-brown (layer 2); *3* – clay blue-grey, from grey to brown (layer 2); *4* – sand; *5* – shingle ferruginate; *6* – peat; *7* – Paleozoic aleurolites (terrace socle); *8* – taluses, which have most big thickness; *9* – places of 14C-dates (of 2003) samples collecting; *10* – disposition of main strippings, only principle strippings were showed on scheme; *11* – disposition of sample for U/Th dating; *12* – section intervals, where samples for spore-and-pollen analysis were collected; *13* – layer number, *14* – places, where samples for malacology analysis were collected and these samples numbers; *15* – disposition of *Unioidae* shells.
2 pav. Bedobos pjūvio bendra schema

bog from oxbow lake facies (Fig. 2) in the Geochronology Laboratory of Institute of Geography, St. Petersburg State University the U/Th-date 120 ± 13 ka BP was obtained. The principle of this method of dating, its possibility and limitations were published (Кузнецов и др., 2003). The date obtained for the buried peat bog of the Bedoba section conforms very well with the age of the stratotypical sections of Mikulino (Riss-Würm) sediments in Mikulino and Nizhnyaya Boiarshchyna settlements, 113 ± 11 ka BP and 119,5 ± 11 ka BP respectively (Кузнецов и др., 2003). For examination of the U/Th-date for the Bedoba peat bog, we received in the same laboratory three ^{14}C-dates. Only for the clay of secondary pond facies the date of 52100 ± 1680 (ЛУ-5044) years was obtained. For the peat bog of oxbow lake lens the following dates (Figs. 2, 3) were odtained: the overhead of the peat bog ≥ 56900 (ЛУ-5035) and in the middle of the peat bog ≥ 53500 (ЛУ-5040) years. The new ^{14}C-dates confirm the erroneousness of ^{14}C-dates received in the seventh decade of the 20th century and also relate the peat bog in the Bedoba section to the Kazantsovian time.

In stream shingle of the Bedoba section, in 1968 (Лаухин, Метельцева, 1973) hundreds of *Unioidae* valves were collected, allowing to suppose a warmer climate than at present. In clay of the oxbow lake facies fresh-water and subaerial molluscs were collected. These molluscs are characterized by a great ecological plasticity: *Radix (=Lymnaea) peregra, Lymnaea* cf. *zebrella (=palustris), Coretus (=Planorbarius) corneus, Gyraulus acronicus, Bathyomphalus contortus, Anisus aff. strauchianus, Valvata aliena, V. cristata.* However, absence of molluscs (in spite of a great quantity of shells) of typical loessic forms such as *Pupilla loessica, Succinea oblonga elongata, Vallonia tenuilabris,* present not only in the periglacial, but also the recent malacofauna of Northern Priangarye, can indicate comparatively mild climatic conditions. Palaeobotanical data give a more definite evidence about the palaeoclimate. In total, 43 taxa were determined, of them 24 taxa by the palynospectra (very poor) and 22 taxa by carpological analysis. The specific composition of the flora on the whole is similar to its present composition in the Irkineeva River basin. However, many species have the areals situated essentially to the South and West from the Lower Angara River; these are *Najas flexilis, N. tenuissima, Ceratophillum submersum, Zannichella palustris* (many carpoids), etc. These data, already in that time, permitted to reconstruct for the time of sediments of the stream and oxbow lake facies accumulation a warmer and milder climate than at present, *i.e*. an interglacial climate (Лаухин, Метельцева, 1973).

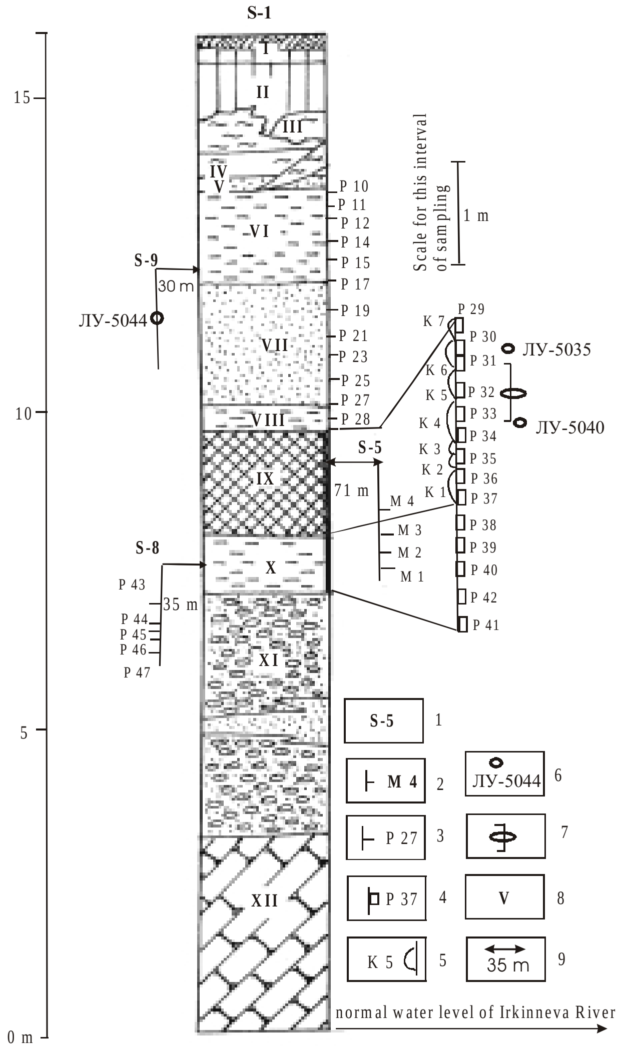

Fig. 3. Disposition of samples, which are discussed in this paper. Stratigraphic column was showed only for stripping 1. For strippings 5, 8 and 9 was showed only samples disposition. For layers 9 and 10 of stripping 1 was showed samples disposition in extended scale. Lithologic symbols see no Fig. 2.
1 – stripping numbers; *2* – placers of samples of malacofauna collection; *3* – placers of samples collecting for spore-and-pollen analysis from layers 6–8 of stripping 1 and from layer 11 from stripping 8; *4* – intervals of samples collecting for spore-and-pollen analysis from layers 9 and 10 of stripping 1: *5* – intervals of samples collecting for carpological analysis from layer 9 of stripping 1; *6* – places of samples collecting for ^{14}C-dating (dates of 2003); *7* – place of samples collecting for U/Th-dating; *8* – layer numbers (layers from fig. 2 and Fig. 3 correlation was showed in text of this paper); *9* – distances of strippings 5, 8 and 9 from stripping 1.
3 pav. Mėginių paėmimo vietos atodangos pjūvyje

MALACOFAUNA

In summer 2002, collection of malacofauna and macroflora was repeated by the authors of this paper. As before, the remains of malacofauna and macroflora were collected from only stream and oxbow lake facies, but from overlying sands and clay of constrative alluvium only palynospectra were studied (Figs. 2, 3).

5678 shells of molluscs were determined (Table 1). The malacofauna includes 23 taxa, of them 22 taxa are fresh-water and one (*Limacidae* gen.) is subaerial. In new determinations, only *Lymnaea peregra, Valvata aliena* and *Bathyomphalus contortus* were repeated; moreover, *Lymnaea peregra* and *Valvata aliena* were repeated in high numbers (210–567 shells in a sample). As before, no species of the loess complex were noted. Considerable quantity (to 340 valves in a sample) were the numbers of *Gyraulus albus*, which is typical of the interglacial of Pleistocene and Holocene deposits of Eastern Europe and in particular in Belarus (Санько, 1999). They often are noted together with the eurythermal species *G. laevis*. A considerable quantity or predominance of *G. albus* over *G. laevis* usually indicates a malacofauna belonging to interglacial optimum. Such correlation of this species was observed in a sample from the middle part of oxbow lake sediments of the Bedoba section. However, the most thermophilous species in this malacofauna is *Unio (Pectunio) annulatus*, which had been earlier determined by Ya. I. Starobogatov (Лаухин, 1982) on hundreds of shells. In summer 2002, only the first tens of poorly preserved Unio shells were collected. At present, *U. annulatus* lives in the Ilek and the Ural Rivers near the Orenburg city (Яцко, 1970). In Siberia, *Unio* does not live at all, but it was widespread in the Neogene.

The malacofauna of the Bedoba section belongs to the Boreal fresh-water fauna group. By many parameters this fauna is similar to the Mikulino (Eem, Riss-Würm) Interglacial and Holocene fauna of Middle and Northern Europe. This fauna contains no extinct species. In this fauna cold-resistant species are absent, and to the number of relatively thermophilous species *Unio* sp. and *Gyraulus albus* belong.

Table 1. **Fauna of molluscs of section Bedoba from alluvial sediments of Irkineeva River (dranage-basin of Angara), specimens. E – ecological groups according to S. W. Alexandrowicz (1987)**
1 lentelė. **Bedobos pjūvio moliuskai iš Irkinevos upės (Angaros baseinas) aliuvio nuogulų (E – ekologinės grupės pagal S. V. Aleksandrovičių)**

E	Species	M1	M2	M3	M4	M5	M6
7	*Limacidae gen.*			3			
10	*Valvata sibirica* Middendorf		363	5	55	92	1
10	*Lymnaea truncatula* (Müller)			1		1	
10	*Lymnaea peregra* (Müller)		209	42	210	98	2
10	*Segmentina nitida* (Müller)		11	225	24	21	
10	*Sphaerium lacustre* (Müller)		2	49	1	1	
10	*Pisidium obtusale* (Lamarck)		1			30	
11	*Valvata aliena* Westerlund + *V. aliena korotnevi* Lindholm	2	24	567	23	90	
11	*Physa fontinalis* (Linnaeus)		3	2	1		
11	*Lymnaea stagnalis* (Linnaeus)		2	6	60	2	
11	*Lymnaea auricularia* (Linnaeus)		20	10	21	27	
11	*Myxas glutinosa* (Müller)					1	
11	*Anisus vortex* (Linnaeus)		1	2	53	13	
11	*Bathyomphalus contortus* (Linnaeus)				11		
11	*Gyraulus albus* (Müller)		75	340	5	58	1
11	*Gyraulus laevis* (Alder)	1	369	247	209	555	
11	*Armiger crista* (Linnaeus)	1	366	70	624	242	2
11	*Pisidium milium* Held		2			11	
11	*Pisidium subtruncatum* Malm		1	16	3	20	15
11	*Pisidium cf. casertanum* (Poli)			13		20	1
11	*Pisidium* sp.					13	5
12	*Unio annulatus* Kobelt (according to Ya. I. Starobogatov)	11					
12	*Pisidium nitidum* Jenyns		10			4	

PALAEOCARPOLOGY

Palaecarpology analysis of the peat bog and clay of the oxbow lake (Figs. 2, 3) revealed 104 taxa (Table 2). The type of the remains is different: sclerotia, oöspores, oogonia, megaspores, endocarps, tegmens, seeds, fruits, fruit stones; for *Picea, Larix, Pinus* seeds and needles (in Table 2 the quantity of seeds is shown in numerator and of needles in denominator), more rarely shortened shoots; for *Betula* and *Alnus* – scales and fruits (in Table 2 the quantity of fruits is shown in numerator and of scales in denominator). When the macroremains (for example, seeds, fruits, etc.) were numerous, in Table 2 they are shown as “мн” (many) (more than 100 specimens) or “ом” (very many). The character of taxa distribution in a section and time-related changes of flora allow to single out in its composition three complexes, each corresponding to a specific stage of environmental development.

Table 2. **Flora of Bedoba section on palaeocarpology data (collection of season-2002)**
2 lentelė. **Bedobos pjūvio flora paleokarpologiniais duomenimis (2002 m. vasaros kolekcija)**

	M5	M6	M2	M3	M4	K1	K–2	K3	K4	K5	K6	K7
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Cenococcum graniformae (Sow.) Ferd. et Winge	–	4	–	–	–	2	–	1	–	12	мн	мн
Nitella sp.	–	14	–	–	–	мн	18	–	–	–	–	мн
Chara sp.	–	–	–	–	–	–	–	–	–	–	–	мн
Azolla interglacialis Nikit.	–	–	–	–	–	28	8	8	1	4	–	–
Abies sibirica Ldb.	1	–	–	–	–	4/2	1/4	1/1	–	–	–	–
Picea sect. Eupicea Willk.	3/–	–	2/1	3/5	1/–	8/ом	–/мн	2/мн	5/ом	3/76	–/4	–/2
Larix sibirica Ldb.	3/–	5/–	3/–	1/2	25/мн	63/мн	–/ом	13/ом	17/84	21/32	–/18	5/мн
Pinus sibirica (Rupr.) Mayr	–	–	–	–	–	1	–	–	–	–	–	–
Pinus silvestris L.	–	–	–	–	–	–	–	1/–	–	2/1	–/1	3/9
Sparganium emersum Rehm.	–	–	1	–	–	9	1	3	1	5	4	–
S. microcarpum (Neum.) Raunk.	–	–	–	–	–	1	–	–	–	–	–	–
S. minimum Wallr.	–	–	–	–	–	–	–	2	–	–	–	–
S hyperboreum Laest..	–	–	–	–	–	–	–	–	–	–	1	1
Sparganium sp.	–	–	–	–	–	–	–	3	–	–	–	–
Typha sp. *div.*	–	–	–	–	–	мн	мн	мн	39	28	–	–
Potamogeton friesii Rupr.	7	56	2	1	–	18	5	–	–	–	–	51
P. gramintus L.	–	–	–	–	–	1	–	–	–	–	–	–
P. natans L.	–	–	–	–	–	–	1	–	–	–	–	1
P. panormitanus Biv.-Bern.	1	–	–	–	–	–	–	–	–	–	–	–
P. pectinatus L.	9	27	32	79	15	44	8	3	2	2	–	7
P. praelongus Wulf.	–	2	–	–	–	–	–	–	–	–	–	5
P. pusillus L.	2	2	3	3	2	–	–	1	1	–	–	–
P. trichoides Cham. et Schlecht.	–	–	–	5	–	–	–	–	–	–	–	–
Zannichellia palustris L.	3	1	–	1	5	ом	ģķ	8	3	–	–	–
Najas marina L.	–	–	–	–	–	15	8	–	–	–	–	–
Caulinia ex gr. *tenuissima* (A. Br) Tzvel.	–	–	–	–	–	–	–	1	–	–	–	–
Alisma plantago-aquatica L.	–	–	–	–	–	4	–	–	–	–	–	–
Damasonium sp.	–	–	–	–	–	–	–	1	–	–	–	–
Scirpus sylvaticus L.	–	–	–	13	–	8	10	7	–	14	–	
Schoenoplectus lacustris (L.) Palla	–	–	–	–	–	5	4	–	–	1	–	3
Sch. tabernaemontani	–	2	–	–	–	19	13	3	12	40	2	7
(C. C. Gmel.) Palla												3
Eleocharis palustris (L.) Roem. et Schult.	–	–	–	–	–	3	4	8	–	4	–	
Carex diandra Schrank	–	–	–	–	–	2	10	мн	25	92	–	–
C. elongata L.	–	–	–	–	–	1	2	–	–	–	–	–
C. paucifloroides Wieliczk.	–	–	–	1	–	4	5	2	–	4	–	–
C. pseudocyperus L.	–	–	мн	мн	–	мн	75	64	96	ом	–	–
C. riparia Curt.	1	–	–	–	–	–	–	5	6	11	–	–
C. vesicarya L.	–	–	–	–	–	мн	мн	мн	мн	мн	–	ом
C. sugen. Vignea (Beauv.) Kirschl.	–	–	1	1	1	мн	ом	мн	42	ом	–	–
Carex sp. div.	–	2	–	–	1	мн	–	–	–	–	54	–
Calla palustris L.	–	–	–	–	–	4	2	2	3	3	1	1
Lemna trisulca L.	–	–	–	–	–	51	мн	48	11	мн	–	–
Betula sect Albae Reg.	–	–	–	2/–	–	12/2	16/1	21/–	5/3	мн/1	–	6/–
B. fruticosa Pall.	–	–	–	–	–	24/14	10/–	17/1	2/1	5/2	6/–	–
B. pendula Ehrh.	–	–	–	–	–	–	–	37/28	–	–	–	–

Table 2 (continued)
2 lentelės tęsinys

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
B. pubescens Ehrh.	–	–	–	–	–	–	–	30/13	–	–	–	–
B. humilis Schrank	–	–	–	–	–	8/–	8/4	2/1	2/2	6/1	–	–
Betula sp.	–	–	–	2/–	–	–	–	–	–	–	–	
Alnus hirsuta Turcz.	–	–	–	–	–	85/26	20/4	6/1	8/–	9/–	–	–
Urtica dioica L.	–	–	–	–	–	4	8	2	–	2	–	–
Rumex maritimus L.	–	–	–	–	1	96	25	6	10	4	–	–
R. crispus L.	–	–	–	–	–	4	–	1	–	–	–	–
Rumex sp.	–	–	–	–	–	–	2	–	–	–	–	–
Fallopia convolvulus (L.) A. Love	–	–	–	–	–	1	–	–	–	–	–	–
Polygonum lapathifilium L.	–	–	–	1	–	–	–	–	–	–	–	–
Polygonum sp.	–	–	–	–	–	–	–	–	–	1	–	–
Chenopodium cf. album L.	–	–	–	1	–	–	–	–	–	–	–	–
Ch. hybridum L.	–	–	–	–	–	3	–	–	–	–	–	–
Ch. polyspermum L.	–	–	–	–	–	–	–	2	–	–	–	–
Ch. rubrum L.	–	–	–	–	–	1	7	3	2	6	–	–
Chenopodiaceae gen.	–	–	2	–	–	–	–	–	–	–		
Caryophyllaceae gen.	–	–	–	–	–	–	–	–	–	3	–	–
Coryspermum sp.	1	–	1	–	–	–	–	–	–	–	–	–
Nuphar pumila (Timm.) DC	–	–	2	–	–	–	–	–	–	–	–	–
Brasenia sp.	–	–	–	–	–	1	–	–	–	–	–	–
Ceratophyllum demersum L.	34	–	24	1	37	14	3	2	–	2	–	–
C. submersum L.	–	–	–	1	60	30	2	–	–	–	–	–
Batrachium sp.	–	–	–	1	–	–	–	–	–	–	–	1
Ranunculus acer L.	2	–	–	–	–	–	–	–	–	–	–	–
R. gmelinii DC	–	–	–	–	–	5	7	14	–	–	–	–
R. cf. repens L.	–	–	–	1	–	–	–	–	–	–	–	–
R. sceleratus L.	–	–	–	–	–	5	14	24	10	25	2	11
Chelidonim majas L.	–	–	–	–	–	–	–	–	–	–	1	–
Spiraea cf. betulifolia Pall.	–	–	–	–	–	–		–	–	1	–	–
Crataegus cf. altaica Lge.	–	–	–	–	–	1	–	–	–	–	–	–
Comarum palustre L.	–	–	–	–	1	1	4	14	1	–	1	2
Filipendula ulmaria (L.) Maxim.	–	–	–	–	–	1	1	–	–	–	–	–
Potentilla sp.	–	–	–	–	–	4	24	24	2	3	–	–
Rubus idaeus L.	–	–	–	1	–	3	2	–	–	2	–	–
R. saxatilis L.	–	–	–	–	–	–	–	1	–	–	–	
Rubus sp.	–	–	–	–	–	–	–	–	1	–	–	
Euphorbia sp.	–	–	–	–	–	–	1	–	–	–	–	–
Empetrium nigrum L.	–	–	–	–	–	–	–	–	–	–	–	2
Viola cf, palustris L.	–	–	–	–	–	3	–	3	–	–	–	–
Viola sp.	–	–	–	–	–	–	2	2	–	4	–	–
Hippuris vulgaris L.	5	2	2	1	4	16	20	48	1	3	9	1
Myriophyllum spicatum L.	–	2	3	1	–	–	–	4	6	13	–	20
M. verticillatum L.	–	–	–	–	–	–	–	3	1	–	–	–
Cicuta virosa L.	–	–	–	1	–	1	–	–	2	8	1	1
Apiaceae gen.	–	–	–	–	–	1	–	–	–	–	–	–
Swida sanguinea (L.) Opiz.	–	–	–	–	–	1	–	–	–	–	–	–
Chamaedaphne calyculata (L.) Moench	–	–	–	–	–	–	–	–	1	1	–	1
Lysimachia thyrsiflora L.	–	–	–	–	–	–	–	10	2	82	66	56
L. vulgaris L.	–	–	–	–	–	–	–	–	1	–	–	–
Menyanthes trifoliata L.	–	1	–	–	–	1	1	18	37	83	мн	2

Table 2 (continued)
2 lentelės tęsinys

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Scutellaria galericulata L.	–	–	–	–	–	3	1	–	1	–	–	–
Lycopus europaeus L.	–	–	–	–	–	–	–	1	–	1	–	–
Mentha sp.	–	–	–	–	–	1	6	2	–	3	–	–
Sambucus racemosa L.	–	–	–	–	–	3	–	–	1	1	2	2
Lonicera xylosteum L.	–	–	–	–	–	–	2	–	–	–	–	–
Bidens tripartita L.	–	–	–	–	–	1	–	1	–	1	–	–
Carduus sp.	–	–	–	–	–	–	–	–	–	1	–	–

The most abundant and taxonomically diverse complex was related to K1-5 samples (Fig. 3), which characterize almost all peat bog (below 40 cm from the top). It is characteristic of mixed forests of interglacial type consisting of *Abies, Picea, Larix, Betula* and *Alnus* Siberian species. At present, *Abies* in the Irkineeva Basin is found near the eastern boundary of the area. The Eurasian element is represented widely (*Picea sect. Eupicea, Pinus sylvestris, Betula sect. Albae, Lonicera xylosteum, Swida sanguinea, Sambucus racemosa*), but by the quantity of remains it noticeably lags behind the Siberian elements. Interesting is a find of *Sambucus racemosa*, because in the present flora of Siberia it is absent or noted as an introduced species (Кац и др., 1965).

Important is the find of a single seed of *Brasenia*, morphologically very similar to the exotics of the Mikulino floras of the European part of Russia, Belarus and Eemian floras of Central and Western Europe (Величкевич, 1982, Velichkevich, 1991). So far, no remains of *Brasenia* have been found in Pleistocene floras of Siberia (Никитин, 1970). The abundance of *Azolla interglacialis* megasporea is significant. This species is regarded as characteristic of the Tobolian (Middle-Riss, Likhvin) flora of Siberia and its analogues in Eastern Europe, but V. P. Nikitin (Никитин, 1970) found its megaspores – single, immature, with sings of "depression" – in Kazantsovian deposits. In the Bedoba flora, the megaspores are fully mature, with massulas and without signs of redeposition. In European floras of Mikulino type no remains of this species have been found. Therefore its presence in the Bedoba flora changes the conception about its history in the Pleistocene. We should note the presence in this flora of the extinct species *Carex paucifloroides*, which in European floras was not marked higher than Likhvin (Mindel-Riss) sediments (Величкевич, 1982).

The Bedoba complex includes not very many thermophilous plants. Macroremains of broad-leaved species were not found; however, presence in this complex of the species which were enumerated, and also specimen of climatic optimum of interglacials *Potamogeton trichoides* and some other species of temperate climate, which usually accompanied species of the Brasenia complex (*Sparganium microcarpum, Najas marina, Lemna trisulca, Calla palustris* etc), allows to compare the discussed flora with Mikulinian floras of the European part of Russia and their analogues in more western regions. In all probability, in the lower part of the peat bog of the oxbow lake, facies of the Bedoba section sediments of optimum interglacial and postoptimal stages were represented.

Samples M1–6 (Figs 2, 3, Table 2) correspond to the lower floristic complex, but differ from it in three exponents:

– facial: macroremains of M1–6 accumulation took place in the lake (oxbow lake), but accumulation of K1-5 samples macroremains occurred in swamp conditions of peat formation;

– taphonomical: the taphocenosis of samples M1–6 macroflora was formed in water conditions by mixing, although the mixing was weak; K1–5 appeared in swamp conditions, where the mixing of macroremains was minimum if any;

– technical: samples K1–5 were collected and prepared specially for carpological analysis, but samples M1–6 were washed for studying malacofauna and the macroflora in these samples was "accidental" to a certain extent. Besides, samples M1–6 were collected in a "punctate" way, sometimes from a considerable interval of layers from two strippings (2 and 5), but samples K1–7 come only from one stripping 1 and from fixed intervals of depth from the peat bog top: K1 – 140–166 cm, K2 – 120–140 cm, K3 – 110–120 cm, K4 – 70–110 cm, K5 – 40–70 cm, K6 – 20–40 cm, K7 – 0–20 cm.

For these three reasons no comparison of samples K1–5 and M1–6 was made, although some of the samples M1-6 (at least M1, 2, 5, 6) occur stratigraphically below the samples K1–5 and could characterize the stage of flora development preceding the stage reflected in samples K1–5. However, the differences in floras K1-5 and M1, 2, 5, 6, which are facial, taphonomical and technical, hardly allow to reveal reliably their age differences. However, leaf-by-leaf collection of samples, especially for carpological analysis, which excludes the technical factor, will possibly allow to display age differences of floras from the peat bog and oxbow lake clay underlying this peat bog. In any case, in the vegetation composition such differences were revealed by palynological data (see below).

Higher in the section (sample K6) flora changes abruptly: the taxonomical diversity decreases (only 18 taxa) and the quantity of remains diminishes. Some species remains (*Menyanthes trifoliata, Hippuris vulgaris, Carex* sp. div.) poorly survived, and the abundance of *Cenococcum graniformae* sclerotinas give evidence of a nondepositional hiatus, and appearance of the cold-enduring species *Sparganium hyperboreum* shows that the hiatus was accompanied by cooling. A poor representation of Arcto-Boreal species (*Sparganium hiperboreum*) and preserved forest community elements (*Picea. Pinus, Larix, Betula, Sambucus*) show a short and rather shallow cooling. This complex can be compared with one from early stages of the Last Glaciation, which usually was recorded with difficulty in European sections of the Mikulino-Valday time.

In the very top of the peat bog (K7 sample) there is a complex rich in water plants: *Nitella, Chara, Potamogeton, Myriophillum* etc. Species that were absent in previous complexes (*Empetrum nigrum, Batrachium* sp.) or were presented by single remains appear (*Chamaedaphne calyculata,Calla palustris, Potamogeton praelongus*). From the tree and shrub plant group *Abies sibirica, Betula fruticosa, Alnus hirsuta,* etc. disappear and in the main forest-forming species *Larix sibirica* begins to dominate. Arcto-Boreals are represented only by *Sparganium hyperboreum* inherited from the previous complex. By thermophilicity the upper complex is close to the interglacial, but it is poorer in taxonomical diversity because of disappearance of many relatively thermophilic species (*Ceratophyllum demersum, Filipendula ulmaria, Najas marina,* etc.). Owing to these peculiarities the upper complex is comparable with one of the Early Valday (Brörup, Odderade) interstadial complexes of Eastern European Plain (Величкевич, 1982).

PALYNOLOGY

The picture of the vegetation development, more sketchy but encompassing almost all section below the cover series (Figs. 2, 3), can be deduced from the palynological data. In total, 31 samples were analyzed. In the periglacial alluvium (layers 8 and 9 in Fig. 3) palynospectra are poor: 114–228 pollen grains (p.g.), over 81 p.g. in sample P21; in the oxbow lake alluvium palynospectra are richer: 201–545 p.g., usually 370–420 p.g. Relatively much pollen is found in sands of stream facies (layer 5 in Fig. 2 and layer 11 in Fig. 3): 237–325 p.g.

From the stream facies, only sands from the upper part were studied palynologically (Fig. 2). Palynospectra from it show a spreading of spruce forests with *Pinus sibirica* and *Abies*. In the underwood could grow shrub birch and in valleys larch and birch forests with *Tilia* and *Corylus*. The lows were occupied by Bryales and Sphagnum bogs with sedge. Open localities could be occupied by steppe meadows with *Artemisia* and *Chenopodiaceae*. The vegetation characterizes the conditions less continental and more humid than at present.

In the oxbow lake clay underlying peat (layer 10 on Fig. 3), palynospectra reflect the spreading of larch-birch forests with *Pinus, Picea, Abies* and forest-meadows herbs. Open spaces were occupied by xerophytes and steppe herbs. Side by side with Bryales bogs, sedge bogs appeared with *Ericaceae, Equisetum, Potamogeton,* etc. An increase of humidity and some cooling are noted.

In the peat bog (except its upper part) palynospectra show expansion of dark coniferous forests with *Picea, Pinus sibirica* and *Abies* area. Near the foot of slopes birch-pine forests with *Larix, Corylus* and *Quercus* could be spread. Sedge fen areas with *Ericaceae, Poymoniaceae, Rubus chamaemorus* and water plants grew in number. Along rivers, brakes of *Alnus* and *Salix* formed. Palynospectra reflect considerable humidification and some warming, which probably corresponds to the optimum of the Interglacial.

In the upper part of the peat bog palynospectra are characteristic of spruce forests with *Abies, Larix, Pinus sibirica*, with shrub-birch and *Juniperus* in the underwood. Among *Lycopodium* cold-resistant species (*L. alpinum, L. pungens*) were more (widespread 3.5%) than in the underlying peat. Birch-pine forests with *Corylus* and *Tilia* occupied less areas. Along rivers, brakes of *Alnaster* and *Salix* were spread. Climate was more humid and less continental than at present.

In the oxbow lake clay overlapping peat, palynospectra are typical of birch-pine forests with *Picea, Larix, Pinus sibirica, Abies* and admixture of broad-lived species and with shrub birch in the underwood. Lowlands, were occupied by Sparganium bogs with *Ericales, Rubus chamaemorus* and *Polymoniaceae*. Some cooling on the background of increased humidity is noted, in spite of a considerable (2.6–3.3%) quantity of *Corylus* and *Quercus* pollen.

In the sands, which overlap the oxbow lake lens (layer 7 in Fig. 3), the composition of palynospectra abruptly changes. Here spores predominate (56.5–77.3%), but pollen of woody and shrub species comprises only 10.4–28.5%. Open spaces with herbs (*Gramineae* meadows) and *Bryales* bogs predominate. Among the river valley areas of *Larix*, open woodlands with *Betula* and *Pinus* stretched out. On sandy scarps and eroded slopes *Selaginella sibirica* appeared. Such vegetation indicates a periglacial zone.

In the lower part of the secondary pond facies clay, in the palynospectra the portion of herbs and undershrub plant pollen sharply increased (to 46–62%); among them, *Cichoriaceae* comprised 13–25.5%. *Artemisia* was very numerous. Very different herbs were represented by meadows, steppe, forest and water plants. Palynospectra show spreading areas with disturbed or immature soil cover overgrown by *Cichoriaceae* and *Asteraceae*. Open landscapes with xerophytes (*Artemisia, Chenopodiacae, Ephedra*) and steppe plants increased. Along river valleys, open woodlands of *Larix* with *Betula* (tree-like and shrub-like) stretched out. Climate was sharply continental and dry. These spectra were formed about 52–53 ka BP (date ЛУ-5040), in the second half of the Zirianian glacial time.

In the upper part of the secondary pond facies, clay palynospectra give evidence of spreading open spaces with *Bryales* bogs. *Cyperacerae, Equisetum, Ericaceae* herb-Gramineae meadows grew near these bogs. Along river valleys, open woodlands of *Larix* with *Betula* and *Picea* here and there stutched out. Pollen of tree-like and shrub-like *Betula* is found in equal parts, or there is more pollen of shrub-like *Betula*. In places with immature soil cover, *Cichoriaceae, Artemisia* and other xerophytes grew, while saline substrata were overgrown by *Plumboginaceae*. Spreading of xerophytes together with tundra species of *Lycopodium* and *Selaginalla* and shrub-like *Betula* give evidence of glacial floras. The Zirianian glacier, even according to most courageous reconstructions, was extended to a distance of many hundred kilometers from the Bedoba section, but vegetation even here acquired a “glacial” character. At the same time, this last complex of palynospectra is a natural stage of the previous palynospectra evolution. Moreover, judging by the facies peculiarities of sediments, the time when these two palynospectra complexes changed was very short.

CONCLUSIONS

Comparison of the data on macroflora and results of spore-and-pollen analysis show that macroflora is more sensitive to climatic changes. The cooling in peat accumulation in the oxbow lake lens is reflected much more impressively in the macroflora composition. The vegetation reflected by peat bog palynospectra changed less abruptly than the macroflora composition. And this is natural, because palynospectra reflect the vegetation of a large area around the Bedoba section, but the macroflora shows only local vegetation near this section. Perhaps this is the reason why in the macroflora only plant-satellites of broad-leaved species are found, whereas macroremains of these species in peat have not been noted. Really, it is difficult to expect the growth of these species on a bog in Northern Priangarye, even during the optimum of the Kazantsovian Interglacial. At the same time, throughout the whole peat bog section, practically in all samples pollen of broad-leaved species is present (mostly *Corylus* and *Tilia*, but sometimes *Quercus* which grew, in all probability, not far from the bog where peat accumulated). Moreover, the quantity of broad-leaved species pollen in some spectra reaches 3–4.9% from the total of wood and shrub species pollen. It is a well known fact that broad-leaved species pollen, *Quercus* in particular, does not spread far. Thus, we can see here that a combined employment of palaeocarpological and palynological analysis gives a much more comprehensive picture of the region’s vegetation and provides a more complete material for palaeoclimatic reconstructions than does each of these methods separately.

Thus, palaeobotanical data show that sediments revealed in the Bedoba section were formed during the second half of the Kazantsovian (Riss-Würm, Eem) Interglacial probably including its optimum (stream facies with *Unioidae* and maybe the lower part of the oxbow lake peat bog). The end of oxbow lake facies accumulation is marked by a transition to the Zirianian (Early Würm) Glaciation time. The constrative alluvium (layer 3 in Fig. 2) was deposited in periglacial conditions, probably before the pessimum of the Zirianian glacial time.

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SIBIRO VIDURINĖS DALIES KAZANCEVO TARPLEDYNMEČIO PALEOBOTANINĖ IR PALEOMALAKOLOGINĖ CHARAKTERISTIKA BEDOBOS PJŪVIO DUOMENIMIS

S a n t r a u k a

Angaros upės žemupyje prie Bedobos kaimo esančioje Irkinevos upės atodangoje aptikta konstratinio aliuvio storymė. Atodangos apatinėje dalyje slūgso aliuvio vaginės, senvaginės (su palaidotomis durpėmis) ir salpinės kilmės nuogulos. Jas perdengia konstratinio aliuvio smėlis su antrinio baseino molių lęšiais. Viršuje pjūvį užbaigia perdengianti nuogulų storymė. Senvaginės facijos durpė buvo datuota urano-torio metodu. Gauta 120 ± 13 tūkst. metų data leidžia senvaginį ir vaginį aliuvį priskirti Kazancevo tarpledynmečio horizontui. Paleokarpologinė analizė patvirtino, kad palaidotas durpynas susidarė Kazancevo tarpledynmečio antrojoje pusėje ir galbūt esant klimato optimumui. Durpių kaupimosi pabaigoje konstatuotas atšalimas.

Iš senvaginės facijos molio ir vaginio gargždo sluoksnio buvo surinkta tarpledynmečio tipo malakofauna. Gargžde surastos *Unioidae* fosilinės liekanos. Senvaginių nuogulų vidurinėje dalyje virš *Gyraulus laevis* vyravo *G. albus*.

Pradedant vaginio aliuvio facija ir baigiant antrinio baseino nuogulų, slūgsančių kontrastinio aliuvio viršutinėje dalyje, kraigu, išryškinti palinospektrai atspindi aštuonis augmenijos raidos etapus. Šie etapai apima augmenijos raidą pradedant Kazancevo tarpledynmečio viduriu ir baigiant Zyrianio ledynmečio antrąja puse. Antrinio baseino moliai datuoti radiokarboniniu metodu; jų amžius 52100 ± ± 1680 metų (LU-5044). Vaginio ir senvaginio aliuvio facijose nustatyti palinospektrai apima miško augmeniją su plačialapių medžių priemaiša (lazdyno, liepos ir ąžuolo kartu paėmus iki 3–4,9% nuo bendro medžių ir krūmų žiedadulkių kiekio). Konstratinio aliuvio smėlyje ir antrinio baseino molyje išryškėjo atviriems periglacialiniams kraštovaizdžiams būdingi palinospektrai.

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ПАЛЕОБОТАНИЧЕСКАЯ И ПАЛЕОМАЛАКОЛОГИЧЕСКАЯ ХАРАКТЕРИСТИКА КАЗАНЦЕВСКОГО МЕЖЛЕДНИКОВЬЯ СРЕДНЕЙ СИБИРИ ПО ДАННЫМ РАЗРЕЗА БЕДОБА

Р е з ю м е

Обнажение у с. Бедоба (Северное Приангарье) вскрывает констративную толщу аллювия, сложенную внизу отложениям русловой, старичной (с погребенным торфяником) и пойменной фациями, которые перекрыты констративным аллювием (пески с линзой глин вторичного водоема) и покровной толщей. Для торфяника старичной фации получена уран-ториевая дата 120 ± 13 тыс. лет, что позволяет отнести старичный и русловой аллювий к казанцевскому горизонту. Палеокарпологический анализ показал, что погребенный торфяник сформировался во второй половине казанцевского времени, возможно, включая его оптимум. В конце торфонакопления начинается похолодание. Из глин старичной фации и галечников русловой фации собрана малакофауна межледникового типа с *Unioidae* в галечниках и преобладанием *Gyraulus albus* над *G. laevis* в середине старичных отложений. Палинспектры от верхней части русловых фаций до кровли фации вторичного водоема, которая залегает в кровле констративного аллювия, отражают восемь этапов развития растительности от середины казанцевского межледниковья до второй половины зырянского ледникового времени. Для глин фации вторичного водоема получена ^{14}C-дата 52100 ± 1680 лет (ЛУ-5044). В русловых и старичных отложениях палиноспектры характерны для лесной растительности с примесью широколиственных пород (лещина, липа и дуб в сумме до 3–4,9% от состава пыльцы древесных и кустарниковых пород). В песках констративного аллювия и глинах фации вторичного водоема палиноспектры типичны для открытых перигляциальных пространств.