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Results of palynological analysis of Bedoba section (Late Pleistocene of Middle Siberia)

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The constrative alluvium of the Bedoba section (Northern Priangarie) was studied palynologically. The uranium–thorium (U/Th) date is 120 ± 13 ka (Kazantsovian = Mikulian = Eemian = Merkine time) for the oxbow-like peat bog of this section and for the secondary pond facies in the upper layer of the constrative alluvium. The ^{14}C date, 52100 ± 1680 years (LU-5044), shows the Zirianian time (Early Valdaian = Early Vistulian = Early Nemunas). Palynospectra from the upper parts of the stream alluvium to the upper part of the oxbow-like peat bog reflect the evolution of the southern-taiga forests with *Corylus, Tilia* and *Quercus* admixture. These forests are near to the Kazantsovian Interglacial optimum. In oxbow-like clays which overlap the peat bog, palynospectra reflect some cooling and moistening in this interglacial end. After a long interruption of sedimentation in the first half of the Zirianian time, palynospectra of periglacial vegetation (meadows and *Bryales* bogs with open woodlands among the valley areas) were studied in sands of constrative alluvium. In the lower part of the secondary pond clays, palynospectra reflect the spreading of open spaces with xerophytes. In the upper part of these clays, spaces of *s* bogs appear, moisture increases in cool climate conditions during the Zirianian glaciation degradation.

Key words: Middle Siberia, Irkineeva River, Bedoba section, alluvium, palynology, Kazantsovian Interglacial, Zirianian Glaciation

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INTRODUCTION

Recently, for terrestrial deposits of Central Siberia, for the first time in Siberia, uranium–thorium (U/Th) dates (Арсланов и др., 2004) were obtained. This date, 120 ± 13 Ka, showed the Kazantsovian (Mikulian = Eemian = Merkinë) age of buried peat bog in the Bedoba section on the Irkineeva River, the right tributary of the Angara River in its latitudinal stream (Fig. 1). The composition of the section, its lithology-facies content, palaeobotanical and malacological data for this section have been already published (Velichkevich et al., 2004 Arslanov et al., 2004). Their palaeocarpological analysis was described. The palynological analysis of the section was not completed, and only the main conclusions from materials of this analysis were published (Velichkevich et al., 2004). Now we publish data of its palynological analysis.

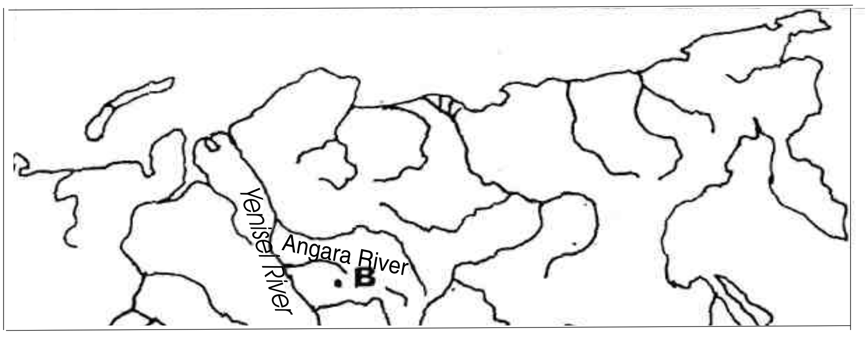

Fig. 1. Location of Bedoba section (B)
1 pav. Bedoba pjûvio vieta

The Bedoba section, 58° 48' 32" NL and 97° 15' 43" EL, uncovers the alluvium and the covering series (Velichkevich et al., 2004). Almost all alluvium series was analysed palynologically (Fig. 2): sands of the upper part of stream facies; clays of the oxbow-like facies with peat bog, which buried these clays; sands of the periglacial alluvium, which constratively overlap the oxbow-like facies and clays of the secondary pond at the top of the alluvium series. Between the top of the oxbow facies and the bottom of constrative alluvium sand facies, an interruption of sedimentation and washout are observed. As a result of this interruption, floodplain facies were washed out in the most part of the section almost completely (Velichkevich et al., 2004).

DESCRIPTION OF PALYNOSPECTRA AND DISCUSSION

Thirty-one samples were analyzed from the alluvial series (Fig. 2). In the oxbow lake and stream alluvium, 200–540 pollen and spore grains per sample were identified; in the constrative periglacial alluvium palynospectra are poorer, showing 114–228 pollen and spore grains per sample.

Beside Pleistocene pollen, along all the section redeposited pollen is found in palynospectra from the Paleozoic and Paleogene, which extended in the Irkineeva River basin. In the north, the Irkineeva river washes out mainly the Permian and the Carboniferous of the Tungusian syneclise western limb and the Lower Paleozoic of the Irkineevian Ridge in the undercurrent. Paleozoic palynomorphs differ from those Quaternary very sharply. Within the Irkineevian Ridge Paleogene occurs in small spots. During the Paleogene, many genera that had been present in the Pleistocene already appeared, but their species their composition differs from Pleistocene very much (Kulkova, Laukhin, 1975). The preservation, character of pollen fossilization, etc. also differ allowing to distinguish them from Pleistocene pollen and to ascribe such pollen and spores to the category of those redeposited.

No special studies of the redeposited pollen and spores were made. But it is obvious even from “accidental” calculation that redeposited palynomorphs were distributed along the section irregularly. Naturally, its content in the buried peat bog was least; in clays of the oxbow lake lens, which include peat bog, its content was 1.5 times higher in the stream facies 8 times, in the constrative alluvial sands 2.5 times, and in clays of the secondary pond facies 4 times higher than in the buried peat bog. Redeposited palynomorphs were not included in the calculation of palynospectra.

The Bedoba section is situated in the south taiga subzone. There pine and larch-pine forests with *Vaccinium* and meadow-steppe herbs in cover predominate. In valleys on high flood plains, on fluvial terraces above floodplains and in closed depressions on watersheds, larch forests with *Picea, Pinis sibirica* and *Abies* stretch. Low places along rivers are occupied by birch forests with *Cyperaceae*, and *Equisetum*, and spruce forests with *Cyperaceae*.

For elucidation of recent vegetation in spore-and--pollen spectra, four surface samples were collected from alluvial silt of the Irkineeva River and recent soil on an outcropping brow. Samples ss-1, 2, 3 were collected from silt of the Irkineeva River stream at a depth of 30 cm (ss-1), on the water line (ss-2) and from the surface of a low flood plain (50 cm) (ss-3). In common composition spectra (Fig. 2), pollen of trees and shrubs predominates (71.5–74%), pollen of herbs and undershrubs taking 13.5–19% and spores 9–12%. Pollen of pine predominates (26–37%). There is much pollen of *Pinus sibirica* (8.5–13.5%), *Picea* (6–11%), *Betula* (8.5–9.8%). Pollen of *Abies* (0.8–3%), *Larix* (0.8–3.2%), shrub birch (4.8–8.5%), *Alnaster* (0.2–1.2%), *Salix* (0.2–0.4%) were noted in small quantities. *Pinus* and *Betula* show a high pollen productivity, so the quantity of pollen of these genera in the spectral composition is too high relatively to their part in the stand.

In pollen of herbs and under shrubs of ss-2 sample, pollen of *Poaceae* makes up 4.5%, forbs 3.4% (*Ranunculaceae, Primulaceae, Onagraceae, Cichcoriaceae, Potamogeton*), *Artemisia* 2.5%, *Cyperaceae* 1.4%, *Ericales* 1.4%. In spores *Bryales* 9.4% and *Polypodiaceae* there are. In ss-1 sample, the quantity of forbs (*Asteraceae, Rosaceae, Sanguisorba, Ranunculaceae, Labiatae, Fabaceae, Urticaceae, Valerianaceae, Onagraceae, Cichcoriaceae, Typha*) rises to 9%, *Artemisia* 6.5%, *Poaceae* 1.8%, *Cyperaceae* 0.9%, *Chenopodiaceae* 0.2%. In spores, *Athyrioidea* makes up 4.2%, *Bryales* 4%, *Sphagnum* 0.2%, *Lycopodium complanatum* 0.4%. In ss-3 sample, pollen of forbs reaches 5.1% (*Asteraceae, Spiraea, Apiaceae, Primulaceae, Onagraceae, Ranunculaceae*), *Poaceae* 2.2%, *Ericales* 1.1%. In the spore group are presented *Bryales* (6.6%), *Athyrioideae* (5.1%).

Spore-and-pollen spectra from silt characterize a south-taiga vegetation: pine forest, larch forests with *Picea, Pinus sibirica, Abies, Betula* and with shrub birch undergrowth, *Alnaster, Spirea* and cover from wood-meadow forbs, *Ericales*, ferns, *Lycopodium, Bryales*. Near streams *Salix, Alnus, Cyperaceae* and aquatic-bog vegetation is spread. The increased percentage of *Artemisia* in ss-1 and ss-3 may connected with *Artemisia* growing on riverbed banks.

The ss-4 sample was collected from soil brow outcrop (16 m above the river). The content of tree and shrub pollen rises up to 92%. *Pinus* predominates (30.6%). The pollen quantity of *Betula* (20%), *Alnus* (10,7%), *Alnaster* (4.1%), *Picea* (15%) rises. The part of *Pinus sibirica* (3.3%), *Abies* (1.7%), *Larix* (3%), shrub birch (3.3%) decreases. Pollen of forbs reaches 3% (*Ranunculaceae, Asteraceae, Cichcoriaceae, Rosaceae, Onagraceae, Primulaceae, Urticaceae*). *Cyperaceae* 1.1%, *Artemisia* 0.6%, *Poaceae* 0.2%, *Ericales* 0.2%, *Chenopodiaceae* 0.2% are few. Spores of *Anthyrioidea, Bryales, Lycopodium annotinum* and *L. complanatum* are also few.

Samples from alluvial silts reflect the character of vegetation of the region, but a sample from soil surface (ss-4) indicates the character of vegetation groups near the place of sample collection. This is the reason for the essential difference in the palynospectrum of

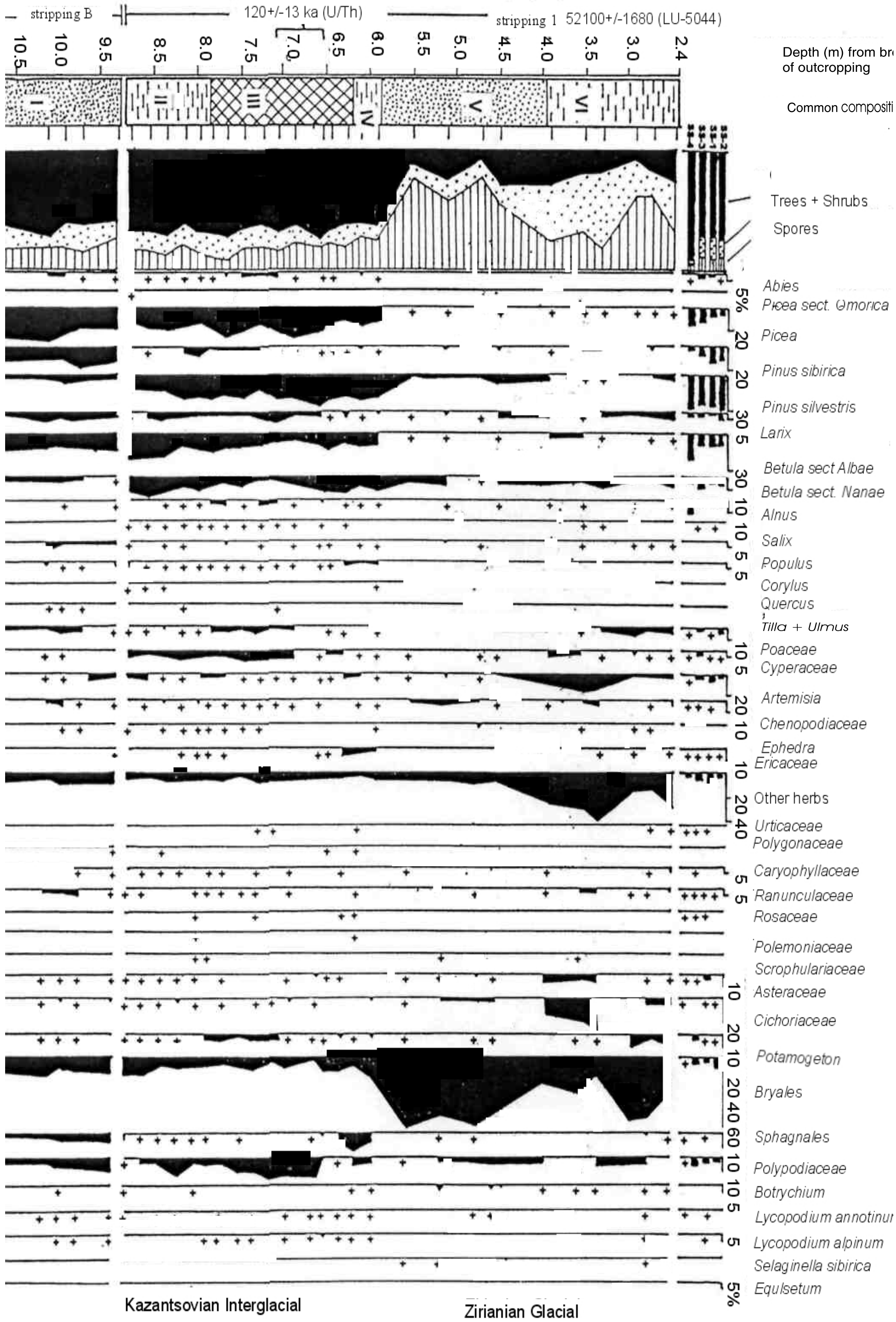

Fig. 2. Stratigraphical column and spore-and-pollen diagram of Bedoba section alluvium series.
Disposition of strippings and description of Bedoba section see in F. Yu.Velichkevich et al. (2004).
For stratigraphical column: I – sands of upper part of stream facies; II and IV – clays of oxbow-like facies; III – peat bog of oxbow-like facies; V – sands of constrative alluvium; VI – clays of secondary ponds facies. For spore-and-pollen diagram: ss – surface species, quantity less than 2% is marked by a cross

2 pav. Bedoba pjûvio stratigrafinis stulpelis ir aliuvio nuogulø sporø-þiedadulkiø diagrama (pjûvis apraðytas ir profiliø vietos yra nurodytos F. Yu. Velichkevich ir kt. (2004) publikacijoje). Stratigrafinës kolonëlës þenklai: I – vaginës facijos virðutinës dalies smëliai, II ir IV – senvaginiai moliai, III – senvaginës durpës, V – konstratinio aliuvio smëliai, VI – antrinio baseino moliai. Sporø ir þiedadulkiø diagramos þenklai: ss – pavirðiniai mëginiai; kryþeliu paþymëti kiekai, nevirðijantys 2%

ss-4 from the palynospectra of silts. The composition of palynospectra of surface samples was established using a comparative material for fossil (Pleistocene) palynospectra interpretation.

In a general comparison of spectra from sands and gravel of the stream facies (layer I in Fig. 2) pollen of trees and shrubs predominates (60–71.5%) (Fig. 2). Spores make up 14.6–19%. Pollen herbs and undershrubs reach 10.5–25.4%. In comparison with the present data, pollen content is less at the expense of spores. In the group of trees and shrubs *Picea* makes up 14.2–26%, *Pinus sibirica* 10.7–19% (more than in the current spectra), *Abies* 0.8–2.8%, *Larix* 1.9–5.5%, *Betula* tree-like 7.1–11%, *Betula* shrub-like 3.3–5.5%, *Alnus* 0.3–0.7%. The quantity of *Pinus* pollen (1.9–7.1%) was considerably less than in the current spectra. Exotic pollen from *Pinus s/g. Haploxylon* and broad-leaved species 1.6–3.9% (*Corylus, Tilia*) were noted. Spores of *Bryales* 5.7–12.5%, *Sphagnum* 2.4–4.6%, *Athyrioidea* 2.4–5.5%, *Lycopodium* 0.8–1.8% are more than recent spectra. *Botrichium* (0.3%) appears. In the pollen group of herbs and undershrubs, the content of *Artemisia* (1.6–9.4%), *Poaceae* (1.2–4.2%), *Cyperaceae* (1.6–2.6%), forbs (4–9%) are close to the current spectra; the content of *Chenopodiaceae* (1.2–6%) is higher; *Ephedra* (0.3–0.4%) was noted. Forbs are presented by meadow (*Ranunculaceae, Labiatae, Apiaceae, Rumex, Plantaginaceae, Allium, Chenopodiaceae*) and aquatic (*Potamogeton*) plants.

Palynospectra show the spreading of spruce forest with *Pinus sibirica* and *Abies* on slopes with underwood from shrub birch, with ferns and *Lycopodium*. In valleys can grow larch and birch forests mixed with broad-leaved species (*Tilia, Corylus*), with *Poaceae* and forbs. Lows were occupied by *Bryales* and *Sphagnum* swamps with sedge. Open localites, stone and nonfixed grounds could be occupied by steppe meadows with *Artemisia, Chenopodiaceae* and *Ephedra*. Such vegetation reflects the conditions less continental and more humid than at present.

In the oxbow lake clay underlying peat (layer II in Fig. 2) palynospectra changed. The part of tree-like (6.2–19%) and shrub birch (6.6–19%), *Pinus* (11.7–19.4%) rises. *Salix* pollen (0.2–1.8%) appeared. Pollen of broad-leaved species is represented by *Corylus, Quercus, Ulmus*. The quantity of *Picea* (9–17%), *Pinus sibirica* 0.4–7.5%, *Larix* (0.7–5%), *Abies* (0.9–1.6%), *Alnus* (0.4–0.9%) pollen is less. Among herbs and undershrubs, the part of *Cyperaceae* (3.2–5.4%) rose. *Ericales* (0.3–0.4%) appeared. The part of *Poaceae* (0.4–2.7%), forbs (3.7–6%), *Artemisia* (1.6–6.9%), *Chenopodiaceae* (0.9–2.7%) descends. Forbs are presented by meadow (*Ranunculaceae, Apiaceae, Polypodiaceae, Brassicaceae, Primulaceae*), steppe (*Asteraceae, Caryophyllaceae*), aquatic (*Potamogeton*) plants. In the spores group, *Anthyrioidea* (1.7–12.4%) and *Bryales* (5.9–14.2%) are numerous. Spores of *Sphagnum* (0.6–3%), *Botrychium* (0.4–0.5%), *Lycopodium* (2–0.4%), *Equisetum* are few.

Palynospectra reflect a wide spreading of larch--birch forests with *Pinus, Picea* (including *P. sect. Omorica*), *Abies* with underwood from shrub birch with ferns, *Lycopodium* and forbs taking part. Side by side with *Bryales* bogs, sedge bogs appeared, with *Ericales, Equisetum, Potamogeton*, etc. taking part. Open locations were occupied by xerophytes (*Artemisia, Chenopodiaceae, Ephedra*) and steppe herbs. Increased humidity and some cooling are noted.

In the lower half of the peat bog the quantity of tree and shrub pollen (60–71.7%), herbs and undershrubs (16.8–22%), spores (6.3–20%) increases. The quantity of *Picea* (12.5–17.4%), *Pinus* (18.5–20%), *Alnus* (1.7–4%) and *Abies* (1.9–3.9%) pollen rises. It is approximately similar for tree-like *Betula* (8–12.5%) and shrub birch (5–7.2%). Pollen of *Pinus sibirica* (1.9–4%), *Larix* (2–2.8%), *Salix* (0.2–1.9%), *Populus* (0.4–2%), broad-leaved species (0.7–1.9%) (mainly *Corylus*, single *Quercus*) are few. Among pollen of herbs and undershrubs, *Ericales* (0.6–1.7%) and forbs (3.5–7.8%) are presented. The part of xerophytes (*Artemisia* 1.3–4.7%, *Chenopodiaceae* 0.2–0.7%, *Ephedra* 0.2–0.4%) descends. Forbs are presented by forest-meadow (*Asteraceae, Ranunculaceae, Cichoriaceae, Apiaceae, Fabaceae, Primulaceae, Scrophulaceae, Urticaceae, Labiatae, Thalictrum, Caryophyllaceae, Chenopodiaceae*), bog (*Rubus chamaemorus, Polemonium*) and aquatic (*Myriophyllum, Potamogeton, Typha*) plants. The part of *Bryales* (3.7–10.3%), *Athyrioidea* (2–10%) and *Sphagnum* (0.2–09%) spores diminishes. *Lycopodium alpinum* and *L. pungens* (total 0.2–0.7%) appear.

The area of dark coniferous forests with *Picea* (including *P. sect. Omorica*), *Abies, Pinus sibirica* with underwood of shrub birch and ferns and *Lycopodium* rose cover increased. Near foot slopes, birch-pine forests with admixture of *Larix* and broad-leaved species (*Corylus, Quercus*) and with a cover of *Poaceae* and forbs spread. Sedge fen areas with *Ericales, Polymoniaceae, Rubus chamaemorus* and aquatic plants (*Potamogeton, Typha, Myriophyllum*) widened. Along rivers, brakes of *Alnus* and *Salix* spread. A considerable humidification and some warming took place, which probably correspond to the optimum interglacial. This conclusion is confirmed also by macroflora remains (Velichkevich et al., 2004).

In the upper half of the peat bog, where the U/Th date 120 ± 13 Ka was obtained, again pollen of trees and shrubs (60–70%) predominates, although the extent of forests can be less than now. Spores comprise 16–22%, pollen herbs and undershrubs 10–20%. Pollen of *Pinus* (18–26.8%) and *Picea* (10.5–24.5%) is abundant (more than in present-day spectra); pollen of birch (3.6–12%) and shrub birch (4.2–15.5%) is less numerous than now. Pollen of *Larix* (0.9–4%), *Abies* (1–3.5%), *Pinus sibirica* (0.9–1.5%), *Alnus* (1.2–3.3%), *Salix* (0.3–1%), broad-leaved species (0.4–3%) (*Corylus, Tilia*) is scarce. Pollen of *Juniperus* appeared. Among spores, the part of *Athyrioidea* rose up to 11.4–16%.

Bryales spores make 2–12%. Spores of *Sphagnum* (0.5–8.3%), *Lycopodium annotinum* (0.3–1.5%), *L. pungens* and *L. alpinum* (total 0.5–3.5%) are sparce. Among pollen of herbs and undershrubs, *Cyperaceae* (3.1–9%) and forbs (4–6.4%) predominate. The content of *Poaceae* pollen (0.3–1%), *Artemisia* (0.8–5.9%), *Chenopodiaceae* (0.5–0.7%), *Ericales* (0.4–6.8%) is less. Forbs are presented by forest-meadow (*Ranunculaceae, Urticaceae, Rosaceae, Caryophyllaceae, Apiaceae, Primulaceae, Asteraceae*) and aquatic (*Potamogeton, Myriophyllum, Typha*) plants.

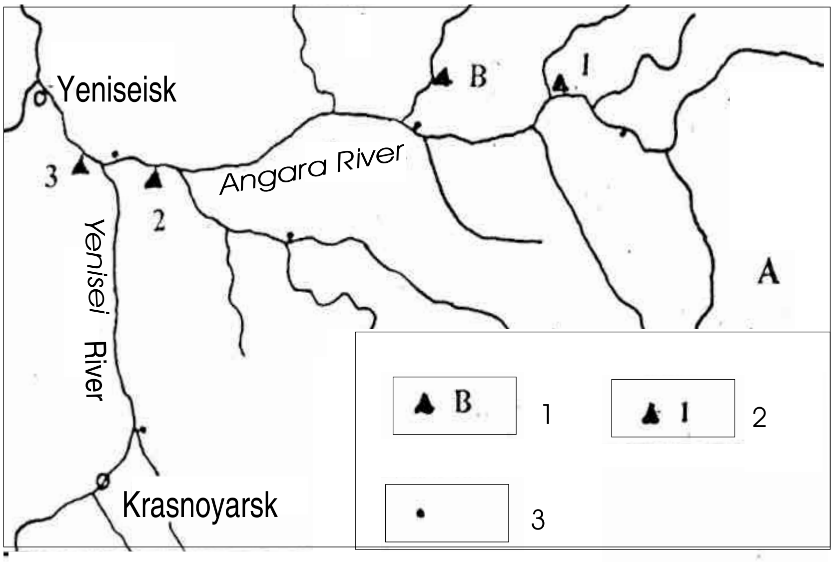

Fig. 3. Distribution of Kazantsovian horizon sections in Northern Priangarie, which have spore-and-pollen diagrams: *1* – Bedoba section; *2* – sections for which layers of Kazantsovian Interglacial optimum were studied (1. mouth of Chadobets River, 2. hole 35 near New-Angarsk settlement, 3. hole 156 near Abalakovo village); *3* – sections in which layers of Kazantsovian Interglacial pre- or past optimum were studied

3 pav. Kazancevo horizonto pjûviø, kurie apibûdinti sporø-þiedadulkiø duomenimis, paplitimas Ðiaurës Paangarëje: *1* – Bedoba pjûvis, *2* – pjûviai, kuriuose iðtyrinëti Kazancevo tarpledynmeèio klimato optimumo sluoksniai (1 – Èadobeco upës þiotys, 2 – græþ. Nr. 35 prie Novo Angarsko gyvenvietës, 3 – græþ. Nr. 156 prie Abalakovo km.), *3* – pjûviai, kuriuose Kazancevo tarpledynmeèio sluoksniai iðtyrinëti iki arba po klimato optimumo

At the time of the formation of the second (upper) half of the peat bog, spruce forests with *Abies, Larix, Pinus sibirica* and the underwood of shrub birch and *Juniperus*, pine forests with admixture of broad-leaved species (*Corylus, Tilia*) occupied less areas. Along rivers, brakes of *Alnus* and *Salix* spread. The increasing (as compared to recent vegetation) areas of dark coniferous spruce forests indicates a more humid and less continental climate.

In the spectra of clays overlapping the peat bog (layer IV in Fig. 2), the part of spores increases to 26.5–29.5% at the expense of *Sphagnum* (5.4–19.7%) abundance. Pollen of trees and shrubs comprises 59.5–61.5%, herbs and under shrubs 11–12%. Spores of *Bryales* (6.1–16%) and *Athyrioidea* (3.8–6.2%) are abundant. Spores of *Lycopodium annotinum* (0.5–1%), *L. pungens* and *L. alpinum* (total 0.3–1.8%), *Botrychium* are few. Among pollen of trees and shrubs, *Pinus* makes up 19–21.3%, *Picea* 12–14.3% (more than in the current spectra). *Picea sect. Omorica* is present. Pollen of tree-like *Betula* (7.3–9.5%) is less than of shrub birch (5.5–13.5%). Pollen of *Abies* (1,1–2.6%), *Pinus sibirica* (1.3–2.6%), *Larix* (0.7–2.2%), *Alnus* (0.2–0.5%), *Populus* (0.2–1.1%) are few. Pollen of broad-leaved species (*Corylus, Quercus*) is sill abundant. Among pollen herbs and undershrubs, *Ericales* make up 3.2–5.5%, forbs 2–5%, *Artemisia* 0.5–3.3%. Pollen of *Poaceae* (0.3%), *Chenopodiaceae* (0.2–0.3%), *Ephedra* (0.8%), *Cyperaceae* (0.2–0.3%) is scanty. Forbs are presented by meadow-forest (*Liliaceae, Cichoriaceae, Polypodiaceae, Rumex, Urticaceae, Thalictrum*), bog (*Rubus chamaemorus, Polemoniaceae*), aquatic (*Typha, Potamogeton*) plants.

Birch-pine forests with *Picea, Larix, Abies* with the underwood of shrub birch and fern cover, *Lycopodium*, forbs spread. Lows were occupied by *Sphagnum* bogs with *Ericales, Rubus chamaemorus, Polemoniaceae*, aquatic plants. Open locations were occupied by xerophytes and *Plumbogenaceae*. The oxbow lake clays were formed in conditions of higher humidity and some cooling of the second half of the Kazantsovian Interglacial.

The constant presence of broad-leaved species pollen (sometimes in large quantities – 1.5–3.9 up to 4.9%) in palynospectra of the Kazantsovian Interglacial attracts attention, whereas macroremains of these species in this section are absent. At present, broad-leaved species grow far from the Bedoba: in Western Siberia (2000–2300 km south-west) and in Daurya (1600–1800 km south-east). Until now, admixture of broad-leaved species in forests of the Kazantsovian time has been reconstructed in Middle Siberia in the Angara River valley (latitudinal stream) and in the Yenisei River valley near the Angara River mouth (Гричук, 1959; Лаухин, 1966, 1982; Садикова, 1967; Архипов, Волкова, 1994; Волкова и др., 2003, etc). However, it is well known that in valleys of the big rivers of Middle Siberia (especially of those flowing from south to north) the temperature of water is higher and the vegetative season is longer than on flat interfluvial and small river basins. For instance, in the present valley of the Yenisei River near Yeniseisk town (Fig. 3) the water temperature is higher than the of air temperature in August by 2.7 °C, in September by 3.2 °C, in October by 4.6 °C. It is natural that the warming influence of water cannot spread far off. In general, it is limited by valley boundaries. That's why the vegetative season in big valleys of Middle Siberia is 10–15 days longer than beyond (Галахов, 1964). In layers of the Kazantsovian time optimum, in the latitudinal stream of the Angara River (Fig. 3) the sum total of broad-leaved species pollen reaches sometimes 10%. Usually *Quercus* pollen predominates (up to 4–8%), *Ulmus, Tilia* and *Corylus* pollen are less (Лаухин, 1982 etc). It is interesting that in the layers in which the quantity of broad-leaved species pollen is highest, together with this pollen shrub-birch pollen were noted (hole 156 near Abalakovo village, hole 35 near New--Angarsk settlement, etc). In the Kazantsovian layers beyond its optimum limits (Fig. 3), the variety of broad-leaved species is minimal (usually it is *Ulmus* or *Corylus*) and their pollen quantity rarely exceeds 1%.

The Bedoba section lies in the valley of a small river, near the boundary with the middle-taiga subzone, almost 50 km north from the Angara River and is separated from it by the Irkineeva Ridge, which fully excludes (and excluded) the warming influence of the Angara River on the local climate. Probably predomination of *Corylus* (usually 1.2–3 to 3.7%) in Bedoba in the composition of broad-leaved species during the optimum of the Kazantsovian Interglacial can be explained by this fact, whereas in the Angara and Yenisei river valleys during this time among broad-leaved species *Quercus* predominated. It is interesting to note that the bulk of *Quercus* pollen in the Bedoba section is found in the lower half of the peat bog (layer III in Fig. 2). These data give evidence of the wide spreading area of broad-leaved species in Middle Siberia forests during the optimum of the Kazantsovian Interglacial, but not of their spreading only in the valley of rivers flowing from South to North of Siberia.

In the constrative alluvium sands (layer V in Fig. 2), the composition of palynospectra sharply changes. Here pollen of trees and shrubs comprises only 10.4–28.5%. Spores (56.5–77.3%) predominate. Pollen herbs and undershrubs make up 12.3–16.4%. *Bryales* spores (48–73.3%) predominate. Spores of *Athyrioidea* (0.9–4.8%), *Lycopodium* (0.5%) are few. *Selaginella sibirica* (1,7%) appears. Among herb and undershrub pollen, forbs (5.2–7.4%), *Poaceae* (2.6–5.8%), *Artemisia* (0.9–3.5%), *Chenopodiaceae* (1–4.4%), *Ephedra* (2,5%), *Cyperaceae* (0.5–1.2%) is present. Forbs are presented by forest-meadow (*Labiatae, Caryophyllaceae, Asteraceae, Cichoriaceae, Scrophulariaceae, Thalictrum*), aquatic (*Potamogeton*) plants. In the pollen of trees and shrubs, *Betula* is scarce (0.9–1.6%), followed by shrub birch (1.2–6.1%), *Pinus* (2.5–8.5%), *Pinus sibirica* (2.6–3.2%), *Picea* (1.7–4.2%), *Larix* (1.2–5.2%), *Alnus* (0.5–0.9%).

In that period, open spaces with forbs-*Poaceae* meadows and Bryales bogs predominated. Along river valleys could be preserved areas of open larch woodlands with *Betula, Picea* and underwood of birch shrub. On sandy scarps and eroded slopes *Selaginella sibirica* appeared. Presence of plants with different ecology is typical of the periglacial zone.

In the description of the section (see above), washout was noted in the beginning of constrative alluvium sedimentation (or before it), which resulted in a considerable destruction of floodplain facies. With these facies, traces of transition from the Kazantsovian Interglacial to the Zirianian Glaciation were destroyed also.

The next change of palynospectra composition took place in the lower part of the secondary pond clays (layer VI in Fig. 2). The quantity of tree and shrub pollen remained the same (18.5–28%), but the part of herbs and undershrubs (up to 47–62%) increased at the expense of spores (19.3–30.9%). Pollen of *Cichoriaceae* (13–25.5%) predominates. Pollen of *Artemisia* (9.3–15%) is abundant. Pollen of *Poaceae* (0.5–4.1%), *Cypraceae* (1.2–8.8%), *Chenopodiaceae* (1.2–5.3%), *Ephedra* (0.5%) is scarce. Forbs are presented by meadow (*Ranunculaceae, Plantagenaceae, Liliaceae, Apiaceae, Scrophulariaceae, Chenopodiaceae, Thalictrum*), steppe (*Asteraceae, Plumbaginaceae, Caryophyllaceae*), forest (*Linnaea, Majanthemum, Vaccinium)* and aquatic (*Potamogeton*) plants. Trees and shrubs are presented by shrub birch (3.9–7.7%), *Larix* (1.1–6.6%), *Picea* (0.6–1.8%), *Pinus sibirica* (1.8–5%), *Alnus* (0.5–1.2%), *Salix* (0.6–1.1%), *Populus* (1.1%). In the group of spores, *Bryales* (12.5–29.9%) are abundant and *Anthyrioidea* (2.9–6.5%) are less.

The areas with disturbed or immature soil cover extpaded. On these areas *Cichoriaceae* and *Artemisia* spread. Open landscapes with xerophytes (*Artemisia, Chenopodiaceae, Ephedra*) and steppe plants increased. Along the river valleys, open *Larix* woodlands with *Betula* (tree-like and shrub-like), ferns and forest--meadow forbs were preserved. Along the rivers, *Alnus, Salix, Populus* grew. The climate became sharply continental and dry.

If forest spectra of the oxbow lake clays were abruptly replaced by spectra of open areas in the constrative alluvium, the increased continentality and dryness of climate left more gradual traces in the changes of palynospectra in the upper sands of the layer VI (Fig. 2).

In the upper half of the secondary pond clays the quantity spores grew (32–63.5%). Pollen of herbs and undershurbs makes up 21–42.8% and of trees and shrubs only 8–25.2%. *Bryales* spores predominate (29.8–54.5%). There are less spores of *Athyrioidea* (3.2–4.8%), *Sphagnum* (1.7–2.2%), *Lycopodium annotinum, L. alpinum* (total 0.4%), *Selaginella sibirica* (1.3%) and *Equisetum* (5.7%). Among herbs and undershrubs, pollen of forbs is numerous (12–26%); *Poaceae* (3.5–8%), *Cyperaceae* (0.5–2.4%), *Artemisia* (2.2–2.9%), *Chenopodiaceae* (0.9–

6.8%), *Ephedra* (0.8–1.3%), *Ericales* (0.5–0.8%) are less abundant. Forbs are presented by meadow (*Ranunculaceae, Saxifragaceae, Urticaceae, Rumex, Plantaginaceae, Liliaceae*), steppe (*Plumbaginaceae, Caryophyllaceae, Asteraceae*), aquatic (*Potamogeton*) plants. *Limonium* (from *Plumbaginaceae*) grows on saline and saltierra substrata. In the group of tree and shrub pollen, shrub birch (2.4–8%), *Larix* (2.4–6.3%), *Pinus sibirica* (3.1%), *Picea* (0.5–1.3%), *Alnus* (0.5%) is scarce.

At the end of the formation of the alluvial series, open spaces with *Bryales* bogs spread widely. *Cyperaceae, Equisetum, Ericaceae* and herb-*Poaceae* meadows grew near these bogs. Along the river valleys, open *Larix* woodlands with *Betula* and *Picea* here and there could be preserved. In areas with immature soil cover *Cichoriaceae, Asteraceae* and xerophytes and on saline substrata *Plumbaginaceae* grew. The presence of xerophytes together with tundra species of *Lycopodium* and *Selaginella* and shrub-like *Betula* give evidence of glacial floras. Sedimentation of secondary pond clays was probably finished under conditions of cooling and increasing humidity.

CONCLUSIONS

Thus, palynological data show that the part of the Bedoba section, which was studied by spore-and-pollen analysis, was formed during the second half of the Kazantsovian (Mikulian = Eemian = Merkine) Interglacial, including its optimum. At the end of oxbow like facies accumulation, transition from the Kazantsovian Integlacial to the Zirianian (Valdaian = Vistulian = Nemunas) glacial time begins. Constrative alluvium was deposited following the interruption of sedimentation in periglacial conditions of the Zirianian glacial time. In the Bedoba section, for the first time, vegetation of the Kazantsovian Interglacial time was characterized beyond the valleys of big rivers flowing from the south. The vegetation of the Kazantsovian time in the Yenisei River and Angara River valleys, which flow from the south, essentially differs from the vegetation of the same period beyond these valleys. In the palynospectra of Kazantsovian forests in the Yenisei River and Angara River valleys prevail (up to 10%) broad-leaved species, among them *Quercus* often predominates. Beyond these valleys broad-leaved species pollen makes less than 5% and *Corylus* and *Tilia* predominate.

A comparison of palynological data with data on malacofauna and macroflora (Velichkevich et al., 2004; Arslanov et al., 2004) showed that different groups of palaeontological remains fix the optimum on different stratigraphical levels: mollusks do it in the upper part of layer II (Fig. 2), macroflora within the limits of the whole buried peat bog except the upper 40 cm, and spores with pollen only in the upper layer of the peat bog (layer III). A kind of shift in time occurs: the optimum of the interglacial is reflected first in mollusks composition when the common composition of the vegetation (palynological data) is influenced by humidity and cooling then the optimum shows itself in the macroflora composition and only afterward in the palynospectra composition, when macroflora fixes some (short and rather shallow) cooling.

The non-coincidence in time of the optimum displayed in the macroflora and palynospectra can be explained by formation peculiarities of palynospectra and macroflora complexes. Macroflora reflects vegetation changes within the limits of a local swamp. On the one hand, it is more conservative, and small differences in the vegetation of all region, reflected in the differences of palynospectra, in macroflora composition can be absent. On the other hand, the cooling at the end of peat forming, which is clearly reflected in swamp macroflora, could be not yet displayed in the vegetation of the whole region, of the surrounding vegetation subzone, because not only the zonal type of vegetation but also the local vegetation of the swamp influence palynospectra composition (even of a peat bog).

More complicated is the problem of the optimum, which is based on the malacofauna data. It is not displayed in palynospectra. Macroflora in layer II (Fig. 2) is absent. Maybe this optimum was overlooked in palynospectra because of rarely analyzed plynological samples, and only a condensation of samples can reveal it. In this case it will be reasonable to speak about the second optimum of the Kazantsovian time. And, last but not least, in the stream alluvium (layer I) palynospectra reflect a more thermophilic vegetation than in layer II. Besides, in layer I there are many *Unionidae*, implying one more, the third, optimum of the Kazantsovian time, displayed in the Bedoba section. The sharply different facial composition of sediments (shingles of layer I, oxbow lake peat of layer III) and palynospectra cast shades on such supposition. Its verification requires condensation of samples from the lower part of the peat bog and a more detailed palynological study of the stream shingles. However, even at present it is possible to speak about the complex structure of climate during the Kazantsovian Interglacial optimum in Middle Siberia to the North from the latitudinal flow of the Angara River.

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BEDOBA PJÛVIO PALINOLOGINËS ANALIZËS REZULTATAI (VIDURIO SIBIRO VËLYVASIS PLEISTOCENAS)

S a n t r a u k a
Bedoba pjûvio (Angaros ðiaurëje) konstratinio aliuvio nuogulos iðtyrinëtos palinologiðkai. Paaiðkëjo, kad urano--torio metodu datuotos senvaginiø durpiø nuogulos priklauso Kazancevo (Mikulino = Emio = Merkinës) tarpledynmeèiui (120 ± 13 tûkst. metø). Antrinio baseino nuogulos konstratinio aliuvio virðutinëje dalyje, datuotos radiokarboniniu metodu (^{14}C:52100 ± 1680 metø (LU-5044)), priskiriamos ankstyvojo Zyrianio laikotarpiui (ankstyvasis Valdajus = Vislis = Nemunas). Nuogulose tyrinëti palinospektrai, pradedant nuo vaginio aliuvio iki senvaginio aliuvio durpiø virðaus, atspindi pietinës taigos miðkø su lazdynø, liepos ir àþuolo priemaiða raidà, artimà Kazancevo tarpledynmeèio optimumui. Palinologiniai spektrai senvaginiame molyje, kuris dengia durpes, rodo tarpledynmeèio klimato atðalimà ir drëgnesnes aplinkos sàlygas baigiantis tarpledynmeèiui. Po uþsitæsusios nuosëdø kaupimosi pertraukos Zyrianio laikotarpio pirmojoje pusëje konstratinio aliuvio smëliuose iðryðkëjo periglacialinës augalijos palinospektrai. Jie leidþia atkurti pievø ir pelkiø þaliaspalviø samanø vaizdà, ðalia kuriø slëniuose augo kenio retamiðkiai. Antrinio baseino apatinës dalies moliø palinospektrai patvirtina iðsiplëtusius atvirus kraðtovaizdþio plotus su kserofitine flora. Kaupiantis virðutinës dalies moliams padidëjo þaliøjø samanø pelkiø plotai, degraduojant ankstyvojo Zyrianio ledynams ðaltas klimatas tapo drëgnesnis.

Станислав Лаухин, Галина Шилова

РЕЗУЛЬТАТЫ ПАЛИНОЛОГИЧЕСКОГО АНАЛИЗА РАЗРЕЗА БЕДОБА (ПОЗДНИЙ ПЛЕЙСТОЦЕН СРЕДНЕЙ СИБИРИ)

Р е з ю м е
Палинологически изучен констративный аллювий разреза Бедоба (северное Приангарье). Для старичного торфяника этого разреза имеется уран-ториевая дата 120±13 тыс. лет (казанцевское время), а для фации вторичного водоема вверху констративного аллювия – ^{14}C дата 52100 ± 1680 лет (ЛУ-5044) – конец ранне-зырянского времени. Палиноспектры от верхов руслового аллювия до верхов старичного торфяника отражают эволюцию южнотаежных лесов с примесью лещины, липы и дуба, близких оптимуму казанцевского межледниковья. В старичных глинах, перекрывающих торфяник, палиноспектры отражают некоторое похолодание и увлажнение в конце этого межледниковья. После длительного перерыва осадконакопления в первой половине зырянского времени в песках констративного аллювия изучены палиноспектры перигляциальной растительности: луга и зеленомошные болота с лиственничным редколесьем по долинам. В нижней части глин вторичного водоема палиноспектры отражают расширение открытых ландшафтов с ксерофитами. В верхней части этих глин увеличились площади зеленомошных болот, увеличилась влажность в условиях холодного климата деградации зырянского оледенения.