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PALYNOLOGICAL STUDIES OF HOLOCENE LAKE SEDIMENTS IN THE HEADWATERS OF THE RIVER BEZYMIANKA (WEST CAUCASUS)

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ABSTRACT. Comparative analysis of recent and fossil pollen spectra of bottom sediments in glacial lakes of the Caucasian Reservation has shown vegetation and climate dynamic during last 6000 years.

Throughout the second half of the Atlantic in the place of recent upper alpine meadows, an open crook-stem birch forest was spread.

The warm and humid climate of the Atlantic favoured the existence of high water level in glacial lakes. The Subboreal cooling radically changed the upper alpine landscape. The open crook-stem birch forest shifted downwards by several hundred meters and the lakes after their regression became bogged up.

KEY WORDS: Pollen spectra, lake sediments, West Caucasus

INTRODUCTION

The river Bezymianka flows in the eastern part of the Caucasian Biosphere Reservation. It is a right tribute of the river Minor Laba. The relief here is high mountainous with well pronounced old glacial formations, the river valley being a trough.

The river headwaters are on the offshoots of the Aishkho Range, which at present is a watershed between the northern and southern parts of the West Caucasus. The Aishkho Range is composed of Lower Jurassic sediments (Geologia SSSR 1964). These are mainly argillaceous slates, aleurites, sandstones. Since these rocks are soft and easily yield to erosion, the relief here is smooth (the ridges of the ranges are broader, the summits of the mountains are more rounded).

The climate of the region under study is high-mountainous. Winter is cold and long (6–7 months), summer is short. Average temperature in July hardly reaches 10–12°C (Panov et al. 1980). At night even in summer there can often be frost. The winds are strong and durable. West and south-west air mass transition predominates.

The basin of the Bezymianka river is situated in four vertical belts: high-mountain dark coniferous forests, subalpine and alpine meadows giving way at higher altitudes to the belt of thinning subnival vegetation. The forest-line runs at an altitude 2000–2200 m a.s.l. In these forests *Abies* is a prevailing species.

Subalpine elfin woods mainly consist of *Betula litwinowii, Acer spicatum, Salix caprea.* In the alpine and subalpine zones, vast areas are occupied by *Rhododendron caucasica.* Along with it there grow *Vaccinium vulgare, Vaccinium vitis-idaca* and *Empetrum caucasica.*

In the herbaceous group there are *Nardus stricta, Campanula odorata, Geranium gymnocaulon, Myosotis alpestris*, etc. In the alpine mesophillic meadows there usually grow *Calamagrostis arundinaceae*, which can be as high as 0.5–1 m. There are also *Poa longifolia, Helectrotrichon pubescence, Agrostis planifolia, Bromus arvensis,* etc. (Zapovedniki Kavkaza 1990). This group is rather rich, but in the subnival and nival belts, short grass meadows become thinner with their taxonomic composition less rich. *Carex* and *Taraxacum* are prevalent.

In the alpine belt at altitudes 2400–2600 m a.s.l. a few lakes of glacial origin are situated. Bottom sediments of Korgo and Bathing Chamois' lakes have been studied by the method of spore-pollen analysis.

MATERIAL AND METHODS

The factual material analysed was collected as a result of field work in August, 1992. Altogether 17 samples of recent and holocene lake, bog and soil sediments were selected and studied. The absolute age of the Holocene formations was determined by the radiocarbon method. The material for spore-pollen analysis was first treated be the alkaline method and then by acetolysis. On the average, in each sample one could determine and count up to 500–600 sporomorphs. The pollen and spore percentage was determined separately for arboreous plants and shrubs, herbs and spores. In a similar way spore-pollen spectra diagrams were compiled.

The studied preparations are kept in the Palynotheca of the Palaeobiological Institute of the Georgian Academy of Sciences.

RESULTS OF INVESTIGATIONS

The character of recent pollen spectra formation was studied on muddy samples taken from the bottom of Bathing Chamois' lake and Korgo lake. The former is situated at an altitude of 2485 m a.s.l. Genetically it belongs to a cirque basin. Its maximum depth is 3 m. The area of the lake is 3000 sq.m., its length and width are 75 and 50 m, respectively. In the past the lake was much larger with a higher water level. This is evidenced by geomorphological structure of the plain adjacent to the lake as well as by existence of a lake terrace where by means of a carried down trench, strata of lake clays were discovered which were dammed by a peat-bog. The palynological characteristics of these sediments will be discussed below.

However, as to subfossil pollen spectra, they are distinguished by large amount of transported AP pollen (Fig. 1). In the spectrum of sample 1 taken from the bottom of Bathing Chamois' lake the AP pollen content reaches 48.5%. The major part of it accounts for pollen grains of *Alnus* (up to 37%) and *Pinus* (up to 29%). Also, there is considerable amount of *Abies* (up to 13%) and *Picea* (up to 5–8%) pollen. Among broad-leaved trees, the content of *Tilia* and *Carpinus* is predominant. There is little pollen of *Fagus, Quercus, Castanea, Betula.* Among shrubs, pollen of *Corylus* prevails over that of *Rhododendron* (Fig. 1).

In the NAP group, *Caryophyllaceae* (up to 16.7%) and *Gramineae* (up to 14%) are dominants. *Polygonaceae, Chenopodiaceae, Ranunculaceae* are represented by a considerable amount of pollen. *Carex, Saxifragaceae, Taraxacum, Cirsium* are permanently observed in the spectra, while *Umbelliferae, Leguminosae, Labiatae, Plantago* etc. are found sporadically in the form of single pollen grains.

Among sporiferous plants, monolete spores of ferns are obviously prevalent, all of them being transported. *Botrychium lunaria* and mosses are represented by single spores.

Korgo lake is also situated at the headwaters of a left tribute of the Bezymianka river at an altitude of 2548 m a.s.l. The lake area is 2500 sq.m., the length is 100 m, the width is 25 m. The maximum depth exceeds that of Bathing Chamois' lake, reaching 8 m.

The spore-pollen spectra are characterized by considerable participation of transported AP pollen (up to 44%). NAP accounts for 37.6%, while sporiferous plants – for 18.2%. In the AP group the pollen of *Alnus* and *Pinus* is prevalent: up to 60% and 18%, respectively. The role of *Abies* is much reduced. There is little pollen of *Picea, Tilia, Castanea, Fagus. Betula, Carpinus, Ulmus, Quercus* being found in the form of single grains. Shrubs are mainly represented by *Corylus* (up to 8.2%). Then come *Rhododendron* and *Daphne.* Among the NAP group, *Caryophyllaceae* and *Gramineae* prevail: up to 25.8% and 21.2%, respectively. There is rather a lot of pollen of *Artemisia, Chenopodiaceae, Carex, Ranunculaceae, Boraginaceae, Geraniaceae.* However, the whole pollen of *Artemisia* and *Chenopodiaceae* is transported from lower vegetation belts. *Plantago, Plumbaginaceae, Labiatae, Saxifragaceae, Polygonaceae, Cichorium, Cirsium, Taraxacum,* etc. are represented by single pollen grains.

Among sporiferous plants, monolete spores of ferns prevail which are also transported from below. There are few spores of *Sphagnum, Botrychium, Pteridium tauricum,* the spores of the latter being transported from lower belts.

The pollen spectra of the lake samples were compared with those of soil samples (3, 4) taken on the coast of the lakes under study (Fig. 1). As is evident from the diagrams, the mentioned spectra have both common and distinguishing features. The role of transported pollen in the soil spectra is as large. One and the same taxa are dominants. However, in soils the first dominant is *Pinus* rather than *Alnus.* The role of other conifers in the soil samples is more significant. In the NAP composition the same regularities are observed. The pollen of *Gramineae* predominates, however, the amount of *Caryophyllaceae* reduces abruptly. That is why this component in the soil spectra becomes subdominant. The second dominant is the pollen of *Ranunculaceae.*

The comparison of the soil and lake spectra also shows a dramatic decrease of sporiferous plants content in the soils. The taxonomic composition of spores is rather poor. Only monolete spores of ferns can be mentioned. Probably, this fact can be explained by better conditions of sporomorph preservation in lakes compared to soils.

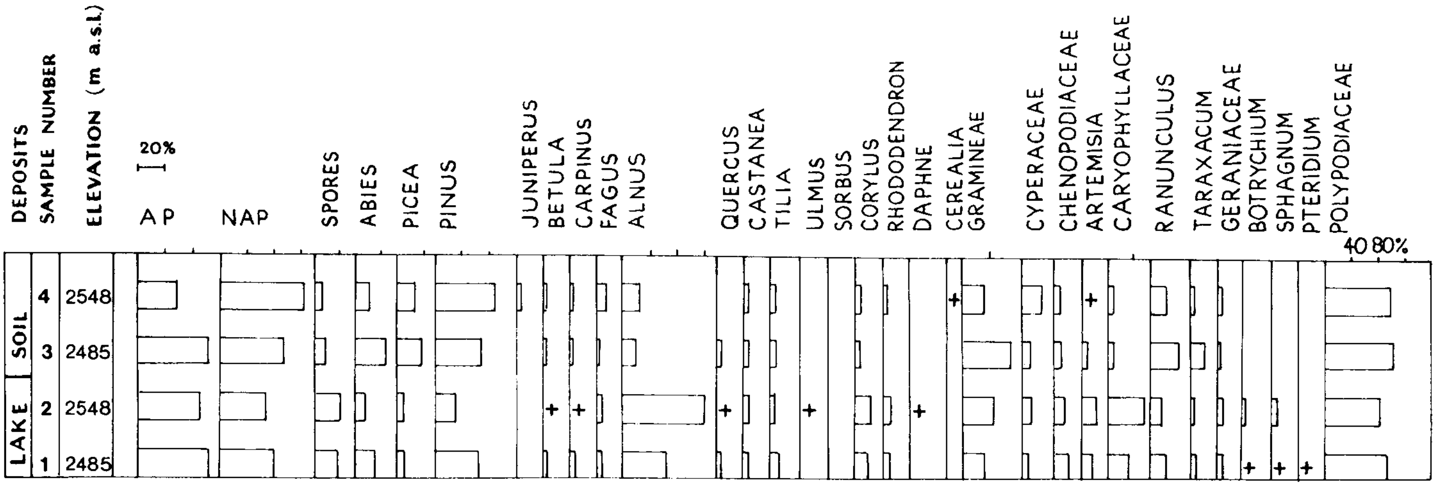

Fig. 1. Spore-pollen diagram of recent sediments at the headwaters of the river Bezymianka 1, 2 – lake samples, 3, 4 – soil samples

As to fossil spore-pollen spectra of the profile under study (the terrace of Bathing Chamois' lake), they are characterized by the following peculiarities. The profile itself consists of blue lake clays (130–90 cm), then being replaced by a peat-bog stratum (90–10 cm) covered with soil on top. The age of the lower peat stratum at a depth of 85–90 cm is 4500 ± 80 BP (MGU 1391)*, and at a depth of 40–45 cm – 2970 ± 85 BP (MGU 1392) (Fig. 2).

The principal peculiarity of the spore-pollen diagram is prevalence of the NAP pollen throughout the whole profile. The minimum AP content in the lowest strata is as low as 11–17%. In the upper part the role of arboreous plants and shrubs increases up to 40%. The amount of sporiferous plants, on the contrary, at the base of the profile is the largest (up to 26%). The middle part of the diagram is characterized by the maximum content of the NAP pollen (72–75%).

In the AP group in general, the pollen of *Pinus, Alnus* and *Abies* can be considered as dominant. Among broad-leaved trees, the pollen of *Castanea* and *Tilia* prevail. In the NAP group there is a lot of *Carex* and *Gramineae* pollen.

The above mentioned are the most common features of the pollen spectra. However, individual strata are marked by specific peculiarities of the spectra, which form the basis for dividing the diagram into six pollen zones (Fig. 2):

Pollen zone 1 (depth 120–105 cm): *Alnus-Tilia-Betula- Caryophyllaceae-Gramineae*

Pollen zone 2 (depth 105–80 cm) : *Abies-Alnus-Pinus-Cyperaceae-Taraxacum*

Pollen zone 3 (depth 80–50 cm) : *Pinus-Alnus-Castanea-Cyperaceae-Gramineae*

Pollen zone 4 (depth 50–30 cm) : *Pinus-Abies-Alnus-Cyperaceae-Umbelliferae*

Pollen zone 5 (depth 30–15 cm) : *Pinus-Alnus-Abies-Umbelliferae-Polygonaceae*

Pollen zone 6 (depth 15–0 cm) : *Pinus-Abies-Alnus-Rhododendron-Umbelliferae*

DISCUSSION

Comparative analysis of recent pollen spectra of different types of sediments in the river Bezymianka headwaters as well as those of vegetation belts of other regions of the Caucasus situated above the forest-line (Kvavadze & Rukhadze 1989, Kvavadze & Efremov 1990, 1993) made it possible to establish specific criteria for deciphering high-mountain fossil spectra. Guided by these criteria, we could reconstruct first of all the local vegetation and climate of the region under study during the last 6000–5000 years.

At the earliest stages round Bathing Chamois' lake (see zone 1) there grew vegetation community of the upper forest-line where open crook-stem birch forest dominated. As we have already mentioned, at present here the forest-line runs at an altitude 2200 m a.s.l. Thus, in the middle of the Holocene, the forest- line was shifted upwards almost by 300 m. All the other vegetation belts, were situated higher than nowadays too. The

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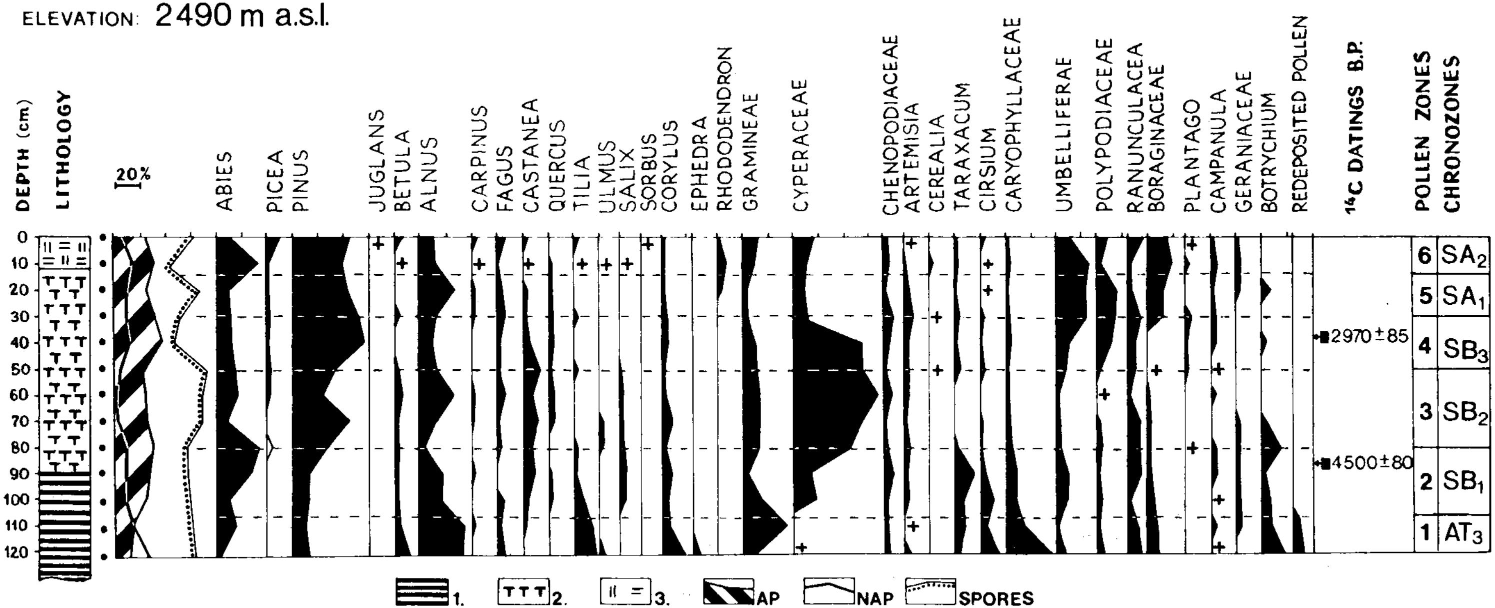

Fig. 2. Spore-pollen diagram of the profile near Bathing Chamois' lake 1 – clay, 2 – peat, 3 – soil stratum

spectra also point out to the fact that the dark-coniferous forest area in the river basin compared to the recent time was very much reduced, whereas that of the broad-leaved forests, on the contrary, enlarged. In flood-plain forests *Alnus* and *Tilia* dominated.

It seems that the local vegetation round the lake was represented by plenty of *Gramineae* and *Caryophyllaceae*. There was very little *Carex*. Mesophillic meadows with rich herbs spread above the lake. On the wet bottoms of the troughs and cirques grew *Botrychium, Lycopodium, Sphagnum*.

The mentioned peculiarities of the cenoses point to warmer climatic conditions of that time compared to the recent ones. Besides, humidity was high. These climatic peculiarities were characteristic of the West Caucasus during the second half of the Atlantic (Kvavadze 1990) and we refer the lower thickness of the lake sediments to this period.

The next stage of vegetation evolution (see pollen zone 2) was marked by gradual replacement of the open crook-stem birch forest first by subalpine and then by alpine meadows. The forest-line shifted downward by several hundred meters. The lake level seemed to lower, because the coast became bogged up. The content of *Gramineae* reduced abruptly. As to lower forest belts, the fir forest area gradually increased. In broad-leaved forests the role of *Tilia* decreased significantly. Such changes in vegetation resulted from cooling at the beginning of the Subboreal. It is just coolings that cause an increase in intensity and duration of winds transporting the pollen of plants growing in lower belts. That is why the diagrams of coolings (pollen zones 2, 4, 6) show that the AP amount rise, while that of NAP, on the contrary, decreases. This is a very important regularity which is clearly seen in recent material as well. With increasing altitude, i.e. with enhanced cold, pollen transport reaches very high values (Kvavadze & Efremov 1990, 1993). In some cases this index is as high as 80–85%. As a rule, this takes place on summits of mountains and ridges of ranges. The third stage of vegetation evolution (pollen zone 3) was distinguished by repeated shift of vegetation belts upwards. Again fragments of crook-stem birch forest spread in the vicinity of Bathing Chamois' lake. At this time *Betula* was mixed with *Pinus,* which, most probably, was the result of climatic dryness in the first half of the Subboreal (Kvavadze 1990). All the rest lower belts also shifted downwards. In the middle mountains chestnut forests seem to expand which also suggests climate warming. The whole bottom of the lake was covered with bogs where peat accumulation was taking place.

At the fourth stage (pollen zone 4) the vegetation again reacted to degradation of climatic conditions. The forest-line shifted downwards; so did broad-leaved forests. In dark-coniferous formations, in addition to *Abies*, the role of *Picea* increased. The area of pine forests expanded which was associated with continuing drying up of the climate. Around the bogged up lake there grew subalpine meadows with prevalence of *Umbelliferae*. Part of the bogs themselves started drying up.

The fifth stage of vegetation evolution (pollen zone 5) coincides with the beginning of the Subatlantic. From the spectrum one can observe further reduction of the bogged up sites. On the slopes in the immediate vicinity of the lake, there grew alpine meadows with fragments of subalpine vegetation along the river valleys which nowadays, are often azonal elements, too. Compared to the previous stage, the upper forest-line shifted upwards significantly which can be explained by climate warming up in the second half of the Subatlantic-1. The composition of the alpine meadows was rather diverse and rich. However, it very much differs from that of alpine meadows of the Atlantic, in that cenosis dominants of the Subatlantic-1 were *Umbelliferae, Boraginaceae, Polygonaceae, Ranunculaceae* rather than *Gramineae* and *Caryophyllaceae*. This cenosis structure may result from grazing. In general, the first traces of economic activity of man in high mountains can be found from the spectra of the Subboreal-2, since it is in these spectra that pollen of *Cerealia, Plantago major* etc. appeared for the first time. Here, as well throughout the whole diagram the presence of *Artemisia* and *Chenopodiaceae* is a consequence of long-distant transport from the steppes adjacent to the mountains of the North Caucasus.

At the very beginning of the sixth stage of vegetation evolution (pollen zone 6) there occurs an abrupt cooling reflected in the diagram by a great increase of the role of *Abies* whose area seemed to expand again. The belt of broad-leaved thermophillic species shifted downwards so that their participation in the spectra becomes hardly noticeable. Around the former lake the bogs ceased to exist. For the first time in alpine and subalpine meadows there appeared thickets of *Rhododendron* which as a rule is a secondary element (Dolukhanov 1966, 1989). Most probably, *Rhododendron* began growing in birch, pine and goat willow clearings. By the end of the stage under study, climatic conditions grew milder and not with standing man's influence, the upper forest-line shifted upwards again. The area of fir forests reduced, while that of spruce forests enlarged considerably. The role of *Gramineae* and *Carex* in the alpine meadows structure grew rather significantly. Prevalence of natural course in vegetation evolution seems to be the result of nature protection measures in this region during the last century.

CONCLUSION

The carried out investigation has shown that in the studied region of the Caucasus, vegetation and the whole landscape underwent most essential changes at the beginning of the Subboreal period. Under the action of strong cooling and reduction of atmospheric precipitation, the lake which must have existed during the whole Atlantic was deprived of its feeding and became grown over. The sediment genesis and presence of redeposited pollen of the Jurassic period at the profile basement, indicate glacial origin of the pralake. Most probably, at the very beginning, the water body basin was formed due to erosion activity of a glacier which was lying here during the Boreal cooling. In the Atlantic the glacier withdrew leaving in its place the lake under study. In the Atlantic the lake was situated within the upper forest-line consisting of thickets of crook-stem birch forst. Thus, the upper forest-line was about 300 m higher compared to the present time. A similar conclusion was made by authors working in other regions of the Caucasus (Margalitadze 1967, 1982, Serebriannyi et al. 1984, Janelidze 1980, Kvavadze 1990).

A new stage in evolution of the lake and vegetation around it began in the Subboreal-1. The lake itself ceased to exist 4500 ± 80 BP and here peat formation processes started. The crook-stem birch forest was replaced by subalpine and then alpine meadows. However, during the climate warming which took place in the Subboreal-2 and Subatlantic-1, fragments of crook-stem birch forest again penetrated through the vegetation surrounding the former lake. However, this crook-stem forest did not form a continuous belt. Perhaps, this was, to some extent, hindered by short-term warming and man's economic activity in the late Holocene (mainly stock-breeding). The latter is supported by occurrence of secondary thickets of *Rhododendron.*

As to the forests in general, it was the dark-coniferous forest belt that underwent maximum changes. It not only shifted vertically in either direction, but its spreading area varied considerably. The taxonomic composition of the forest also varied. In the late Holocene, the role of *Picea orientalis* becomes much more important.

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