Acta Palaeobot. 35 (1): 73–83, 1995

ON THE PROBLEM OF ACTUOPALYNOLOGY IN THE CARPATHIANS AND CAUCASUS

LEON STUCHLIK[1] and ELISO V. KVAVADZE[2]

[1] W. Szafer Institute of Botany Polish Academy of Sciences, Lubicz 46, 31–512 Kraków, Poland
[2] L. Sh. Davitashvili Institute of Palaeobiology, Georgian Academy of Sciences, 4 Potochnaya, St., Tbilisi 380004, Republic of Georgia

ABSTRACT. Some results of actuopalynological studies in the Carpathians and Caucasus are compared. The variability of pollen spectra formed in the mountains depend not only from the floristical composition of the vegetation but also from other factors as relief, ecological and climatic conditions etc. Some differences in forming pollen spectra in Caucasus and Carpathians are also confirmed. A special attention was taken to pollen productivity and pollen from long distance transpot.

KEY WORDS: actuopalynology, Carpathians, Caucasus

INTRODUCTION

The role of the palynological method of studying floras for palaeoecology can hardly be overestimated since floristic composition of fossil spore-pollen spectra allows us not only to reconstruct the character of vegetational cover, but it is also a source of information on climate, relief, edaphic and many other conditions. By the type of reconstructed palaeovegetation of water ecosystems we can judge of the depth of water body, its salinity, carbonization. Introduction of mathematical methods into palynology has made it possible to quantitatively estimate the elements of palaeoclimate and periodicity of their changes.

In contrast to plain territories, in mountaneous regions palynological studies are connected with additional complications. The floristic composition of spore-pollen spectra strongly depends on many factors, among which the most important is a very complex system of winds. In many cases the mechanism of pollen and spore distribution in strongly dissected relief of high mountains both within short and long ranges remains unknown. In moderate and especially in northern latitudes the wind velocity increases with altitude in the mountains, reaching enormous values on tops and main ridges (Barry 1981) where pollen spectra are evidently distorted by pollen from long distance transport.

Since ecological conditions in the mountains change literally at every step, here it is also necessary to pay attention to variability of the pollen regime of plants and their morphological peculiarities. Besides, pollen spectra are strongly influenced by extremal conditions of the nival and subnival belts. In order to find out these and some other question we are studying spore-pollen spectra of recent deposits in the mountain systems of the Caucasus and Carpathians (Stuchlik & Kvavadze 1987, Kvavadze 1993, Kvavadze & Stuchlik 1988, 1990).

MATERIALS AND METHODS

During last ten years nearly all genetic types of sediments were studied. At the Black Sea bottom deposits of the shelf were examined, while on the continental part the samples for pollen analysis were taken from each vegetational belt up to the alpine and nival ones. Numerous transects were made whose lenght varies from several meters to tens of kilometers (Figs 1, 2). At the sites of samples selection a detailed geobotanical description of the vegetation was carried out. In the Caucasus 70 such sites were made, while in the Carpathians – only 20. By the pollen analysis method about 600 samples from the Caucasus and more than 70 samples – from the Carpathians were studied. The majority of the sites studied by us are located on the territories of reservations and national parks, where natural vegetation is much better preserved.

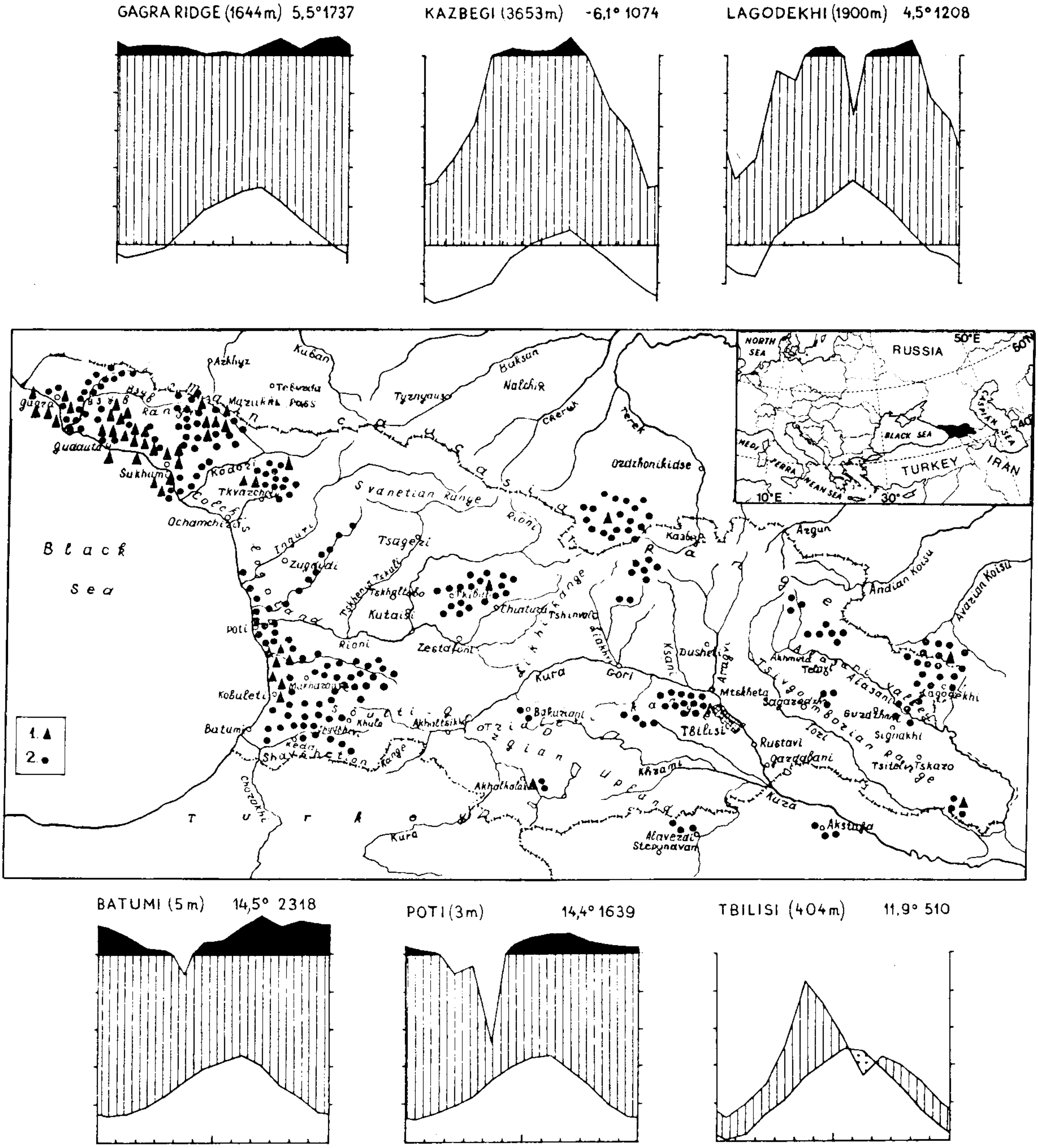

Fig. 1. Location of the studied Holocene sections (1) and sites of recent samples selection (2) in the Caucasus

RESULTS OF INVESTIGATIONS

Lowland forests. On the Colchis lowland in the vicinity of lake Paleostomi, in the Mussera Reservation as well as in the flood-plain of the Alazani River (Eastern Georgia) we have studied swampy forests consisting of *Pterocarya pterocarpa* and *Alnus barbata*. These forests widely spread during the Atlantic period of the Holocene are almost completely exterminated nowadays. The vegetation of these forests is interesting and rather peculiar.

In the swampy forests five sample sites were made from which more than 20 samples of alluvial soils and bottom sediments of lakes were taken. All pollen spectra are characterized by evident predominance of pollen of arboreal plants among which pollen of *Alnus barbata* and *Pterocarya pterocarpa* prevails reaching in the spectra an amount up to 50–58% and 40–52%, respectively. It should be noted that in Eastern Georgia the amount of *Pterocarya* in the spectra is lower than in Colchis and does not exceed 25–30%.

Among the coniferous there are *Pinus, Picea, Abies,* whose pollen is transported by

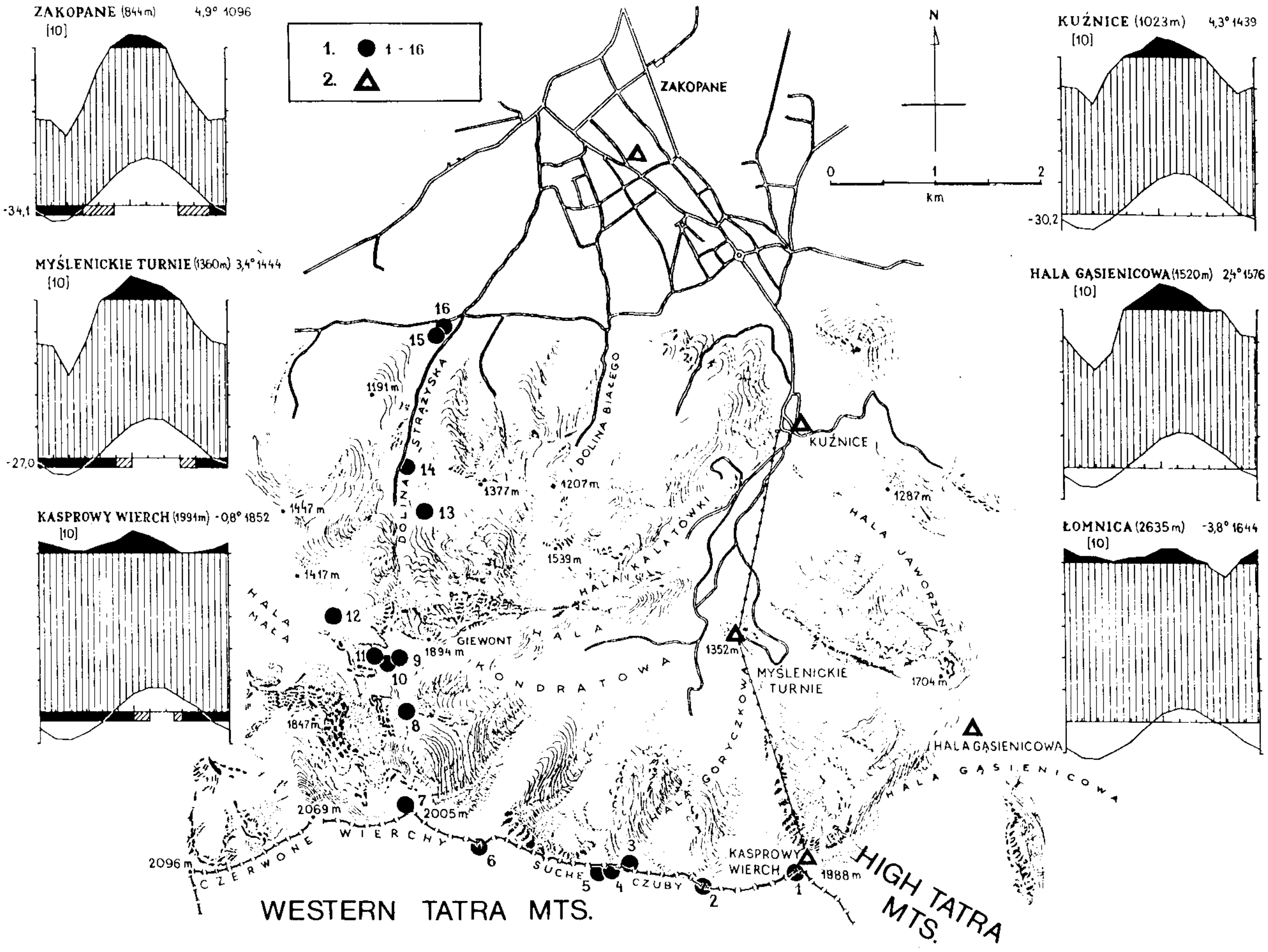

Fig. 2. Sites of recent samples selection in the Polish Carpathians (Tatra Mts.). 1 – described sites, 2 – location of climate stations

wind from surrounding mountains. Among broad-leaved species *Carpinus caucasica* should be mentioned (from 2 to 24 %). Its maximum is observed in the sample taken immediately under its stand. The pollen of *Acer, Betula, Castanea, Fagus, Fraxinus, Juglans, Tilia, Ulmus* is found in small quantities, and pollen of bushes and lianas (*Cornus, Corylus, Hedera)* is found as single grains.

The composition of herbaceous plants is marked out by a certain peculiarity. Among them there is a large amount of *Carex* and very few pollen grains of Chenopodiaceae, Gramineae, Umbelliferae, and Compositae. Spores are rich and abundant representad.

It is interesting to note that on the surface of the Colchis lowland swamps we have found redeposited pollen brought by flood water. According to the evidence of foresters, during floods in the 12th square of the 2nd protected sector water stagnates for a very long period. Among the redeposited forms Taxodiaceae, *Carya* and *Cedrus* are predominant, but as a whole the amount of the secondary pollen here is small (from 0.5 to 2.5% of the whole amount of pollen).

The comparison of the pollen spectra with geobotanical description has allowed us to reveal a lot of interesting details. Those arboreal plants which grow as individuals are not found in the pollen spectra.

However, in general the dominants of all the three vegetational strata are represented in the spectra. It is important to note that *Pterocarya* provides more pollen in Colchis than in Eastern Georgia, though its pollen is more spread just in the East. Thus, in Colchis the *Pterocarya* pollen is completely deposited on the places of growing and it is almost not transferred for long distances. This fact is evidenced by the pollen spectra of the alpine belt (Fig. 3) where there is no *Pterocarya* at all. But in the alpine belt of the Lagodekhi Reservation the *Pterocarya* pollen is always found in

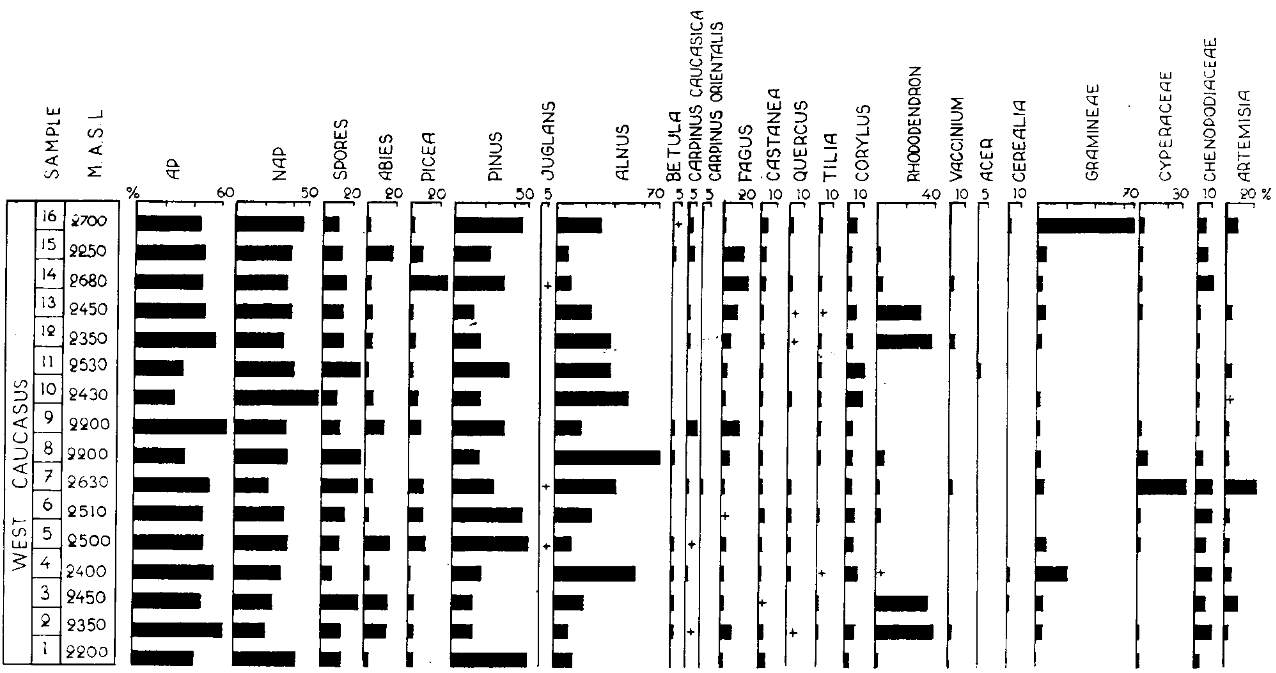

Fig. 3. Subfossil pollen spectra of the alpine belt in the Western Caucasus (Abkhazia)

the amount of 1–4% (Fig. 4). In addition, a certain difference is observed in morphological peculiarities of the *Pterocarya* pollen, it is much larger in Colchis, while in Eastern Georgia it is smaller and with less pores.

spectra. However, in the humid climate of Western Georgia pollen productivity of *Quercus* and *Carpinus* is much lower than in the East where the climate is much drier (Fig. 5). As to the pollen productivity of *Castanea,* here

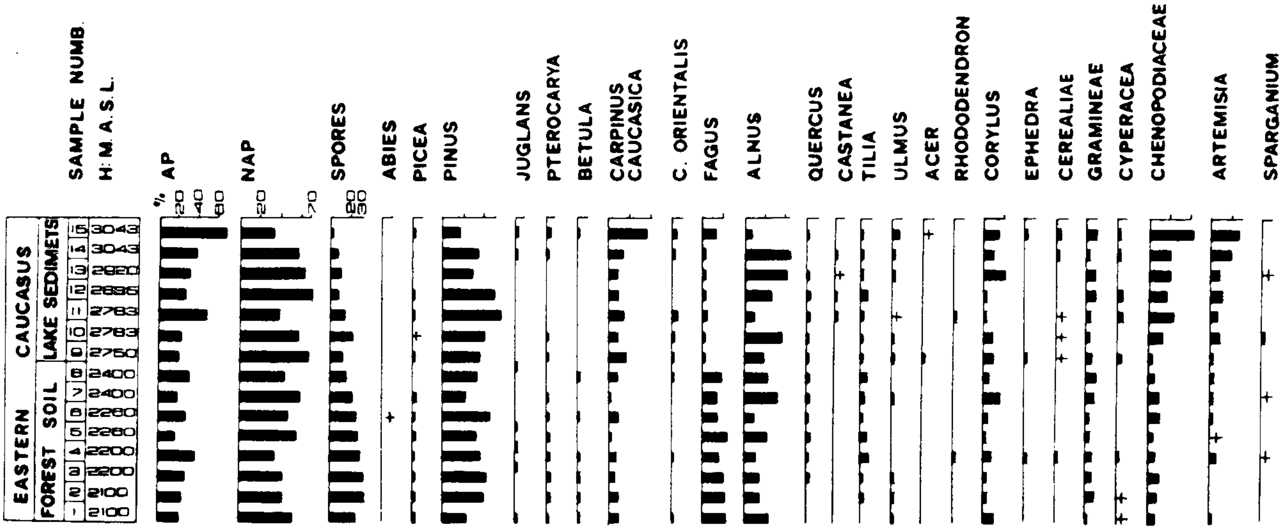

Fig. 4. Subfossil pollen spectra of the alpine belt in the Eastern Caucasus

Mixed broad-leaved forests. Decidous forests have been studied in the piedmont belt in various parts of Georgia. As it is seen from the diagram (Figs 5, 6) in the western part of the Caucasus the existing forests type has found rather an adequate reflection in the spectra. However, in the humid climate of Western Georgia pollen productivity of *Quercus* and *Carpinus* is much lower than in the East where the climate is much drier (Fig. 5).

the situation is quite reversed, in the spectra taken in Western Georgia the amount of *Castanea* pollen reaches up to 60–70%.

The undergrowth as a whole is represented by pollen spectra of broad-leaved forests components, however, in soils the participation of

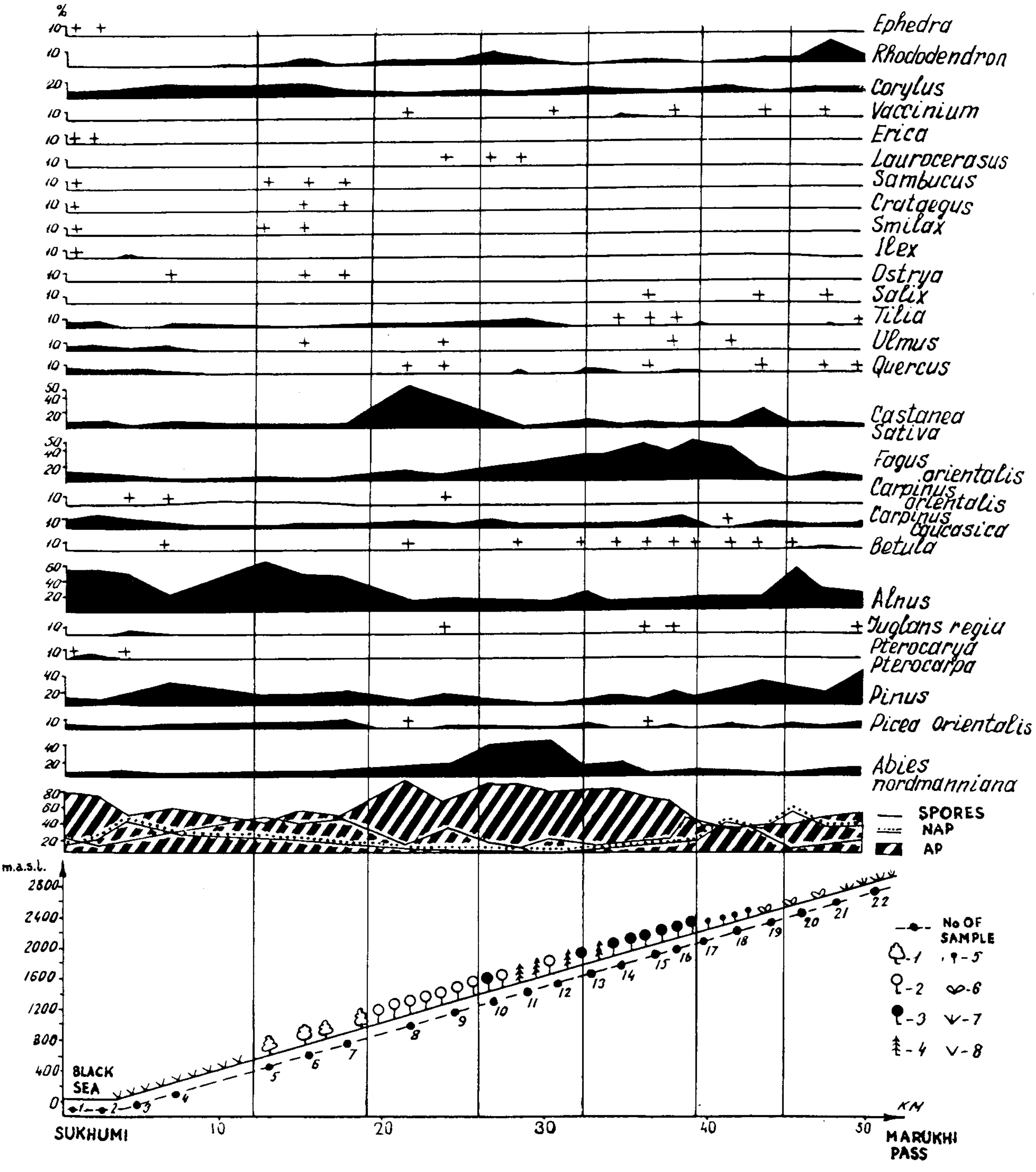

Fig. 5. Subfossil pollen spectra of deposits on the transect Sukhumi – the Marukhi pass (Western Caucasus): 1 – alder, 2 – chestnut, 3 – beech, 4 – conifers, 5 – beech elfin woodland, 6 – subalpine tall grasses, 7 – alpine meadows, 8 – sea shore vegetation and lowland meadows

Rhododendron ponticum and *Ilex colchica* is very low. *Buxus, Laurocerasus* and *Juniperus* are almost absent from the spectra, single pollen grains are found very seldom and only in lacustrine deposits and acid soils of high mountain regions. A similar situation is observed for preservability of the *Daphne* pollen which is found very rarely.

The distribution of pollen of broad-leaved species in Eastern Georgia is also different from that in Colchis. A large amount of *Quercus* and especially *Carpinus* pollen comes into the alpine and subnival belt of the Lagodekhi Reservation (up to 30%) from a long distance transport. The amount of the *Carpinus* and *Quercus* pollen in the alpine spectra in the

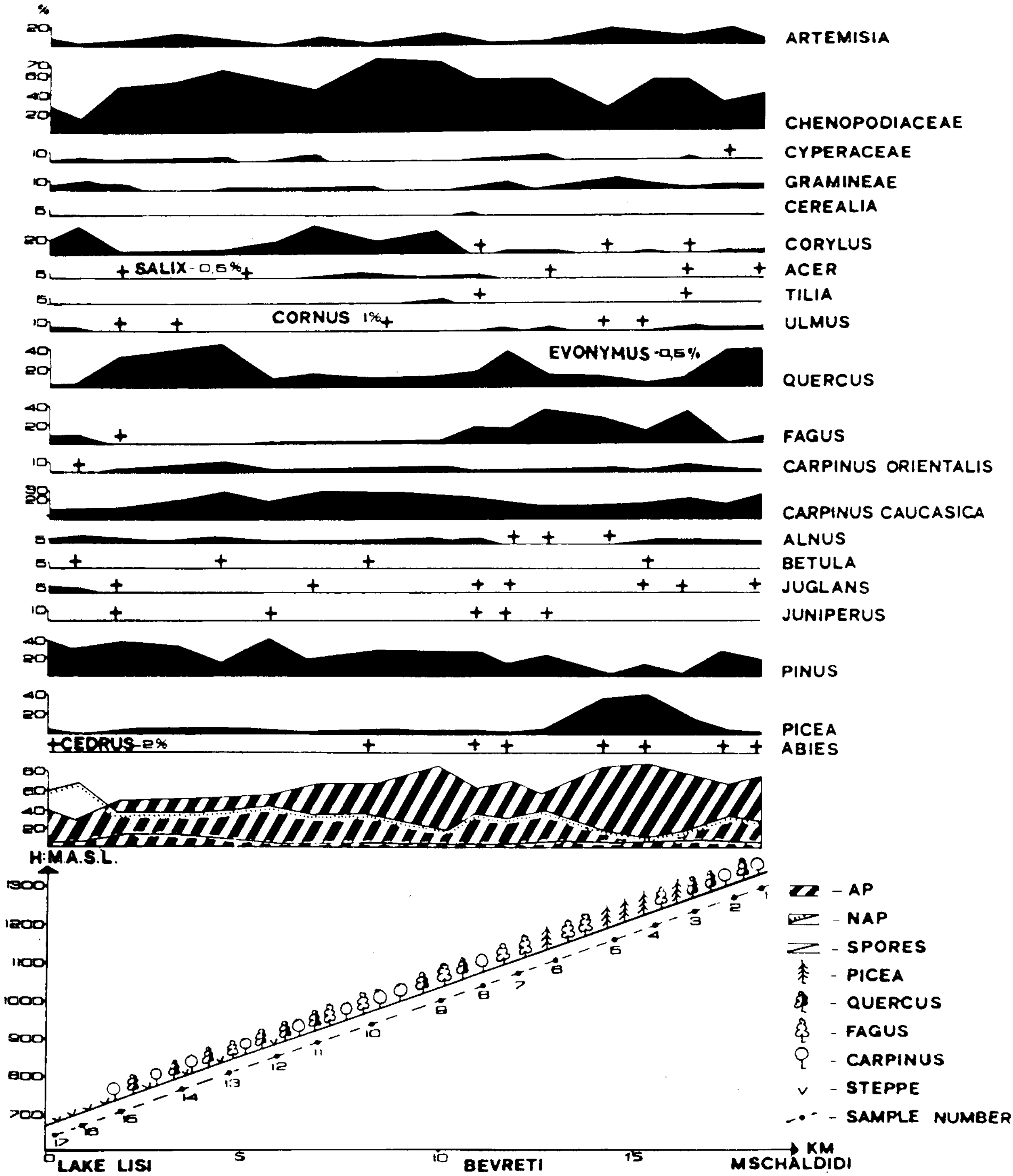

Fig. 6. Subfossil pollen spectra of deposits along the transect Lake Lisi-Tskhinvali (in the vicinity of Tbilisi)

Western Georgia does not exceed 4–6% (Fig. 3). The same is observed for *Juglans, Tilia, Ulmus and Carpinus orientalis* pollen. In the Carpathians, pollen is transferred for a long distance, too.

The problems of variability of the above mentioned broad-leaved species were beyond the scope of our work, but we cannot help paying attention to strong variability of *t*he *Carpinus* and *Carpinus orientalis* pollen morphology in Eastern Georgia. There exist a lot of forms which resemble *C. betulus* more than *C. caucasica*. This variability is observed in the size of pollen grains and their form, exine thickness, the number and size of apertures. Variability is also marked in the *Juglans* pollen which has survived in its natural state in the forests of Eastern Georgia. Unlike the pollen of cultivated plants on the territory of Western Georgia and in the Carpathians, here the pollen grains of *Juglans* have a thinner exine, and the size of grains and apertures are also different.

Beech and beech-coniferous forests. The forests consisting of *Fagus orientalis* on the territory of the Caucasus are spread most of all. In the mountains of Abkhazia up to 50% of all the forests constitute of beech forests. The same is observed in the mountain forests of the Lagodekhi and Zakatala Reservations. Just in these two regions we studied subfossil pollen spectra under the stand of *Fagus*. As a result, we have observed the following regularities. In the case when the beech forest belt is situated lower than the coniferous belt, the amount of the *Fagus* pollen in the spectra is as a rule much lowered. An exception to this rule are soil spectra taken under the beech forest canopy in the Tsiskari Reservation at an altitude of 1150 m a.s.l., where the climate is distinguished by high humidity. The amount of precipitations here is the highest (more than 3300 mm). The quantity of the *Fagus* pollen in the spectra reaches 45–53% on the average. The spectrum of purely beech forests in the high mountains above coniferous forests is also adequate to the reality. In Abkhazia along the valleys of the rivers Amtkal, Adanga, Sibista, Didi and Patara Khodjal at the forest border grow beech forests changing to beech elfin woodland. The amount of pollen in such forests reaches 65–71% on the average (Fig. 5), and falls down to 25–30% in the spectra of the beech elfin woodland.

These regularities are observed for the deposits with good pollen preservability conditions, i.e. in which pollen concetration is high. In the deposits of coarse mechanical texture (thin skeleton soils, coarse-grain sand, gravel and pebbles, etc.) the *Fagus* pollen is either absent at all or found in the form of single grains.

In beech coniferous forests both in the Caucasus and Carpathians the role of the *Fagus* pollen in the spectra is usually reduced since it is known that the coniferous produce much more pollen than *Fagus* does. Thus it has been established that the pollen productivity of *Picea* is three times as large as that of *Fagus* (Bortenschlager et al. 1984).

Apart from this, a small amount of *Fagus sylvatica* pollen under its canopy in the Tatra Mts can be explained by the distortion of spectra by the *Pinus* pollen transported here in large amount (up to 50%) by strong winds from the territories rather remote from the beech forests belt (Fig. 7).

The problem of the *Fagus* pollen distribution was given much attention by us. In Western Georgia *Fagus* pollen is almost not spread for significant distances even within high mountains where the beech forest forms a forest border (Fig. 5). However, in Eastren Georgia in treeless lanscape of lowlands and high-lands the content of *Fagus* pollen in the spectra increases and reaches 10–24%. We were very much suprised with the results obtained when studying subfossil spectra of the Ukrainian Carpathians (Kvavadze 1988, 1993). In the alpine belt *Fagus* pollen is marked permanently in large amounts (40–60%).

In the subfossil spectra of the alpine belt in the Polish Carpathians (High Tatra Mts) *Fagus* is also present, its content reaching 10–18%, is almost the same as under the beech forest canopy (Figs 7, 8).

As far the problem of morphological variability of *Fagus* pollen is concerned, we should note that the pollen grain size changes insignificantly. However, besides sizes the pollen produced by the beech croocked forest is marked out by thin exine and a great number of underdeveloped forms.

Coniferous forests. On the territory of Abkhazia we have studied pollen spectra of the fir forests with a small admixture of spruce. As a whole, the amount of *Abies* pollen reaches high values. Thus in the Ritsa Reservation it is equal to 45–70% in the spectrum. In mixed *Picea-Abies* forests the *Abies* pollen content falls down. Thus, as a rule, *Picea* pollen content in the forests of Adjaria and Guria increases reaching 80%. The spectra under the spruce forest canopy of the Ukrainian and Polish Carpathians are also rich in pollen of *Picea abies* (Figs 7, 9). The amount of the *Abies alba* pollen have been adequately reflected in the spectra as well. However, the participation of the larch-tree (*Larix*) in the pollen spectra of the Tatra Mts has not found an adequate reflection. Its pollen is not preserved in the studied soils at all. The spruce and fir pollen is spread very well, but it is transported from lower altitudes into the alpine belt of the Caucasus not in large amounts (not exceeding 10–

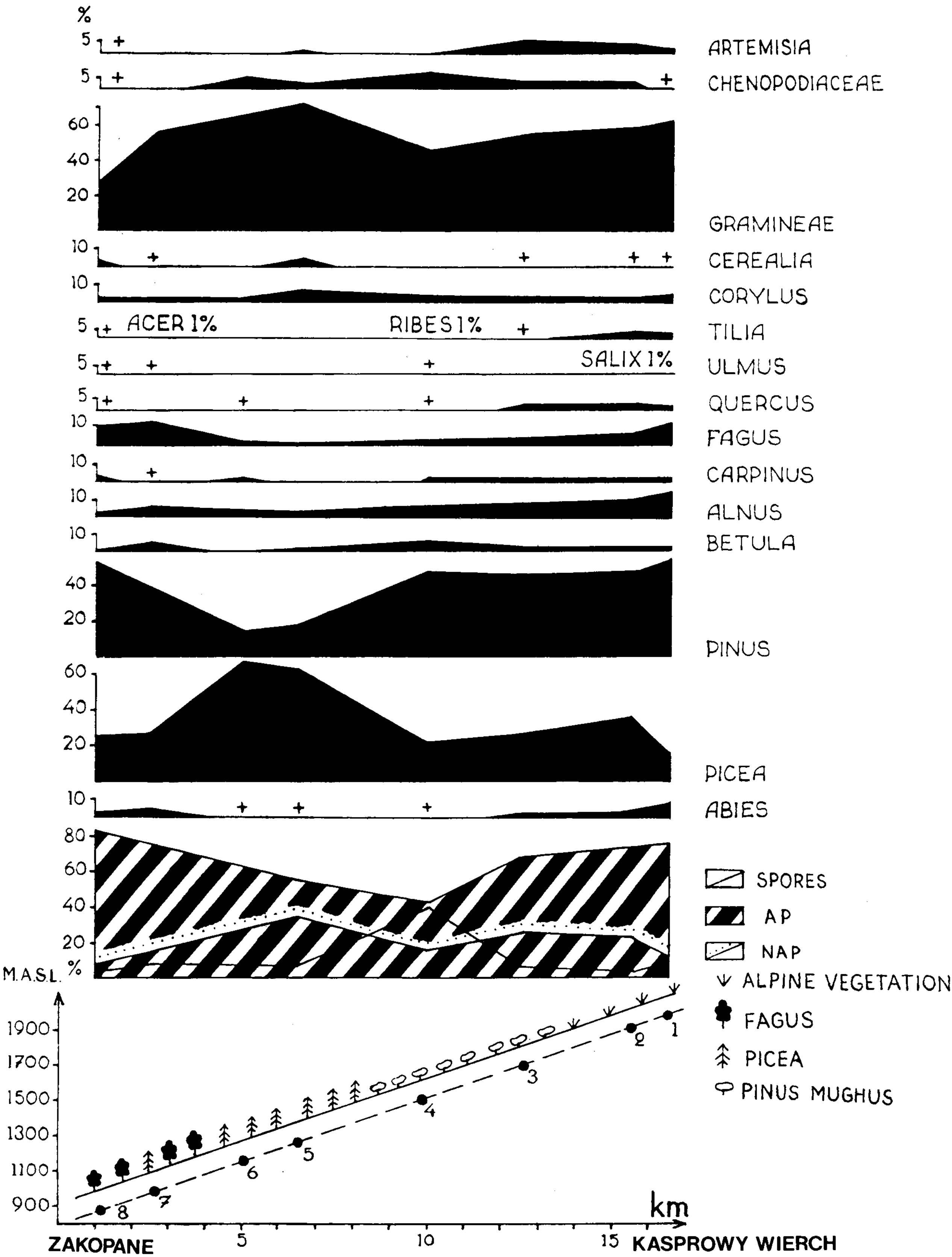

Fig. 7. Subfossil pollen spectra of deposits along the transect Zakopane – Kasprowy Wierch., Tatra Mts

15%). There is little *Abies* and *Picea* pollen in treeless landscapes of lowlands. A somewhat different pattern of pollen distribution is observed in the Carpathians. In the alpine belt of

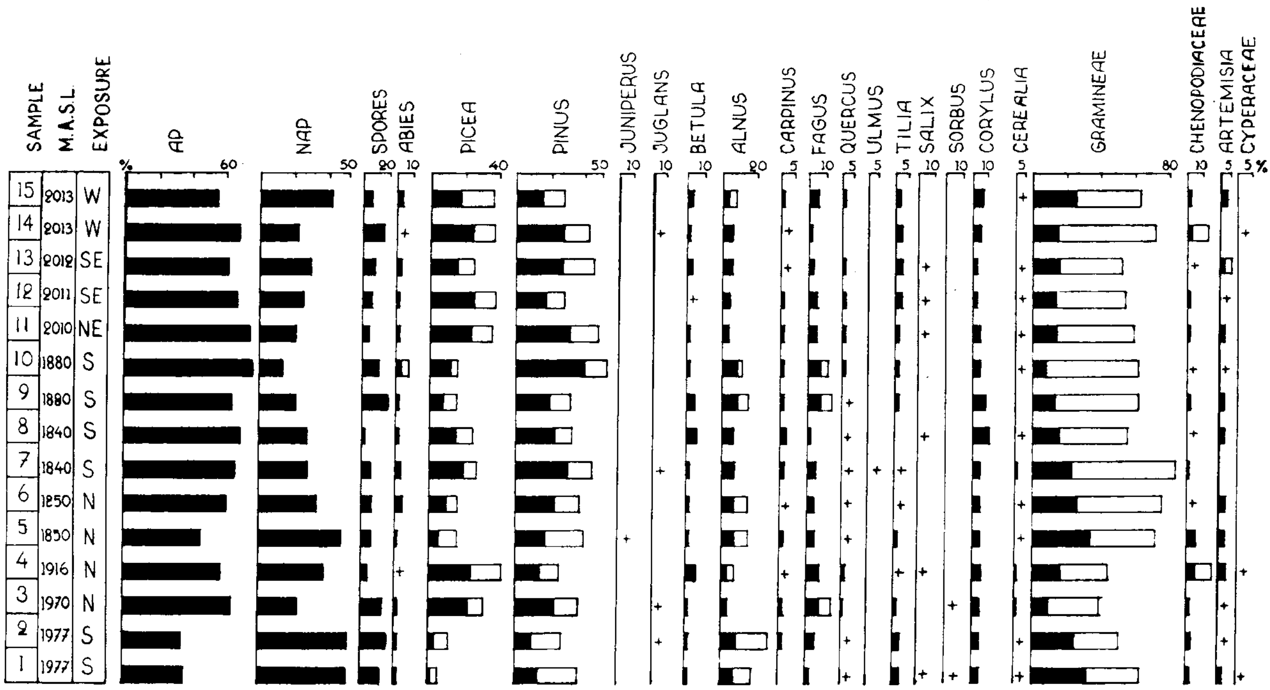

Fig. 8. Subfossil pollen spectra of the alpine belt soils in the Polish Carpathians (Tatra Mts)

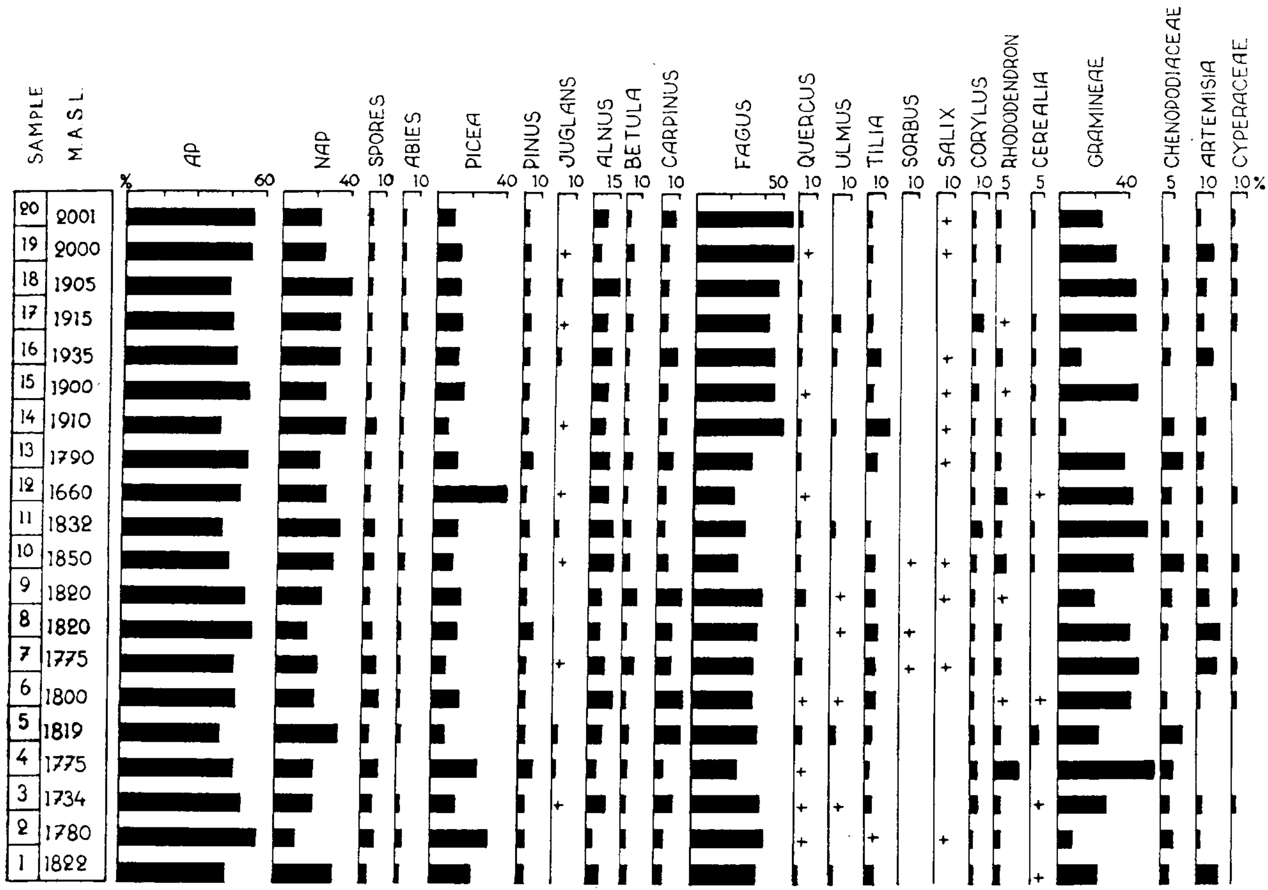

Fig. 9. Subfossil pollen spectra of the alpine belt soilds in the Ukrainian Carpathians

the Tatra Mts the *Picea* pollen amount reaches 25–42% on the average. In the Ukrainian Carpathians the *Picea* pollen is also transported from lower altitudes into the alpine belts and in more quantities than in the Caucasus. At the same time in Eastern Georgia (Lagodekhi) where the coniferous forest belt is absent at all, in the spectra of alpine and subnival belts the *Picea* pollen is always present but only from long distance transport. The territory of spruce forests was removed more than 150–200 km to the west of the Lagodekhi Reservation. One can observe the variability of the *Picea* and *Abies* pollen in size, exine thickness and sometimes exine sculpture.

DISCUSSION

The analysis of the pollen regime of the forest dominants in the mountains of the Caucasus and Carpathians shows a direct dependence of pollen productivity on ecological conditions.

Fagus orientalis is considered a hydrophilous species characteristic for marine climate and that is why only in the Tsiskari Reservation where the amount of atmospheric precipitations is very high, and in the highlands of Abkhazia where annual precipitations reach 3000 mm, *Fagus* produces a large quantity of pollen.

Carpinus and *Quercus* are less hydrophilous, than *Fagus*, that is why in Eastern Georgia these species find better conditions and produce more pollen, than in Western Georgia.

At the same time the subfossil spectra of hornbeam forests in different regions of the Caucasus have shown that in any conditions *Carpinus caucasica* produces more pollen than *C. orientalis*. This difference is rather essential. Various species of *Rhododendron* are characterized by different indices of pollen productivity. Under thickets of *Rhododendron kochii* in the Ukrainian Carpathians only single pollen grains of it are found while in soile of the Caucasian alpine belt under *Rh. caucasica* the amount of its pollen reaches 40%. Less pollen can be under *Rh. flavum* (up to 20%), while in the thick unpassable thickets of *Rh. ponticum* forming undergrowth the content of its pollen hardly reaches 3%. At the same time *Rh. ponticum* gives more pollen on open space than in forest undergrowth.

In transportation of pollen in the conditions of mountain relief the main role is played by direction and velocity of wind. As we have already mentioned, in the Carpathians due to their more northern position stormy winds blowe much oftener, which is evidenced by many wind-falls. During our expeditions from time to time we could observe large areas of spruce forests destroyed by winds. In the Caucasus similar phenomenon has not been revealed. That is why we do not observe such intensive pollen transfer from one belt to another as it is registed in the spectra for the Carpathians. At the same time the material has revealed that at equal dissection of relief and equal intensity of winds in Western and Eastern Caucasus the pollen of one and the same plant is transported differently. Distribution of the pollen of *Carpinus orientalis, Fagus, Quercus* and other species is an obvios case. In Western Georgia which differs from eastern regions in its humid marine climate, pollen is not transferred for long distances (except for *Pinus* and *Alnus* pollen which is transported for long distances everywhere).

At the same time in the dry climate of eastern part of Georgia the pollen of broad-leaved and many other plants is transported better for rather long distances. A similar phenomenon is mentioned in literature for the coniferous pollen. In dry air exchange of the pollen takes places more intensively and covers longer distances than in humid air (Nekrasova 1983).

When studying fossil spectra it is necessary to take into account a large amount of long distance introduced pollen of arboreal species in highlands of the Ukrainian and Polish Carpathians. Straight forward interpretation of the fossil spore-pollen spectra from quantitative estimate of plants groups can lead to mistakes. In literature there exist such examples (Kozij 1934, Serebryannyi et al. 1984).

REFERENCES

BARRY R. G. 1981. Mountain weather and climate. Methuen, London-New York.

BORTENSCHLAGER J., BORTENSCHLAGER S. & FRANK A. 1984. Pollenflug in Innsbruck 1977–1983 (Tirol, Östereich). Ber. Naturw.-Med. Ver. 71: 213–240.

KOZIJ G. 1934. Stratigrafia i typy florystyczne torfowisk Karpat Pokuckich. Pamiętnik Państwowego

Instytutu Naukowego Gospodarstwa Wiejskiego w Puławach, 15 (1): 161–225.

KVAVADZE E. V. 1988. Soderzhanie privnosnykh pyl'tsy drevesnykh v sporo-pyl'tsevykh spektrakh Kavkaza i Karpat (summary: The content of introduced arboreal pollen in subfossil spore-pollen spectra of the Caucasus and Carpathian high mountains). Bull. Acad. Sci. Georg. SSR, 132 (1): 193–196.

— 1993. On the interpretation of subfossil spore-pollen spectra in the mountains. Acta Palaeobot., 33 (1): 347–360.

— & STUCHLIK L. 1988. Znachenie izucheniiya subretsentnyckh sporovo-pyl'tsevykh spektrov dlya vosstanovleniya istorii razvitiya golotsenovoy rastitel'nosti Kolkhidy (summary: On the role of subrecent spore-pollen spectra in the reconstruction of the history of the Holocene vegetation in Colchis). Izv. Akad. Nauk Gruz. SSR, Ser. Biol., 14 (4): 250–257.

— & — 1990. Subrecent spore-pollen spectra and their relation to recent vegetation in Abkhasia (North-Western Georgia, USSR). Acta Palaeobot., 30 (1/2): 227–257.

NEKRASOVA T. P. 1983. Pyl'tsa i pyl'tsevoi rezhim khvoinykh Sibiri (summary: The pollen and pollen regime of the coniferous). Izd. Nauka, Novosibirsk.

SEREBRANNYI L. R., GOLODKOVSKAYA N. A. ORLOV A. B., MALIASOVA E. E., IL'VES E. O. et al. 1984. Kolebania lednikov i protsessy morenonakoplenia na Tsentral'nom Kavkaze. (Fluctuations of glaciers and moraine accumulation processes at the Central Caucasus). Izd. "Nauka", Moscow, (in Russian).

STUCHLIK L. & KVAVADZE E. V. 1987. Subrecent spore-pollen spectra and their relation to recent forest vegetation of Colchis (Western Georgia, USSR). Palaeontographica Abt. B, 207 (1–6): 133–151.