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Late Glacial and Holocene History of Lakes, Climate and Vegetation in the Middle Urals, Russia

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ABSTRACT. Pollen evidences derived from the study of lacustrine and bog deposits in the Middle Urals, were used to reveal the main stages in the development of lakes and vegetation during the Late Glacial and Post Glacial time, from the Older Dryas. History of plant assemblages was traced as related to the fluctuations of water level in lakes and climatic changes during the Holocene period. A particular kink period was proposed to exist in the Post Glacial history of lakes and vegetation development at the boundary of the Atlantic and the Sub-Boreal periods. It was an interval when the climate turned to change towards cold and aridity thus providing gradual elimination of nemoral elments in the forests, shrinkage and paludification of numerous water basins, many of which transformed to become peat-bogs.

KEY WORDS: pollen analyses, sapropel, peatbogs, vegetation, climate.

Introduction

The work presented was performed in relation to archaeological investigations held in the surroundins of the city of Ekaterinburg in the Middle Urals, Russia.The location of the bank sites and Neolithic settlements found in the upstreams of the Iset' River indicate that numerous lakes existed there at that time, many of which later turned to become peat bogs, while the others changed their sizes significantly. Our work seeked to study history of lakes and peat bogs of the territories where archaeological sites had been found and to describe paleoenvironments of the ancient people, especially features of paleovegetation and paleoclimates.

The region of our studies is situated in the central lowland part of the Middle Urals, the eastern macroslope, 250–300 m over the sea level. Modern vegetation dominates the south-taiga forests of birch and pine, sometimes added with spruce. The climate is now continental, with mean annual temperature ranging about +1 °C. The mean annual rainfall is about 500–550 mm Four peatbogs originating from the lakes were studied.

1. The peatbog adjacent to the lake of Peschanoe, appoximately 20 km west from the centre of Ekaterinburg city (56°54'N, 60°19'E).
2. The peat-bog named Romanovskoe is situated at the right bank of the Iset' River (56°54' N, 60°22'E), being adjacent to a Neolithic-aged settlement, excavated by V.F. Kerner.
3. The peat-bog near the island named Kamennie Palatki is situated at the left bank of the Iset' River (56°54'N, 60°25'E). The multi-layer sites (Mesolithic, Neolithic, Bronze and Iron Age) situated at the island are excavated by V.D.Viktorova, S.N.Panina at all.
4. The peat-bog around the lake named Karas'e is situated at the eastern borderline of the city of Ekaterinburg (56°46'N, 60°45'E). The archaeological site at the island of Razboinichiy was excavated by N.M. Chairkina.

Methods and material studied

The deposits of lakes and bogs were studied mainly by pollen analysis. The samples were collected by the author by means of Instorf's hand borer. At the Karas'eozersky peat-bog, samples were taken from the pit wall directly. The frequencies of each individual pollen group were calculated as a percentage of a total sum of trees and bushes pollen grains. Radiocarbon dates were obtained for the site of the Karas'eozersky peat-bog by N.G.Erokhin (Institute of Plant & Animal Ecology RAS = IPAE, Ekaterinburg) based on the burried-wood samples. Other sections were dated by the author by correlation of the pollen diagrams to the C-14 dated pollen records from the Ayatsky peatbog in the Middle Urals (Khotinsky, 1977).

Results and analyses

The deepest deposits were revealed in the peat-bog of the Peschanoe-lake. They consisted of 4 m sapropel and 3 m turf. Stratigraphy of the section evidences that the peat-bog was formed by paludification of a lake bay. Eight pollen assemblage zones are proposed (Fig. 1). This section is concerned as the basic one.

Pollen spectra of the bottom loams (pollen zone 8) indicate to the dominance of herbs and shrubs, that is the special "tundra-steppe" communities being characteristic for the vast periglacial zone dated to the Late Pleistocene time. The tree vegetation there was represented mainly by spruce and larch open forests, sometimes with rare pines and birches. Three peaks of grasses and shrubs probably correspond to three cold periods, the Younger, Middle and Older Dryas, being divided with two warmer intervals, when the role of trees in vegetation increased significantly, mainly due to pine proportions. The warmer epochs probably correspond to the Belling and Allerod stages distinguished in Europe (Kind, 1974).

The formation of the sapropel deposits was started after the sharp though short warm period indicated by the changes in the pollen spectra (zone 7). Then the role of trees, especially pine and partially spruce, increased significantly, while the proportions of grasses and shrubs were seen to reduce.

The following upper layers of the sequence (zone 6) demonstrated new spread of the herbaceous vegetation, though not so wide as during the Younger Dryas time. Among those, the proportion of sagebrushes decreased gradually, while those of gramen rose. The role of forests was seen to decline but it remained dominating. Within the trees group, the share of pine fell, while those of spruce and larch came to rise. On the whole, vegetation of this period can be described as open spruce-and-larch, and pine-and-birch forest of the "park" type; sometimes with siberian pine. Climatic conditions seemed to be more cool and wet than during the previous phase.

Pollen zones 6 and 7 refer to the Pre-Boreal period. They reflect phases of the so-called "Polovetsky" warming and the following "Pereslavsky" colder time within the Pre-Boreal which were previously described for European regions of Russia and the Middle Urals. Warming of the Pre-Boreal beginning provided dewatering of many water pools being not deep enough, and formation of turf layer under the sapropel strata in them (Sukachev and Poplavskaya, 1946; Khotinsky, 1977).

On the diagram of the Ayatsky swamp, the maximum larch peak was recorded in the deposits with the absolute C-14 date of 9780 ± 210 BP (Mo-398). The horizon where the larch curve fell sharply gave the date of 9110 ± 210 BP (Mo-397) thus corresponding to the boundary between the Pre-Boreal and Boreal periods. Both of these levels are clearly observed on the diagram from the deposits of the Peschanoe Lake marking the line between the pollen zones 6 and 5.

Zone 5 describes vegetation of the Boreal time, when the closed forests were forming already. Pines were the dominating trees, with addition of birch, spruce, larch, and siberian pine. Sometimes abies trees were marked, too, added with *Ulmus*, rare oaks and lime-trees. Such vegetation character evidenced about warmer climatic conditions than those of the Pre-Boreal time were.

Zones 4 and 3 refer to the Atlantic period. The lower border of it corresponds to the pollen assemblage of the sediments from the Peschanoe Lake, 490 cm deep, with sharply increased share of the frutescent birches. This shows to the colder time at the boundary between the Boreal and Atlantic times observed at the vast territories of the northern hemisphere (e. g. Kind, 1974).

Judging by the pollen assemblages of the zone 4, the first half of the Atlantic revealed increase of warmth. Birch-and-pine forests were the dominant type, with admixture of spruce, larch, and siberian pine. Proportions of the broad-leaved trees increased gradually. No abies pollen is marked. The highest pine proportions indicate to the climate dryer than it was before.

The second half of the Atlantic period (pollen zone 3) is associated with the Holocene climatic optimum when the combination of heat and moisture was the most favourable for the development of the nemoral flora. Pollen assemblages obtained for the Middle Urals show that at that time there grew pine-and-birch forests with admixture of spruce, abies, siberian pine, and the highest proportions of the broad-leaved species were observed. Among those sometimes hornbeam could be met, the species now lacking in the Urals.

Three radiocarbon dates were obtained for the sediments of the Atlantic. The middle of the period corresponding to the continuous *Ulmus* curve rise and oak pollen occurrence showed 6230 ± 150 years BP (Mo-394). The second half terminal with its maximum percentages of the broad-leaved species was marked with a couple of the dates: 4720 ± 200 (Mo-390) and 4630 ± 150 (Mo-389).

On the diagram of the Ayatsky peat-bog, the upper line of the Atlantic time was proposed to correspond to the level of the elms curve fall being dated to about 4500 years BP. On the diagram of the Peschanoe lake, this corresponded to the pollen assemblage of the peat layer adjacent to the sapropel stratum 310 cm deep, where the frequence of pine pollen was seen to increase sharply and that of *Ulmus* fell to the minimum value. In the sequence, this was the level where the sapropel layer was substituted for the turf.

Pollen zone 2 reflects the Sub-Boreal period. Unique or very rare finds of abies and siberian pine grains within the zone indicate to more arid (though not quite uniform) climate conditions during this time interval. Pine forests with some portion of birches dominated in vegetation, small admixture of spruce and nemoral species were also marked. Aridity of climate encouraged desiccation and paludification of water basins.

Zone 1 ought to be referred to the Sub-Atlantic period. Pollen assemblages show that humidity increased at that time, while thermal conditions worsened. The proportions of spruce, abies, and siberian pine increased in the forests, whereas those of nemoral species fell and the hornbeam disappeared at all. *Sphagnum* mosses were marked to spread widely, thus also indicating to the humidity rise and further development of paludification processes.

Pollen assemblages of the other analyzed sections were proposed to be younger. Accumulation of organogenic sediments in the sections began during the Atlantic time. The pollen zones distinguished on the diagrams are good enough for the correlations with those of the basic section near the Peschanoe Lake.

The relative dating of sediments in the Karas'eozersky peat-bog (Fig. 2) was done taking account of the available radiocarbon dates and archaeological artifacts. Radiocarbon date of 4960 ± 210 years BP received for the upper sapropel layer corresponds to the end of Atlantic terminal. Archaeological finds dated to the late Eneolithic and early Bronze Ages were collected in the upper sapropel layers and within the lower strata of the turf. Thus one can concern, that paludification of both lakes, Karas'e and Peschanoe (also Romanovskoe, Kamennye Palatki) started about 4500–4000 years ago, i.e. just at the boundary of the Atlantic and the Sub-Boreal periods, or at the very beginning of the latter.

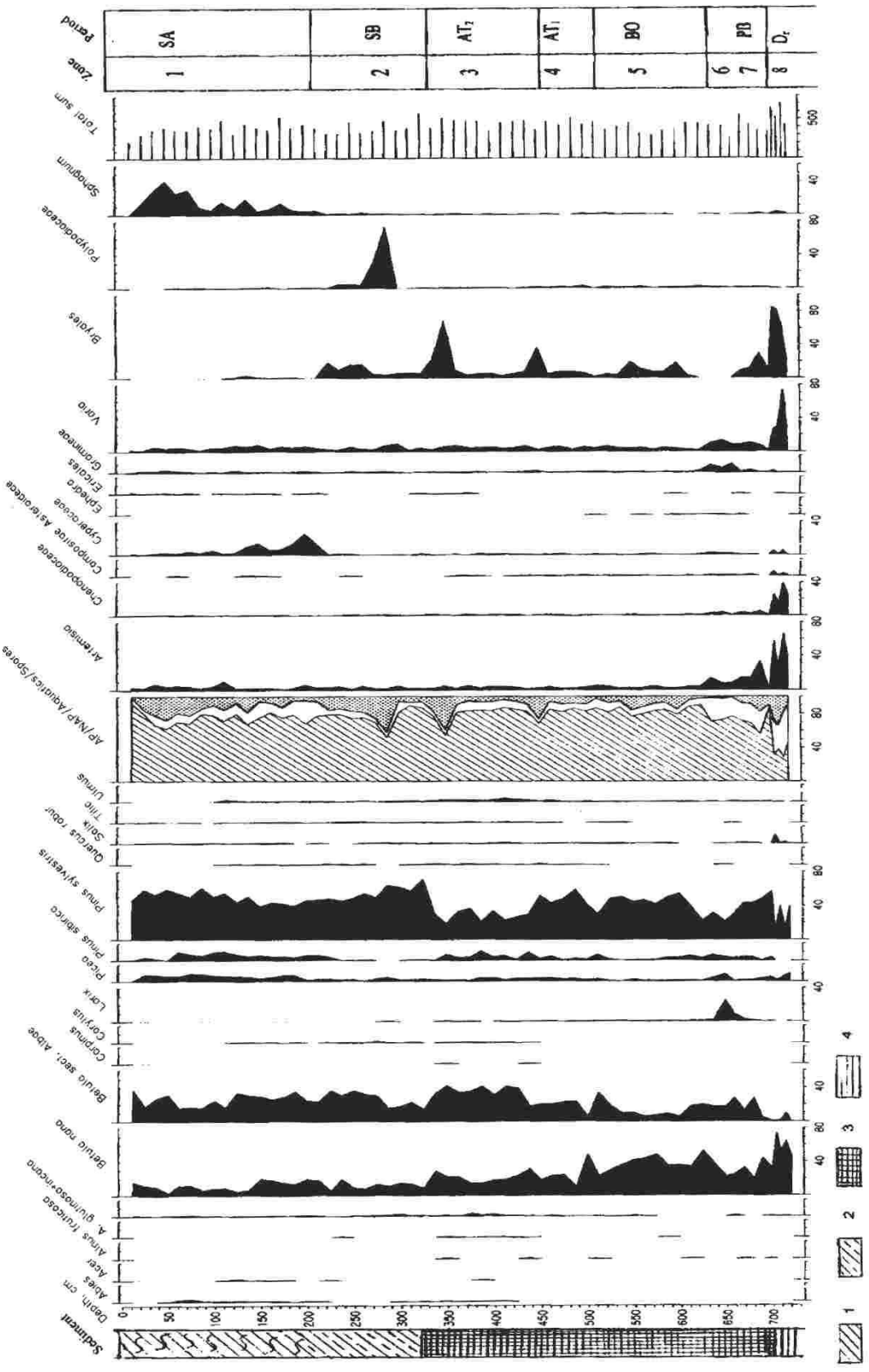

Fig. 1. Pollen diagram of the peatbog at the Peschanoe Lake.
1 - sedge-sphagnum peat, 2 - hypnum sedge peat, 3 - sapropel, 4 - clay.

Discussion and conclusions

Archaeological studies of many peat-bog sites in the Middle Urals had shown that archaeological artifacts and the cultural layers dated to the late Eneolithic time were revealed either at the boundary between the sapropel and turf strata, or within the upper sapropel and lower turf layers (e. g. Raushenbakh, 1956). Thus, one can speak about a widely spread process, lake paludification, which developed practically everywhere in the Middle Urals at the boundary between the Atlantic and the Sub-Boreal periods and was caused by the same reasons.

Shifts in the vegetation contents were revealed based on pollen evidences from the lake and peat-bog deposits. During the late glacial, the grass-and-shrub communities were shown to dominate, together with spruce-and-larch open forests. By the Atlantic terminal, those were removed by the mixed forests of spruce, pines, and birches, with admixture of abies and broad-leaved trees. All these phenomena ought to be associated to the general process of the climate warming during the Holocene first half, though accompanied by several intervals of relative cold causing some reversals in vegetation development.

At the beginning of the Sub-Boreal, the climate turned to become colder again, which lead to gradual degradation of the nemoral elements in plant communities. The Atlantic terminal and the Sub-Atlantic seemed to be the most humid intervals, which is indicated by the higher percentages of spruce, abies, and siberian pine in the pollen spectra of the forests.

The following stages were marked in the lakes development evidenced by the features of sediments accumulation:

1. The Late-Glacial period, when the loam and mineral deposits were accumulated.
2. The Pre-Boreal stage: Sharp warming at the beginning of the period caused dewatering of many pools and formation of peat layers now observed under the sapropel strata.
3. The Boreal and Atlantic time were the intervals of sapropel accumulation at the conditions of high water levels in lakes.
4. The Sub-Boreal and Sub-Atlantic intervals when increase of climate aridity at the beginning of the stage provided dewatering and paludification of water pools. As a result, many of those turned to become peat-bogs.

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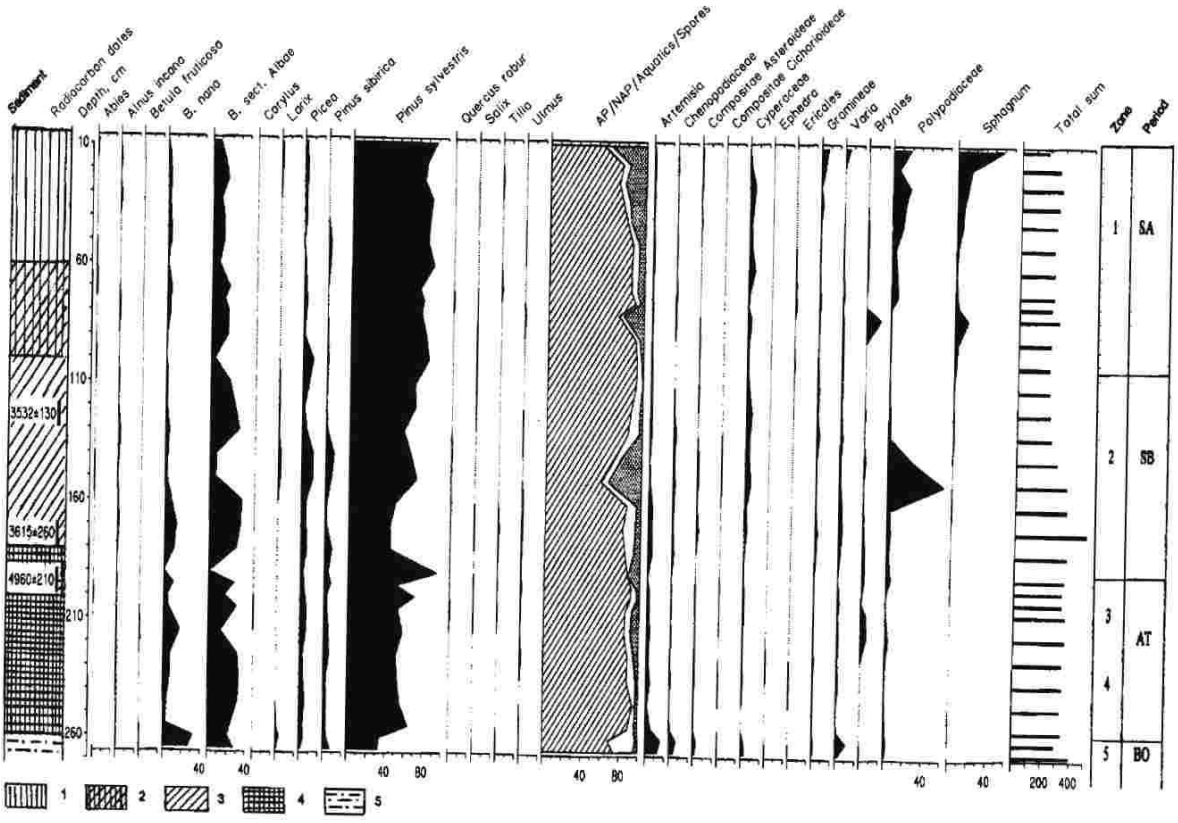

Fig. 2. Pollen diagram of the Karas´ eozerskoe peatbog.
1 - Woody peat, 2 - wood-sedge peat, 3 - sedge peat, 4 - sapropel, 5 - loamy sand.