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SUBFOSSIL POLLEN SPECTRA OF THE STEPPE REGIONS OF EAST GEORGIA

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ABSTRACT. The results of palynological studies of surface samples from Eastern Georgia steppe region are presented. Surface samples taken from different type of steppe vegetation and a short profile were examined palynologically. The pollen analysis of the profile has shown that after the Holocene climate optimum at the beginning of Subatlantic period in the studied area steppe-woodland vegetation was established.

KEY WORDS: surface pollen spectra, late Holocene steppe, East Georgia

INTRODUCTION

On the territory of East Georgia, steppe vegetation is widely spread in its central and south-east part. Steppes occupy hilly piedmonts along the river Kura and almost the whole Iori Tableland. Generally they do not rise above 800–900 m a.s.l. With advancement towards the West, the border of the steppe landscapes lowers down to 600–550 m a.s.l. Above this level the forest-steppe zone spreads. The steppe landscapes in this region appeared as a result of drier and more continental climate (Chibilev 1990). In East Georgia steppes reach the Liskhi Ridge dividing the intermontane Georgia into two climatic zones: humid and arid.

At present three types of steppes are distinguished: Andropogos, *Stippa pinnata* and thorn-steppes where forest elements can be found rather often (Ketskhoveli 1959). But as a rule, regular structure of the steppes is violated by man's economic activity.

At the beginning of June, 1991, we organized an expedition to one of the steppe regions of Georgia situated 45 km to the south-east of Tbilisi. This region is called Udabno-Garedzhi which in Georgian means "desert", since there are very few settlements there. Ten samples of recent deposits were taken for spore-pollen analysis from different hypsometric points. These were samples from soils, bog and lake sediments. In many cases botanical description was made for sampling sites. Great attention was paid to composition of vegetation formations on the sites of intensive grazing.

A BRIEF PHYSICO-GEOGRAPHICAL DESCRIPTION

The region under study is situated to the south-east of Tbilisi on the Iori Tableland (Figs 1, 2) The river Iori surrounds it from the north and east; from the west it borders on the valley of the river Kura, while from the south it adjoins Azerbaijan. The relief is rather peculiar. Cuesta-like ridges are prevalent; they spread parallel to the Main Caucasian Range. The relative altitude of the relief varies from 600 to 989–991 m (the Dodos-Rka and Udabno Ridges). Hills and hillocks are often replaced by steepe escarps and erosional depressions of rather impressive orographic character. The relief is composed of limestones, pebbles, clays and conglomerates of the Neogene period (Maruashvili 1970). Comparatively smaller area is occupied by plane sites formed Quaternary alluvium.

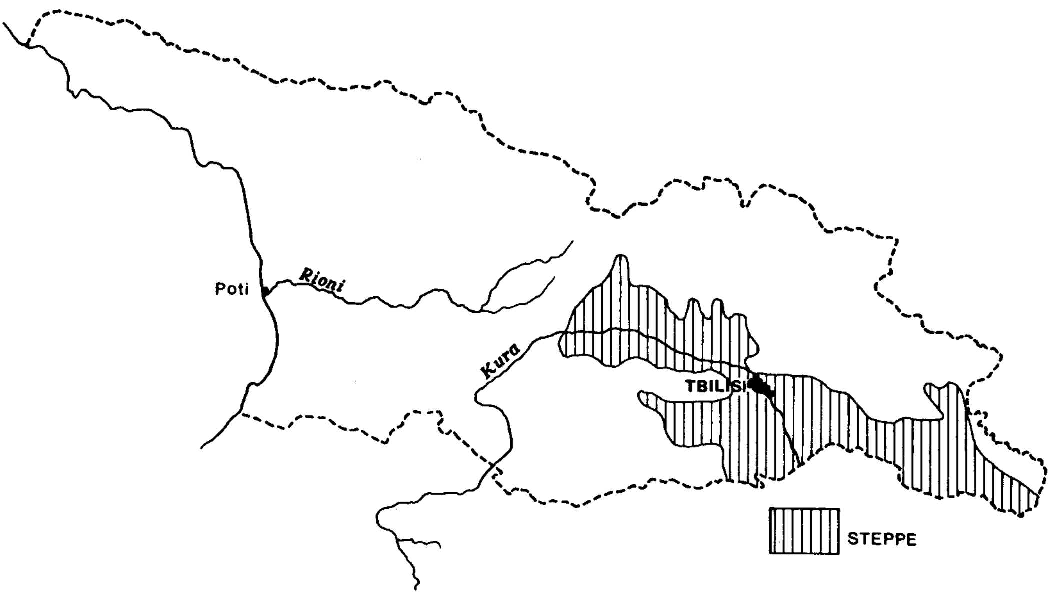

Fig. 1. Schematic map of steppe distribution in Eastern Georgia

The annual precipitations hardly reach 350–374 mm. The rain maximum falls on warm season (June, July). The temperature regime of the climate in this region approaches that of Tbilisi. The average annual temperature is 10.3°, the average temperature in July rises up to 21.1°, while that of January lowers down to –3.9°.

The average wind velocity is 2.2 m/s, while in the west regions along the Kura valley it rises up to 4 m/s. The wind duration also increases westward. In the region as a whole this index does not exceed 2000–3000 hours, while in the Kura valley it rises up to 4000 hours (Svanidze et al. 1987). The strongest and most durable winds blow in summer. North-west winds are prevalent, though south and south-west dry winds as well as east

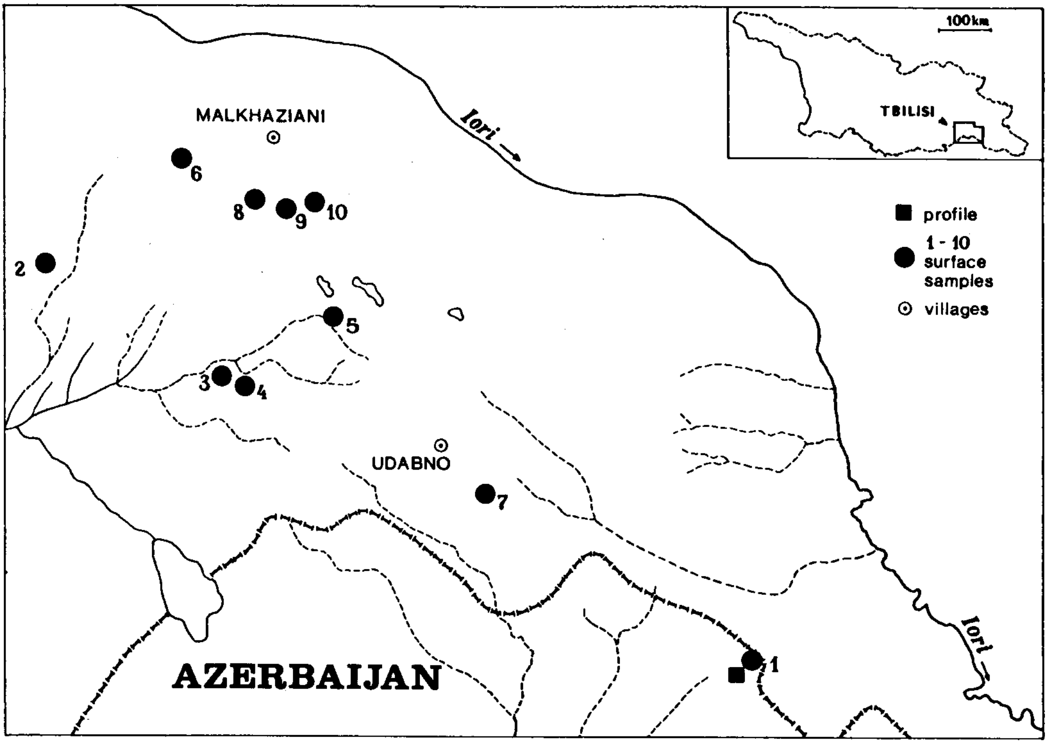

Fig. 2. Schematic map of the Udabno Garedzhi steppe region with localities of the samples investigated

Table 1. *)

a) Air temperature in the village of Udabno, centigrade (H = 750 m)												
Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Av.an
–3.9	0.4	4.5	9.0	15.4	20.7	21.1	19.7	17.5	11.4	6.7	0.9	10.3
b) Atmospheric precipitations in the village of Udabno, mm (H = 750 mm)												
Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annnual sum
5	18	29	56	38	69	84	40	4	3	11	17	374

and north-east winds also play a significant role. The arid climate accounts for extraordinary scarcity of hydrological network. There are practically no permanent watercourses. There are few lakes which dry up in summer. The ground water level is rather low. There are no bog and swamp areas. The climate is distinguished for its aridity.

At low altitudes (from 600 to 700 m) there is steppe vegetation with prevalence of *Artemisia*. At higher altitudes *Artemisia* steppes give way to Andropogos and herb-An-

* All the climate characteristics are given after "Spravochnik po klimatu SSSR" (Reference book for the climate of the USSR), vol. 14, Georgian SSR, part. I, 1971, part II 1973, Gidrometeoizdat, Leningrad.

dropogos meadow steppes (700–1000 m). On some steep hills and in gorges of temporary water courses there grow secondary shrub formations consisting of *Pistacia, Spirea, Ephedra, Paliurus spina-christi,* etc. In the gorge of the Chamdzvralitsqali river we discovered a grove consisting of *Ulmus, Prunus, Rhamnus, Lonicera,* etc. In the vicinity of the village of Malkhaziani plane sites are sowed with cereals, whereas in the rest part of the region under study no ploughed fields were found. Herb meadows here are used for haying, pastures and bee-keeping.

CHARACTERISTIC OF RECENT SPORE-POLLEN SPECTRA

SPORE-POLLEN SPECTRA OF *ARTEMISIA* STEPPES

As was already mentioned, at the lowest hypsometric points, semidesertic steppes spread in which *Artemisia* is predominant. From these regions samples Nos. 1 and 2 were taken (Fig. 3). Sample No. 1 was taken from a small lake which is supplied by underground springs. The relative altitude of the site here is 600 m a.s.l. Soil sample No. 2 was taken at an altitude 650 m.

The analysed samples are distinguished for pollen abundance. The lake deposits are characterized by rich taxonomic compositon which is also typical of other regions of Georgia (Kvavadze 1993).

The main peculiarity of the *Artemisia* steppe spectra is either low amount or lack of monolete spores of ferns and prevalence of *Artemisia* and *Chenopodiaceae*.

In the whole group, the adventitious pollen of arboreal plants accounts for as 11–13%, among which the pollen of *Pinus, Alnus* and *Carpinus* is prevalent. There are also pollen grains of almost all arboreal plants growing in the forests not only on the Gombori, but also on the Trialeti Ridges. The pollen of *Picea, Abies* and *Betula* is most likely brought from the east part of the latter. The pollen of *Pterocarya* is brought by east and north-east winds from the Alazani valley and Lagodekhy piedmonts, because in East Georgia *Pterocarya* grows only there. The availability in the spectra of the pollen of such broadleaved plants as *Fagus, Carpinus, Quercus, Tilia, Ulmus, Juglans* can be explained both by along-distant transport and a short-distant transport from nearby afforested mountains.

In the group of herbs, apart from *Artemisia* and *Chenopodiaceae*, there is a lot of pollen of *Gramineae* and *Compositae*. The pollen of *Leguminosae, Umbelliferae, Polygonaceae, Brassicaceae, Ranunculaceae, Geraniaceae.,* is found in less quantities. The pollen of *Cyperaceae, Labiatae,* etc. is represented in the form of single grains.

The pollen of cultured cereals transported from the neighbouring filds accounts for as low as 1–2%. As to the pollen of such weed as *Plantago* generally growing on trampled down spots, it was only found in the lake sample, because not far away there is a sheep-farm. In the spectra one can find such ruderal elements as *Cruciferae* and *Brassiceae.* Recent vegetation in the studied site is thinned and it consists mainly of *Artemisia* thickets.

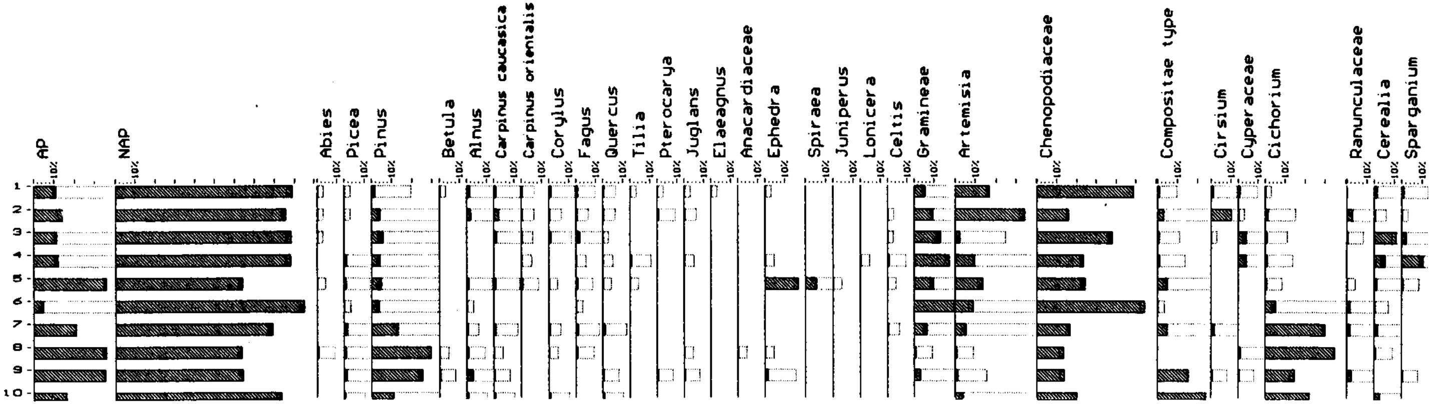

Fig. 3. Subfossil spore-pollen spectra of surface samples from the Udabno Garedzhi steppe region

POLLEN SPECTRA OF BOG AND SHRUB FORMATIONS

The next series of the samples from recent deposits was taken at higher points (from 800 to 820 m). These are samples Nos. 3 and 4 from bog sediments on the bank of one of the tributes of the river Mravalikldistsqaro, and soil sample No. 5 taken under *Ephedra* tickets. The pollen spectra of the bog sediments are distinguished by their excessive saturation with microfossils among which the pollen of *Chenopodiaceae* is prevalent. Monolete spores of ferns are found sporadically.

In the whole group of vegetation, the percentage of the pollen of arboreal plants is 11–35%, that of the herb pollen is 65–89%, while the sporiferous pollen hardly amounts to 0.4–0.5%. Taxonomic abundance of adventitious pollen of arboreal plants is not so impressive as in the previous spectra of *Artemisia* steppes. For instance, there is no pollen of *Betula* and *Pterocarya* there; the amount of *Abies, Carpinus, Quercus* is smaller, while the percentage of the *Pinus* pollen is more or less the same. In the group of herbs the percentage of *Chenopodiaceae* reaches 37%. The second dominant is *Gramineae* (up to 13%). The content of the *Artemisia* pollen falls abruptly in comparision with the spectra of samples Nos. 1 and 2. This value here does not exceed 15%, while in sample No. 2 it amounts to 33%. The content of the pollen of cultured cereals somewhat increases, because corn-fields here are situated much closer. Apart from *Chenopodiaceae,*the amount of such weeds as *Plantago, Rumex, Polygonum, Cruciferae,* etc. rises considerably. On the bog where the samples were taken the following plants grow: *Carex* sp., *Juncus* sp., *Polygonum hydropiper, Bidens tripartitus, Poa palustris, Lolium* sp., *Phleum pratense, Bromus* sp., *Rumex amfibium, Alopecurus palustris, Plantago major.* Around the bog there are largely grazed pastures. One of the central highways goes nearby.

The spore-pollen spectra of the samples taken under *Ephedra* thickects at an altitude of 820 m have the following features. In the whole group the role of arboreal and shrub plants increases (up to 35%). The percentage of sporiferous species does not exceed 0.8%, whil that of herbs is as high as 67%. Among arboreal plants the pollen of *Alnus* and *Pinus* prevails. Among shrubs there is a lot of *Ephedra* (up to 17%) and *Spirea* (up to 5.5%). The adventitious pollen of *Picea, Abies, Fagus, Juglans, Quercus, Tilia, Ulmus, Carpinus* is found in the form of single grains. The pollen of *Lonicera, Spirea, Ephedra* is of local origin. Among herbs, the pollen of *Chenopodiaceae, Artemisia* and *Gramineae* is prevalent, its content being equal to 25%, 14% and 9%, respectively. The pollen content of *Cerealia* corresponds here to 1.6%. Ruderal plants are not widely presented.

Botanical description of site no. 2 is given according to Braun-Blanquet (1951): principle

Shrub layer B consists of *Spirea hypericifolia* (5.5), *Ephedra procera* (4.4), *Asparagus* (1.1), *Prunus* (1.1), *Rhamnus* (1.1), *R. pallasi* (1.1), *Lonicera iberica* (1.1), *Amygdalus nana* (2.2), *Jasminus fruticans* (1.1), *Caragana* (1.1).

In the herb layer C are growing *Vinca herbacea* (2.2), *Lapsana communis* (1.1), *Asparagus* (2.2), *Umbelliferae* (+), *Euphorbia* (+), *Scabiosa*(+), *Bupleurum* (+), *Potentilla* (+), *Tragopogon* (+), *Onobrychis* (+).

Layer D includes only mosses: *Syntrichia ruralis* (4.4), *Camptothecium lutescens* (3.3), *Abietinella abietina* (2.2). The covering is as follows: layer B – 100%, layer C – 20%, layer D – 80%.

As one can see, the pollen spectrum composition has adequately reflected the existing vegetation formation.

POLLEN SPECTRA OF THE SOILS FROM GRAZED MEADOWS

Sample No. 6 was taken at an altitude of 800 m where meadow vegetation was most intensively grazed. The sample was taken as soon as a sheep flock roamed to a new place.

The spore-pollen spectrum is characterized by a negligibly small amount of arboreal pollen (4.7%), among which *Pinus* dominates. Single grains of *Picea, Fagus,* and *Alnus* can by marked out. In the group of herbs, *Chenopodiaceae* content is extremely high (up to 54%). Then comes the pollen of *Gramineae* (up to 20%). The percentage of the *Artemisia* and *Chichorium pollen* is 9.4% and 5.8%, respectively. The pollen of *Polygonaceae, Ranunculaceae, Caryophyllaceae, Geranium, Boraginaceae, Compositae* (genus *Aster*) are found in the form of single grains. The cultured cereals pollen is represented very poorly (0.7%). Pollen grains of *Plantago, Cruciferae, Rumex* and other ruderal plants are not found at all. The content of monolete spores of ferns is as low as 1%.

The vegetation of the site where sample No. 6 was taken is the following: *Chenopodium album, Chenopodium* sp., *Salvia pratensis, Hordeum murinum, Polygonum aviculare, Lolium perenne, Bromus* sp., *Capsella bursa-pastoris, Malva neglecta, Erodium cicutarium, Geranium* sp., *Carduus* sp., *Sisymbrium loeselii.*

The comparison of the pollen spectrum composition with the vegetation shows the adequacy of them. The cenosis dominants are at the same time dominants of the spore-pollen spectrum. Besides, not only the pollen of arboreal plants, but also that of herbs is adventitious. For instance, no *Artemisia* grows on the described site, and there are no cultured cereals here. Spores of ferns are also adventitious.

POLLEN SPECTRA OF SOILS FROM NONVIOLATED HABITATS

Soil sample No. 7 was taken at an altitude of 910 m on a steep hill. The vegetation here is of more natural character. There are no traces of pasturing or any other violations. In the spore-pollen spectra *Cichorium* is prevalent (27%). The second dominant among herbs is the pollen of *Chenopodiaceae* (15%). *Gramineae* accounts for no more than 6.0% and *Artemisia* – 4.9%. There is little pollen of *Geranium, Ranunculaceae, Compositae, Labiatae, Leguminosae, Polygonaceae.* The content of the *Cerealia* pollen is 1.1 %.

The group of arboreal plants occupies 18.4 % in the spectra, with the pine pollen being prevalent, as usual. *Fagus, Alnus, Quercus, Ulmus, Carpinus, Corylus* are marked out in the form of single grains. In the spectrum there is no pollen of *Plantago, Urtica, Cirsium* and other ruderal plants, since there is no dwelling of man and no roads go nearby.

Samples Nos. 8, 9, 10 are taken near an archaelogical settlement of the Late Bronze and Early Iron epoch Naomari Mountain 1 (Kvavadze & Todria 1991), where, also, there are no evident traces of grazing. The altitude of the site from which soil samples were taken is about 940 m a.s.l. The pollen spectra are characterized by an increasing role of sporiferous plants (up to 2.8%). The amount of adventitious pollen of arboreal plants also increases. The dominant of the spectrum in this group is *Pinus*, whose maximum values approach 11–25 %. Apart from *Pinus* the pollen spectra show considerable quantity of *Picea*. *Abies* is marked out only in sample No. 8. Among broadleaved trees one can find single grains of *Fagus, Pterocarya, Quercus* and *Carpinus*. The pollen of *Betula* and *Alnus* is reflected in small quantities. Among shrubs, there are single grains of *Corylus, Rhus, Ephedra*.

In the group of herbs the *Cichorium* pollen is prevalent. In sample No. 8 its amount reaches 32 %, while in sample No. 10 it is equal to 21%. As in sample No. 7, here the second dominant are *Chenopodiaceae* (up to 20 %). The amount of *Compositae* is quite significant, while the role of *Artemisia* in the spectra decreases considerably (down to 1–4 %). The pollen of other herbs is marked out in small amounts. These are *Cirsium, Cyperaceae, Geraniaceae, Ranunculaceae, Umbelliferae, Caryophyllaceae, Labiatae, Boraginaceae, Gramineae*, etc. There is litte pollen of cultured cereals. In sample No. 9 they are not present at all. Among ruderal elements, only in sample No. 8 taken at a beaded path one pollen grain of *Plantago* and two pollen grains of *Urtica* were found.

The analysis of spore-pollen spectra of recent deposits from Udabno-Garedzhi enables us to conclude that all of them adequately reflect the existing vegetation. The pollen of herbs is prevalent in all the spectra. The amount of adventitious pollen of arboreal plants increases with a relative altitude of the site and reaches its maximum on the tops of mountains and ridges which are more open for winds bringing this adventitious pollen from adjacent afforestated mountains.

The pollen spectra are distinguished for the lack or scarcity of monolete spores of ferns at the lowest hypsometric points (from 600 to 800 m a.s.l.). With altitude their percentage in the pollen spectra rises up to 2.8 %. The pollen of ruderal plants *Plantago, Urtica, Cruciferae, Rumex*, reaches its maximum along the roads and shepherds dwellings. The pollen spectra of grazed meadows in the areas with intensively developed cattle-breeding reflect predominance of the *Chenopodiaceae* pollen (more than 50%). The second and third dominants here are *Artemisia* and *Gramineae* (up to 20%). In the pollen spectra of black soils from the meadows in the agrocultural corn-growing areas the *Cichorium* pollen dominates, then come *Compositae* (genus *Aster*) and *Chenopodiaceae*. The amount of *Cerealia* does not exceed 1%. It reaches its maximum in lake and bog deposits (but no more than 2%), due to better conditions for their preservation than in soils.

SPORE-POLLEN SPECTRA OF THE LATE HOLOCENE

In the south-east of the region under study at an altitude 680 m, we have studied a Holocene deposits profile which is a natural outcrop along a gulch. The locality is called

Baidos Kalo. The profile is mainly composed of deluvial and proluvial formations. Thickness of the deposits is 4 m. They are represented by yellow loam. At a depth of 1.65–2.30 m as well as at 2.70–3.71 m the loam has a black tinge, while at a depth of 3.75–3.80 m the deposits acquire a red tinge. Here 12 samples were taken for spore-pollen analysis and studied (Fig. 4). The spore-pollen spectra of three lowest samples taken from the depth 4.0–3.60 m significantly differ from the others. The pollen of arboreal-plants and shrubs increase to its maximum value (up to 54 %). The percentage of sporiferous species is 5 %, *Ephedra procera* is predominant in the spectra. The pollen composition of arboreal plants is rather diverse. Among herbs the amount of the *Cichorium* pollen is evidently predominant. *Chenopodiaceae* and *Artemisia* are subdominants. It is only in this part of the profile that *Cyperaceae* are marked out. The *Gramineae* curve reaches its first maximum. The content of *Cirsium* and *Ranunculaceae* also comes to the maximum values. The rest herbage is fairly abundant.

The spectra of the deposits lying at the depth 3.60–2.20 m are characterized by a gradual reduction of the pollen content of trees and shrubs (down to 10.6%). These are mainly pollen grains of *Pinus, Alnus* and *Carpinus. Quercus* and *Corylus* are also represented by single grains. The first dominant among herbs becomes *Chenopodiaceae,* then *Artemisia.* The role of *Cichorium, Gramineae, Cyperaceae, Caryophyllaceae* drastically decreases. The amount of fern spores in this layer also becomes smaller (0.5%). The redeposited pollen is presented in small quantities, though it is observed in all the samples.

The pollen spectra of the next horizon at the depth 2.30 –1.0 m also have a number of peculiarities (samples No. 3–7). The amount of the arboreal and shrub pollen still more decreases and in sample No. 3 it is as low as 4.5%. For the first time the pollen of *Betula* appears in the spectra. After the pollen of *Picea, Juglans, Ulmus*, *Ephedra* vanished from the second layer, here it is marked out again. The content of *Corylus* increases. Among herbaceous species, the pollen of *Chenopodiaceae* becomes prevalent, reaching its maximum here. On the contrary, the content of the *Artemisia* pollen decreases gradually and its role becomes of minor importance. It should be noted that the amount of the *Gramineae* pollen rises again. The content of *Cirsium* and *Boraginaceae* somewhat increases. For the first time in this layer single grains of *Plantago* are marked out. Fern spores are discovered only is samples No. 6. They are *Polypodiaceae* and *Botrychium.* Redeposited forms are only found in sample No. 7 and also as isolated grains.

The upper part of the diagram (samples Nos. 1, 2) are distinguished by the following features of spore-pollen spectra. The amount of arboreal pollen falls to minimum values (3.8%). This is mainly pollen of *Pinus, Carpinus* and *Fagus.* One can notice single pollen grains of *Quercus, Carpinus orientalis, Alnus* and *Corylus.* In the group of herbs, as in the underlying layer the pollen of *Chenopodiaceae* dominates. *Artemisia* and *Gramineae* are subdominants. Other herbs as *Ranunculaceae, Polygonaceae, Umbelliferae, Saxifragaceae* are represented in small amounts. The polen grains of *Cerealia* are only found in the surface layer spectrum. Sporiferous species are represented by a small amount of *Polypodiaceae.*

Having studied the pollen spectra of the Baidos Kalo profile and having compared

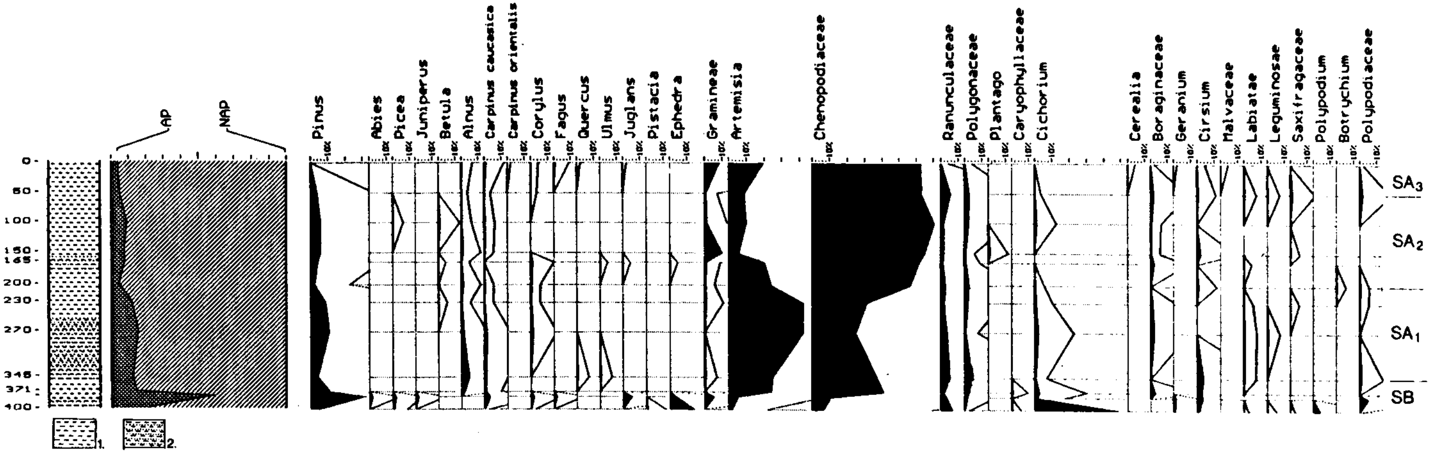

Fig. 4. Pollen diagram of late Holocene sediments from Baidos Kalo: 1 – loamy sand; 2 – loam.

them with the spectra of the previously investigated profiles of Naomari Gora, Dineizi, which are dated by archaeological data (Pitskhelauri 1988; Kvavadze & Todria 1992), we can state that the sediment thickness of the profile under study was formed in the second half of the Subboreal and in the Subatlantic period. In the considered region the second half of Subboreal corresponds to the Late Bronze and Early Iron epochs. At that time the lawermost part of the profile was formed. Proceeding from the peculiarities of the pollen spectra, in the SB the vegetation here was forest-steppe. *Ephedra* thickets were widely spread, which, as we mentioned, nowadays grow at higher hypsometric points.

The pollen spectra composition enables us to conclude that climate at that time was more humid than that at present time. Just for this reason the studied steppe region was densely populated in the epoch of Late Bronze and Early Iron (Kvavadze & Todria 1992). The further warming up of the climate which took place in SA_1 resulted in its aridisation. Forest-steppe vegetation was replaced by steppe one. Dry *Artemisia* steppes like those which nowadays grow at the altitudes of 500–600 m and whose recent spectra were cited by us in the previous chapters.

As is known, the climate cooling took place in SA_2 and it was accompanied by an increase of humidity (Kvavadze et al. 1992). Arid, semidesertic steppe was replaced by richer meadow-steppe vegetation. Man, who abandoned this area in SA_1, was, most likely coming back for a short time either for grazing his cattle or for storing up forage. The pollen spectra point out to intensive development of cattle-breeding. during SA_2. The same tendency went on in SA_3.

CONCLUSION

Our investigations have shown that the main characteristic feature of the spore-pollen spectra of the steppes in East Georgia is negligibly small content or complete lack of monolete fern spores and prevalence of the *Chenopodiaceae* and *Artemisia* pollen. In this case *Gramineae* is the third dominant. It should be noted that strong prevalence of *Chenopodiaceae* in the spectra are preceded by domination of *Cichorium.* In this case the pollen of *Cerealia* is found either in the form of single grains or is absent at all. This regularity is rather distinct. The pollen spectra of *Artemisia* steppes with some features of semideserts are distinguished by maximum content of *Artemisia* (up to 40%) with *Chenopodiaceae* and *Cirsium* as subdominants.

One can observe a clear correlation between the spore-pollen spectra composition and absolute hypsometric point of the locality with elevation of altitude the role of both-short-and long-distant transport of the pollen increases. This is illustrated by an increase of the amount of *Pinus* pollen and fern spores.

The pollen spectra of the Late Holocene show that for the past 3000–3300 years steppe vegetation underwent repeated changes depending on climatic fluctuations.

At the end of the Subboreal and during the very early Subatlantic periods SA_1 at the lowest altitudes (600–700 m) of Udabno-Garedzhi there grew forest-steppe vegetation, though at higher levels there were *Carpinus* forests (Kvavadze & Todria 1992). By the beginning of the Middle Subatlantic forest vegetation was once and for all replaced by steppe, and at low altitudes there appeared *Artemisia* semidesertic steppes, while at higher altitudes *Andropogos* steppes. Some elements of forest-steppe and forest vegetation in the form of fragments remained in deepshaded and more humid gorges.

With an increase of humidity in SA_2, *Artemisia* steppes descended to lower altitudes and in their place there appeared herb-meadow-steppe vegetation.

In SA_3 the *Artemisia* steppe border began to elevate again.

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