ACTA PALAEOBOTANICA
27 (1): 9—26, 1987

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LATE-GLACIAL AND HOLOCENE POLLEN DIAGRAMS FROM JASIEL IN THE LOW BESKID MTS. (THE CARPATHIANS)

Późnoglacjalny i holoceński profil pyłkowy z Jasiela w Beskidzie Niskim (Karpaty)

ABSTRACT. Material obtained from the cores of peatbog sediments, ca 2 m in thickness, taken in the Dukla Mts. (Low Beskids, Carpathians), was used for pollen analyses. Six selected levels were dated by the ^{14}C method. These data are used to present the vegetational changes of the peatbog surroundings since 10 300 B. P.

PRESENT-DAY NATURAL ENVIRONMENT

Characteristics of the region

The Low Beskid Mts. constitute the lowest and narrowest part of the Carpathian arch (Klimaszewski 1935; Starkel 1972). They are ca 1830 km^2 in area and ca 100 km long, whereas the greatest width is up to ca 30 km. The boundary between the Western and Eastern Carpathians runs in this region. The system of mountain ridges extends as a rule in a SE-NW direction. The region is characterized by a very complex mosaic of orographic forms. The highest peak, situated close to the western boundary of the area, rises to an altitude of 999 m. Except for one other peak, which reaches 996 m, no mountain top attains 900 m. The highest mountains are grouped at the opposite ends of the range, which extends in the direction of the parallel of latitude. The lowest floors of the valleys lie at an altitude of 300 m.

Out of the numerous ranges of the Low Beskids, the Dukla Mts., lying in the central part of the region, are the lowest. Here the culminations of ridges and hills reach altitudes from 520 to 720 m. The Dukla Pass (502 m a.s.l.), which is the lowest in the whole Carpathian arch, is situated in this area. The southern summits mark the European watershed, separating the catchment area of the Baltic Sea from that of the Black Sea.

The geological structure of the Low Beskid Mts. is also very complex. They are built of rocks belonging to the Carpathian flysch, Lower Cretaceous-Oligocene in age. Five main stratigraphic-tectonic units have been distinguished here: the Magura nappe, Dukla folds, Silesian nappe, sub-Silesian nappe and the Skolska nappe. The morphology of the region reflects the basic stratigraphic-tectonic elements and the varied resistance of rocks to weathering. The higher parts of mountains are mostly of the Magura series and Dukla folds. These rocks are the poorest in alkali compounds and calcium carbonate. As regards morphology, the rocks richer in calcium carbonate are characterized by a lower and gentler relief.

The rocky substratum is strongly folded and jointed throughout the Low Beskid Mts. (Świdziński 1953; Starkel 1972). In the SE-NW elevations both inclination and degree of scaliness of the main rock formations increase regularly. As a result, the northern and western slopes are generally more humid (and wooded) than the southern and eastern slopes.

The Quaternary covers consist chiefly of loamy-stony or clayeystone colluvial and solifluctional sediments, 10—30 m thick, overlying the slopes. The valleys are filled with fluvial sediments.

Diversified acid and leached brown loamy soils, occupy the greater part of the Low Beskid area. In the mountain ranges they are usually of a medium thickness (up to 50 cm) with a considerable skeleton content (especially where more resistant sandstones occur in the substratum). Soils of this type, occurring on slopes and notably under crops, are exposed to intense processes of deflation. Brown soils, reddish-brown soils, pararendzinas, podsols proper, initial hydrogenic soils and others appear more rarely.

The leading factor that effects the climatic conditions in the Low Beskid Mts. is the relief. The intensity of the mountain climate increases from the piedmont regions towards the highest ranges. In accordance with the classification of the climate of the Polish Western Carpathians (Hess 1965), two climatic zones can be distinguished in this area: a moderately warm zone, with mean temperatures, calculated for many years, lying between 6 and 8°C, and a moderately cool zone with mean temperatures from 4 to 6°C. In this region the boundary between these two zones runs at an altitude of 500—570 m. The zones represent a pluvial type of climate and the whole area belongs to the Carpathian climatic province (Gumiński 1950).

Fairly big differences in mean annual rainfall from ca 700 to ca 900 mm occurring between particular areas are dependent on the relief and altitude.

The region under discussion is characterized by the occurrence of strong southern foehn-type winds blowing from over the Hungarian Lowland. These winds are most frequent in late autumn, in winter, and in early spring, occurring more rarely in summer. They bring about great anomalies in the prevailing weather.

In the Low Beskid Mts. the growing season lasts from 215 days in the valleys to 182 days on the summits (Hess 1965, Hess et al. 1976).

The flora of the Low Beskid Mts. is relatively poor. This is due to their small and weakly differentiated altitudes, and the uniformity of the geologic substratum. At present woods cover 35—50% of the total area here (Święs 1980, 1982). The most intensely wooded parts are the highest mountain ridges at the opposite ends of the Low Beskid range. Mesotrophic communities prevail in its plant cover. The forest communities show the most distinct differentiation according to altitude. Two vegetational zones have been distinguished here: the foothills zone and lower montane forest zone. Remnants of the hornbeam forest (*Tilio-Carpinetum*) occur in the foothill zone, whereas the beech forests (*Dentario glandulosae-Fagetum*), not very widespread acidophilous fir forests, beech forests with *Vaccinium myrtillus* and fragments of other forest communities make up the lower montane forest zone. Alder woods (*Alnetum incanae*) predominate in the river and stream valleys. Both self-sown and planted woods and thickets composed of *Alnus incana*, *Pinus sylvestris* and *Juniperus communis* occur generally on the now uncultivated ground. Apart from the natural meadow communities of the orders *Arrhenatheretalia* and *Molinietalia*, large areas are occupied by semi-natural meadows and synanthropic communities undefinable phytosociologically (Święs 1980, 1982; Grodzińska 1968; Grodzińska & Pancer-Kotejowa 1965). The nearly complete disappearance of the western Carpathian species and the somewhat slower disappearance of the eastern Carpathian species are a characteristic botanical feature of this area. In the botanical division of Poland, this mountain range is distinguished as a separate sub-region and with respect to flora it is intermediate between the west and east Carpathians (Pawłowski 1972).

The beginnings of the colonization of the Low Beskids by fairly numerous groups of people from the circle of the Corded Ware Culture took place as late as the Younger Neolithic. The population increased in the Bronze Age, at the time of the development of the Protoslav Lusatian Culture (Sulimirski 1957, 1959; Machnik 1960, 1962; Żaki 1955). Colonization occurred chiefly in dells and larger river valleys and included communities whose husbandry was mainly based on cattle breeding and pasturage. The region became densely populated as late as the early and late Middle Ages, or in the 13th—15th cc. On the turns of the 14th and 15th century the nomadic-pastoral and pastoral-agricultural population contributed to the devastation of the natural forests in nearly all convenient places in the mountains. This was responsible for marked changes in the local water and microclimatic conditions, increased floods, the deepening of river channels and valleys, drying of slopes, etc. Owing to the considerable depopulation of this area after 1947, fields, meadows and pastures have been turned into swamps, and succession mainly of *Alnus incana*, *Betula verrucosa* and semi-natural herb communities have developed.

Description of the site

The material used for the palynological study comes from a peatbog situated about 20 km to the south-east of Dukla, in the south-eastern part of the Dukla Mts. (49°22′22″ N, 21°53′13″ E), close to the state frontier. The nearest villages, Jasiel and Rudawka Jaśliska, are at a distance of 3—5 km. The peatbog is 10 hectares in area and lies at an altitude of about 670—680 m; it is below the summit of a hill on its side sloping at about 5° northeastnorth ward. It is in the headwaters of a small stream — a left-bank tributary of the Jasiołka (Fig. 1). The peat layer is on the average 1 m thick, the maximum thickness

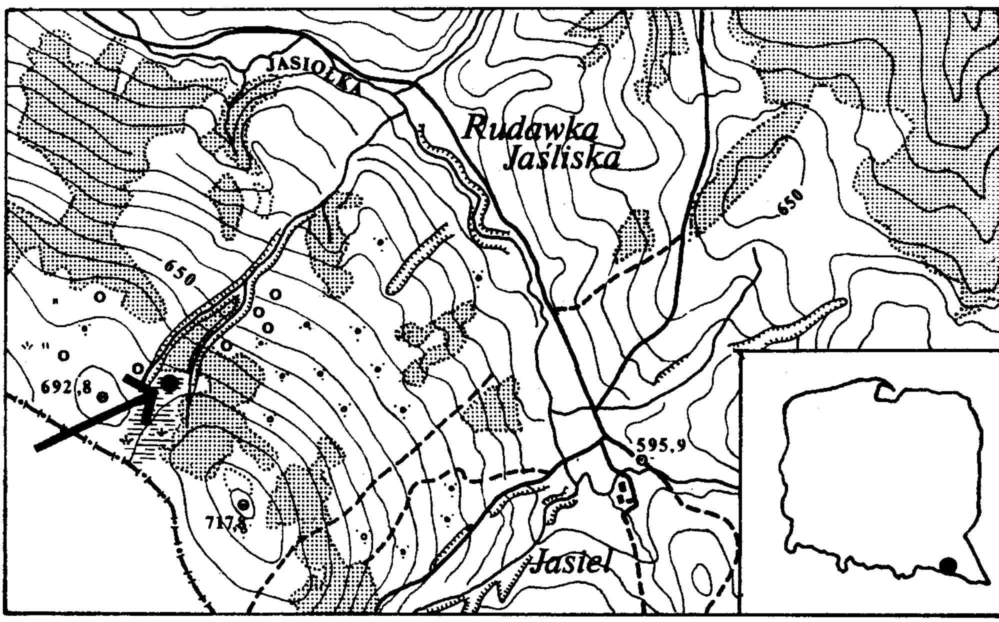

Fig. 1. Map showing the location of Jasiel mire

of the organogenic sediment being about 2 m. The peatbog was drained by several ditches. On its surface there grow clumps of *Salix* sp. div., *Alnus glutinosa*, *A. incana*, *Betula verrucosa*, *Frangula alnus*, *Juniperus communis*, *Vaccinium vitis-idaea*, *V. myrtillus* and above all *Phragmites communis* and *Molinia coerulea*, which form large groups. Mosses of the genera *Sphagnum* and *Polytrichum* overgrow small areas forming a mosaic. Degraded meadow (pasture) communities on a mineral substratum extend south and west of the peatbog. In the north and east a dense fir-beech forest comes near the edge of the peatbog. In the north the peatbog is drained by several streamlets which dissect the projecting rocky bank supporting the sediment layers lying at the bottom of the peatbog. The peatbog is situated within the lower montane forest zone with beech and fir-beech forests now prevailing. The climatic conditions are characterized by the following data: mean annual temperature — ca 5.5°C, mean daily temperature — 5°C, mean annual maximum temperature — 9.7°C, mean annual minimum temperature — 2.3°C, vegetational season — ca 200 days (Hess et al. 1976).

PALAEOECOLOGICAL STUDY

Methods

A series of sounding borings were made in the peatbog to determine the thickness of the organogenic sediments. A maximum organogenic sediment thickness of ca 2 m was found over an area of several hundred square metres about 60 m away from the northern edge of the peatbog and west of the main drainage ditch. Two cores were taken, using the Russian borer 5 cm in diameter, at a distance of 60 m from the northern edge of the peatbog and the forest and about 10 m west of the drainage ditch, in 1972 and 1981. One core was obtained in 1972. In 1981 three borings were performed 0.5 m apart in more or less the same place, and 5 segments, 0.5 m long, were taken from each of them. The results of palynological analyses of the core from 1972 are presented in Fig. 4. From one of cores collected in 1981, samples, 1 cm^3 in volume, were taken at 5 cm intervals for palynological analysis, and the remaining material was secured in 5-cm segments for ^{14}C dating. The material from borehole 2 was divided into sections 5 cm long and washed in order to obtain macroscopic plant remains. The core of borehole 3 was wrapped in plastic film and stored. No determinable fruits, seeds and leaves were found in sediment samples examined for macroscopic plant remain content. The 1-cm^3 sediments samples (40 samples from the borehole of 1972, Fig. 4, and 50 from the borehole of 1981, Fig. 2, 3) were treated by Erdtman's acetolysis, two standard pollen pellets of *Lycopodium* being added in the core of 1981 (Stockmarr 1971). Samples with mineral content were treated with HF prior to acetolysis. At least 400 pollen grains of trees and shrubs and the remaining sporomorphes were counted and identified. The calculation of percentage values was based on the pollen sum of trees, shrubs, dwarf shrubs, and herbs (P). The sporomorphs of aquatic, swamp and cryptogamous plants were excluded. The basis of the calculation of percentage values for the sporomorphs excluded from the sum of pollen was the sum of all the sporomorphs (without the spores of *Lycopodium* and *Sphagnum*, Fig. 2). The AP sum was used as the basis for the calculation of percentage values for the core of 1972 and AP+NAP (without *Sphagnum*) for all the other sporomorphs. The concentration of sporomorphs was calculated by the method described by Stockmarr (1971) only for the core of 1981.

After the completion of pollen analysis 6 levels were selected in the sediment core of 1981 for ^{14}C dating. This examination was carried out in the Laboratory of the Institute of Physics, Silesian Technical University at Gliwice, in 1985. The following age determination were obtained (uncorrected years B. P.):

Gd — 2330 Jasiel 7/35 cm 600 ± 60
Gd — 1945 Jasiel 20/100 cm 4570 ± 50
Gd — 2332 Jasiel 23/115 cm 4960 ± 90
Gd — 2333 Jasiel 31/155 cm 9270 ± 116
Gd — 1847 Jasiel 36/180 cm 9880 ± 120
Gd — 1846 Jasiel 43/215 cm 10340 ± 110

There are no reservations concerning these results.

Stratigraphy of sediments

A simplified Troels-Smith's (1955) system is used in the description. The sequence of layers in the profile collected in 1981 is as follows:

0—20 cm	peat, light-brown, moderately decayed, passing into living turf of *Sphagnum* peat at top, with many pieces of plant tissues (including small wood fragments). Th^{2}4, Dl +
20—118 cm	peat, black-brown, heavily decayed, with many pieces of plant tissues (*Phragmites* and other *Gramineae*, rootlets of *Carex*, small pieces of wood), somewhat loamed at floor. Ph^{3}4, Ag +
118—142 cm	clay, light-brown when freshly taken, dark-grey when dried, hard, with many pieces of plant tissues (chiefly *Phragmites*). As 3, Th^{3}1, Ag +
142—152.5 cm	peat, black-brown, heavily decayed, with many pieces of plant tissues (mainly *Phragmites* and other *Gramineae*, rootlets of *Carex*), compact when dry, somewhat loamed. Th^{3}4, As + + +, Ag +
152.5—161 cm	clay, dark-grey, compact, shrinking little when dry, with many interlayers of plant tissues. As 3, Th^{3}1, Ag +
161—188 cm	peat with gyttja, dark-brown, heavily decayed, compact when dry, with many pieces of tissues of *Phragmites* and other *Gramineae*, rootlets of *Carex*; fairly large wood piece of *Salix* sp. at 170—175 cm. Th^{3}1—2, Ld + —2, Ag +, As +, Sh 1 IV
188—197.5 cm	peat with gyttja, dark-brown, heavily decayed, matted, with many pieces of plant tissues and rootlets and with flat crumbles of flysch rock, up to ca 1 cm; somewhat loamed. Th^{3}2, Ld 2, As + +, Gg +, Ag +

197.5—217 cm	peat with a small admixture of gyttja, dark-brown, heavily decayed, strongly matted, little resilient, with many pieces of *Phragmites* and other *Gramineae* and with rootlets of *Carex* (some rootlets of cf. *Carex gracilis*), loamed. $Th^3 2$—3, Sh 2, As +, Ld 1, Ag +
217—245 cm	clay, grey-brown, compact when dry, with pieces of flysch rock, up to ca 2 cm; large piece of wood of *Pinus cembra* at ca 230 cm. Ag 3, As 1, Sh + + +, Gg + +, IV
245—250 cm	clay, light-grey with rust-coloured patches when dry, with piece of flysh rock, up to ca 4 cm. As 2, Ag 2, Gg + + +

The division of the pollen diagram into local pollen zones and their description

The distinction of the local pollen zones was based on the percentage and characteristic occurrence of sporomorphs in the spectra of given sections of the percentage pollen diagram (Fig. 2) and on pollen concentration diagram (Fig. 3). The same criteria were applied for division as regards the core of 1972.

Pinus — *Gramineae* local pollen zone

Pinus (min. 14.57%, max. 28.24%), *Gramineae* (min. 21.83%, abs. max 59.81%) and *Cyperaceae* (abs. max. 37.23%) are dominant elements in the pollen spectra of this layer. *Pinus* type *haploxylon*, *Larix*, *Juniperus* and *Picea* are their constant components, but their pollen occur in very low percentages and do not form continuous curves. The *Alnus* pollen appears sporadically. *Betula* and *Salix* pollen form rising continuous curves, and within the herb pollen, *Filipendula* shows a similar tendency. The occurrence of *Pinus cembra* in situ is confirmed by the presence of a big piece of wood at a depth of 230 cm. The mineral sediment in the root portion of this layer was marked by a very low pollen frequency so the calculation of the spectra was relinquished at two levels.

A radiocarbon date of 10340±110 years B. P. was obtained for the sample at a depth of 215 cm, i.e. at the floor of the organogenic sediments.

Salix — *Betula* — *Artemisia* local pollen zone

The lower boundary of this zone is marked by a tendency for some curves, above all, those of *Pinus*, *Betula*, *Salix*, *Artemisia* and *Chenopodiaceae* to rise. The *Pinus*, *Betula* and *Salix* concentration curves show analogous tendencies.

The absolute maximum percentage values of *Salix* — 30.5%, *Artemisia*

— 9.79 %, *Chenopodiaceae* — 1.51 % and *Ranunculaceae* — 13.41 %, are a characteristic feature of this zone and so is the first culmination of *Betula* — 13.75 %. *Pinus* type *haploxylon*, *Larix*, *Juniperus*, *Picea* and *Alnus* are still present in the spectra. *Ulmus*, *Corylus* and *Alnus* tend to form continuous curves, particularly in the top samples. *Gramineae* pollen curve decreases considerably (9.81 %).

The floor part of this layer was ^{14}C dated at 9880±120 B. P. and the root part at 9270±160 B. P.

Pinus — *Betula* — *Polypodiaceae* local pollen zone

The lower boundary is marked by the maximum value of *Pinus*, the rise of *Betula* and decline of *Salix* curve and the rising *Picea*, *Alnus*, *Ulmus* and *Corylus* curves. In this zone the percentage values of *Pinus* (30.7 %), *Betula* (17.06 %), *Picea* (4.59 %), *Filipendula* (33.42 %) and *Polypodiaceae* (19.39 %) pollen achieve their absolute maxima. The *Ulmus* and *Corylus* curves show a very distinct tendency to rise. The continuous but low *Quercus* and *Tilia* curves make their beginnings. The *Cyperaceae* reach an absolute minimum (0.45 %). The *Gramineae* curve tends again to rise. The general pollen concentration increases distinctly, notably in the case of such taxa as *Betula*, *Ulmus* and *Corylus*.

Corylus — *Ulmus* local pollen zone

The lower boundary is marked by a distinct fall in the *Pinus*, *Betula*, *Salix* and *Picea* pollen curves and rise in the *Corylus*, *Alnus* and *Quercus* curves.

The zone is characterized by the absolute maximum of *Corylus* (27.65 %), relatively high percentage values of *Ulmus* (6.33 %, 7.17 %) and high concentration of *Pinus* pollen, (its percentage values tending however to decrease). A rapid rise in concentratoin for *Ulmus*, *Corylus*, *Quercus* and *Tilia* pollen is very characteristic. As regards the herbs, the concentration of the *Cyperaceae*, *Gramineae* and *Filipendula* pollen and *Polypodiaceae* spores also increases very much.

Ulmus — *Quercus* — *Tilia* local pollen zone

The further downward tendency observed in the percentage curves of *Pinus* and *Betula* pollen and a distinct fall in *Corylus* mark the lower boundary of this zone. There is a rise in the *Ulmus* curve and also a gentle but systematic rise in the *Quercus* curve.

This zone is characterized by the absolute maxima of percentage values for *Ulmus* (10.60 %), *Quercus* (4.96 %), *Tilia* (2.32 %) and *Fraxinus* (2.32 %), the percentage of *Corylus* being still relatively high (13.5—17.2 %). The course of the percentage curves of these taxa is fairly even, without major fluctuations.

There is a distinct upward trend in the *Alnus* curve (max. 4.54 %). The presence of *Fagus* is represented by a continuous low curve and so is that of *Carpinus* in the top portion. The maximum pollen concentration is also a characteristic feature of the zone. *Pinus*, *Betula*, *Tilia*, *Gramineae*, *Filipendula* and *Artemisia* pollen achieve their maximum concentrations for the whole profile.

Two ^{14}C dates were obtained for this layer: 4960±90 years B. P. for the floor sample and 4570±50 years B. P. for the top one.

Quercus — *Carpinus* local pollen zone

The distinct rise of the percentage pollen curves for *Alnus*, *Fagus* and *Carpinus*, the beginning of the continuous *Abies* curve and a pronounced tendency of *Fraxinus* curve to decline form the lower boundary of this zone.

The systematic though gentle decrease of *Ulmus*, *Corylus* and *Tilia* curves and the very low values of *Pinus* are characteristic features of this zone. The *Fagus* curve rises and so does the curve for *Abies* but far more gently. *Carpinus* has an absolute maximum (4.37 %) here. The course of the *Alnus* curve is fairly even and the *Gramineae* curve rises distinctly. The curve of general pollen concentration shows a continuous though mild downward tendency with the increasing concentrations of *Fagus* and *Carpinus* pollen.

Fagus — *Abies* local pollen zone

The lower boundary is marked by the rise of *Fagus* curve to the maximum values and by a clear growth tendency in the *Abies* and *Sphagnum* curves.

The root portion of the sediments was ^{14}C dated at 600±60 years B. P. This zone is bipartite: the *Fagus* — *Abies* subzone and the *Alnus* — *Sphagnum* subzone can be distinguished. The boundary between them is placed of a distinct rise in the *Alnus* and *Sphagnum* percentage values and the absolute maximum of *Abies*.

Fagus — *Abies* subzone

This subzone is characterized by the absolute maximum of *Fagus* (18.49 %), whose percentage curve has a regular even course. The *Carpinus* curve does not show any major fluctuations, as well. The *Abies* and *Sphagnum* curves rise systematically towards their maximum values. *Alnus* (max. 5.71 %) and *Quercus* (max. 3.81 %) curves have an even course at a relatively high level. The *Ulmus* and *Corylus* curves decline gently and systematically. The curves of *Plantago lanceolata*, *Rumex* and *Secale* rise. A very slight rise in the percentage pollen values of *Artemisia* (1.11 %) and *Chenopodiaceae* (0.30 %) can be observed too.

Alnus — *Sphagnum* subzone

In this subzone the *Abies* curve reaches its absolute maximum (7.24%), the *Sphagnum* curve shows relatively high values (ca 10%) and forms a distinct peak (15.67%) in the middle part of this layer. The rise of *Alnus* pollen curve (max. 34.5%), with a tendency towards an absolute maximum, is characteristic. The pollen of synanthropic plants form already continuous though low curves.

A more or less regular mean pollen concentration is characteristic of the whole of this local pollen zone except for one level at which it is somewhat higher.

Alnus — *Secale* local pollen zone

The lower boundary of this zone is fixed on the basis of the maximum rise of the *Alnus* curve and the steep fall of the *Fagus*, *Carpinus*, *Abies* and *Quercus*.

This zone is characterized, above all, by the absolute maximum of *Alnus* (75.68%), accompanied by a marked fall in the *Gramineae* percentage curve (abs. min. 7.45%). The *Betula* curve shows a slight upward tendency. The *Fagus* and, to a much lower degree, *Quercus* and *Corylus* curves, after a preceding fall, also show a rising trend, and so do the *Gramineae* and *Sphagnum* curves. The fall of the percentage pollen curves of nearly all taxa is here evidently caused by the over representation of *Alnus* pollen. The most distinct upward tendencies in this zone characterize the percentage curves of *Plantago lanceolata* (max. 1.41%), *Rumex* (max. 0.50%) and *Secale* (max. 0.64%), although their percentage values are still very low. The concentration curve descends regularly.

HISTORY OF CHANGES IN NATURAL ENVIRONMENT

History of vegetation in the region of the peatbog at Jasiel during the last 10300 years

The reconstruction of vegetational changes in the surroundings of peatbog at Jasiel (Low Beskid Mts., Carpathians) is based on the pollen analytical results obtained from two profiles and the radiocarbon dates of six levels of the profile collected in 1981.

The composition of pollen spectra from the floor layers of sediments makes it possible to define the vegetation that accompanied the deposition of these layers as the vegetation of open areas. This is indicated especially by the AP NAP percentage ratio (AP forms less than 40%). A fragment of *Pinus cembra* wood found at the floor of the organogenic sediments indicates its growing in situ. Rather low percentage values of pollen of *Pinus cembra*, *Larix*, *Juniperus*, *Picea* as well as *Pinus* type *sylvestris*, *Betula* and *Salix* indicate that these trees and shrubs have already played a certain role in the landscape. Representants of *Gramineae* (tissue of *Phragmites*), *Cyperaceae* (rootlets of *Carex* sp. and of *Carex* cf. *gracilis* were found), *Rosaceae Ranunculaceae*, *Compositae*, *Umbelliferae* families and *Filipendula ulmaria* were dominant herbs, recording, the presence of swamps communities mainly. A relatively small extent of xeric communities can be inferred from the not very high percentage values of *Artemisia* and *Chenopodiaceae* and the lack of other indicators of this type of biotopes.

Both, the ^{14}C date of 10340±110 B. P. for the bottom portion of the organogenic sediments in the middle part of the *Pinus-Gramineae* local pollen zone and the general character of vegetation are indicative of the closing of time late glacial (Younger Dryas).

The next stage of the vegetation development (*Salix-Betula-Artemisia* local pollen zone) still has many traits of the previous period, that is, some contribution of *Pinus haploxylon*, *Larix*, *Juniperus*, *Picea* and *Alnus* pollen to the spectra. The organogenic sediments contain a relatively large admixture of inorganic material, and alternate with mineral layers, what suggests a humid climate with high rainfall and deflation processes, removing mineral material from the slope. This stage is characterized by a distinct tendency for the forest communities to close. In the AP to NAP ratio AP is dominant (from 45 to above 60%). It is chiefly composed of *Pinus* type *sylvestris*, *Betula* and *Salix* pollen. The expansion and closing of these trees are also confirmed by their pollen concentration curves, although the cumulative concentration curve shows no significant changes as yet. A piece of *Salix* wood at a depth of 170 cm is a direct evidence of its presence in situ.

The fluctuations of *Cyperaceae*, *Gramineae* and *Filipendula* pollen values may have been connected with the fluctuations of the ground-water level. The maximum values of *Artemisia* and *Chenopodiaceae* pollen indicate an increasing role of plant communities in rather dry habitats. It is hard to interpret the high values of *Ranunculaceae* (13.41%) in that period in respect of their ecological significance, for it may represent the species of both dry and very damp biotopes.

Two ^{14}C dates mark the time limits of the phenomena discussed above. A sediment sample from the bottom layer was dated at 9880±120 years B. P. and that from the top layer at 9270±160 years B. P. Just above this date but still within the limits of the *Salix-Betula-Artemisia* local pollen zone the continuous *Ulmus*, *Corylus* and *Alnus* pollen percentage curves start rising, and their concentration curves rise also, evidencing the entering of these trees into the communities of the nearby surroundings.

The two earlier stages of vegetation development in the surroundings of the peatbog resulted in a considerable expansion of forest communities during *Pinus-Betula-Polypodiaceae* local pollen zone. These communities, may still have been rather loose, which is evidenced by the *Polypodiaceae* curve (abs. max. 30.78%); no spores of *Dryopteris thelypteris* were found. The *Pinus* type *sylvestris* (abs. max. 30.78%) and *Betula* pollen percentages (abs. max. 17.06%)

were high. Pollen of both these trees and *Polypodiaceae* spores show also high concentrations.

In this stage of the formation and closing of forest communities the spruce *(Picea)* also played an important role. Its curve reaches here an absolute maximum for the whole profile (4.59%). Although there are no direct evidence, its history in the Carpathians (Środoń 1967) and especially in the neighbouring Bieszczady Mts. (Ralska-Jasiewiczowa 1980) permits to suppose that the spruce grew in the Low Beskid Mts. mainly in damp and peaty habitats.

Ulmus, rising from 0.12 to 6.79% and, to a smaller degree, *Corylus* also become important components of the forest communities what is confirmed by the pollen concentration curves. *Alnus* shows no expansive tendencies yet, and *Quercus* appears in the area (the beginning of its continuous curve). The dominant trees and shrubs, forming dense forests, noticeably reduced the role of *Salix*.

Changes occurring in the herbaceous vegetation consist chiefly of the reduction of swamps communities and of the open communities of heliophilous plants. These changes are reflected by the impoverishment of floristic composition of pollen spectra. The deposition of a loam layer shown in the profile of sediments in this phase suggests a period of increased rainfall (Starkel 1960, 1977; Gil et al. 1974).

The following stage of the vegetation development (*Corylus-Ulmus* local pollen zone) brings an essential change in the composition of forests. *Pinus* and *Betula* are already of minor importance. The dominant species are *Corylus* (abs. max. 27.18 and 27.65%) and *Ulmus* (6.33—7.17%). *Quercus*, more slowly *Alnus* (0.60—2.56%) and *Tilia* (1.15%) grow in importance. *Fraxinus* appears in the area and the first pollen grains of *Fagus* are signs of its approaching. In the herbaceous communities the *Gramineae* (24.32%) and *Cyperaceae* (6.27%) occur in the largest numbers. The *Polypodiaceae* do not play a major role any longer and the frequency of *Filipendula* falls markedly (23—13%). The aquatic plants *(Potamogeton)* are present in small quantities. In spite of a large admixture of organic matter (pieces of *Phragmites* tissues) the sediment is here mineral (loam). The pollen concentration in the sediment is very high. The percentage values of *Pinus* and *Betula* are low but their pollen concentration is high. The concentration of *Quercus* and *Tilia* increases distinctly and that of *Alnus* at a considerably slower rate.

Further changes in the plant cover (*Ulmus-Quercus-Tilia* local pollen zone) go towards the growing importance of mixed deciduous forests composed of *Ulmus* (10.60%), *Quercus* (4.96%), *Tilia* (2.32%) and *Fraxinus* (2.53%). *Corylus* (13—17%) plays an important role in their understorey. *Fagus* (0.20—0.73%). *Acer* and *Carpinus* (0.95%) are new elements. In the herbaceous communities the *Gramineae* and *Cyperaceae* again show a small rise. A distinct enrichment of the swamp communities *(Potamogeton, Sparganium* and *Lysimachia)* is visible.

The general pollen concentration attains the highest values with the maximum pollen concentration values of *Pinus* and *Betula* while their percentage values approximate to the minimum ones.

These changes in the plant cover take place within a time interval from 4960±90 to 4570±50 years B. P.

The changes of vegetation occurring in the region of the Low Beskid Mts. after ca 4500 B. P. include a slowly proceeding decrease in the *Corylus* and *Ulmus* role and the spread of *Carpinus* (abs. max. 4.37%), *Fagus* (max. 8.19%) and *Abies* (max. 0.71%). They enter mixed deciduous forests, in which *Quercus*, *Tilia*, *Fraxinus*, *Acer* and *Alnus* keep playing an important role.

Gramineae pollen prevailing in NAP (above 40%), represents mainly *Phragmites*. The proportions of *Filipendula* and *Lysimachia* are also noticeable. The aquatic plants are represented by *Potamogeton*.

The higher rate of sediment accumulation is probably responsible for the decline in the general pollen frequency curve, although the dominant elements are still characterized by high values.

The formation of fir-beech and hornbeam forests is completed during the next phase (*Fagus-Abies* local pollen zone), fir and beech forming lower the montane forest zone and the hornbeam the zone of foothill forests.

The first distinct traces of human activity, that is rising continuous curves of *Plantago lanceolata*, *Rumex*, cf. *Cannabis* and *Urtica* are another characteristic feature of this place. The *Artemisia* and *Chenopodiaceae* pollen percentage values also rise in the spectra. The rapid increase of the *Alnus* curve should be ascribed to increasing human activity and the colonization of post-agricultural areas by *A. incana*, which nowadays often plays the role of a pioneer species in such habitats in the Carpathians (cf. Bieszczady Mts. — Ralska-Jasiewiczowa 1980). The destruction of hornbeam forests is illustrated by the decline in *Ulmus*, *Corylus*, *Tilia*, *Fraxinus* and *Acer* pollen curves and the fluctuation of the *Quercus* curve. The fir-beech and high situated hornbeam forests did not suffer any serious harm still at that stage. Changes in anthropogenic indicators are the basis for the distinction of two local pollen sub-zones. The rising *Sphagnum* curve must be referred to the rising humidity of climate. The date of the top portion of this phase, 600±60 years B. P., fairly well corresponds with the historical phases of settlement from the 13th c. onwards.

The last stage of changes in the plant cover of this area (*Alnus-Secale* local pollen zone) comprises fluctuations in the tree and herb pollen values, which are connected with the human activity within the now prevailing plant communities. The influence of man's husbandry is reflected by the occurrence of pollen of cultivated and synanthropic plants. In the pollen diagram under study the curves for these plants are very low (abs. max. *Secale* — 0.64%, *Rumex* — 0.50%, *Plantago lanceolata* — 1.41%), which probably results from the type of farming, in which pasturage and animal breeding played an important role. Under the conditions of the increasing expansion of this type of farming *Fagus* and *Alnus* seem to be the stablest components of the plant cover.

LOCAL AND REGIONAL HISTORY OF THE VEGETATION OF THE LOW BESKID MTS. AT THE DECLINE OF THE LATE GLACIAL AND IN THE HOLOCENE

The results of studies on the fossil floras of the late glacial and the Holocene have been, as yet, published from the following localities in the region of the lowest depression in the Carpathian arch: Roztoki near Jasło (Szafer & Jaroń 1935; Szafer 1948), Cergowa Góra near Dukla (Więckowski & Szczepanek 1963), Besko near Sanok (Koperowa 1970). Kępa near Krosno (Gerlach et al. 1972) and Szymbark—Kamionka near Gorlice (Gil et al. 1972; Gil et al. 1974). As a contribution to the IGCP Project No 158 K. Harmata again carried out a palaeobotanic investigations of sediments in the region of Roztoki near Jasło (this volume). Several layers of sediments from Besko, Kępa, Szymbark—Kamionka and Roztoki were dated by the ^{14}C method. There is a comprehensive monograph of the area bordering on the Low Beskid Mts. in the east written by Ralska-Jasiewiczowa (1980), whereas in the west the nearest profiles analysed are those of a peatbog at Bryjarka (Pawlikowa 1965) and somewhat more distant peatbogs in the Nowy Targ Basin (Koperowa 1962; Obidowicz MS).

The sites in the Low Beskid Mts. and neighbouring Doły Jasielsko-Sanockie studied by the palaeobotanic methods are situated within the limits of two adjoining climatic-vegetational zones of the Carpathians and provide the bases for the investigation of the history of vegetation from the decline of the late glacial throughout the Holocene.

The occurrence of *Pinus sylvestris*, *P. cembra*, *Betula* type *alba*, *B. nana*, *Larix*, *Juniperus* and *Salix*, and of plants of dry habitats, also of importance here and represented chiefly by *Artemisia* and *Chenopodiaceae*, is a common feature of the plant cover of this region till the spread of trees and shrubs with greater thermal requirements.

The presence of *Pinus cembra* evidenced in situ gives the plant cover of this area a montane character and distinguishes it from late glacial floras from the lowlands.

Pinus sylvestris played an important role in the vegetation of the mountainous parts of the Low Beskid Mts. at that time. It was the codominant or dominant tree in the plant cover. As the deciduous trees appeared and expanded, *Pinus sylvestris* persisted in larger valleys, being a retreating species in higher situations.

Picea abies is another interesting species in this area. Its macroscopic remains found at the sites in Doły Jasielsko-Sanockie (Besko, Kępa — needles, Roztoki — seeds) are accompanied by very low slight percentage values in the pollen profiles (Roztoki, Besko, Kępa, Jasiel). In the Low Beskid the occurrence of spruce is very distinctly attached to peatbogs. The spruce played a certain role in these habitats in the initial stages of the formation of Holocene forest communities. In the younger Holocene it did not form a separate vegetational zone here and its distribution was clearly conditioned by the lack of suitable habitats. In the ranges of the East and West Carpathians, neighbouring on the Low Beskids, the spruce had a significant role in the forest communities during the climatic optimum of the Holocene. It was only the expansion of *Carpinus* and particularly of *Fagus* and *Abies* that reduced the area of its occurrence chiefly to the higher locations where it formed a separate vegetation zone (upper montane forest zone).

The occurrence of *Alnus* in the Doły Jasielsko-Sanockie region from the decline of the late glacial onwards is also confirmed by macroscopic remains (Roztoki — seeds) and, sometimes, by significant percentage values of pollen (Besko — 5%). As the formation of mixed deciduous forest proceeds, *Alnus* (probably *A. glutinosa*) is a forest-forming element in lower locations and valleys of the area studied. The marked restriction of *Alnus* role, as the grounds in the valleys deforested by man increase in area is a characteristic feature in its Holocene history. On the other hand, in the more humid climatic phases in the younger Holocene, *Alnus* (or more strictly *A. incana*) played a pioneer role in the colonization of the grounds situated on steeper and more humid slopes no longer cultivated by people.

In the younger Holocene *Abies*, *Carpinus* and *Fagus* are codominant elements of the forests of the Low Beskid Mts., just as they are in the other ranges of the Carpathians. In the pollen diagrams from sites in the Low Beskid region the continuous curves for *Carpinus* and *Fagus* begin nearly at the same time. It is the rule that *Carpinus* attains its maximum earlier, and later its frequencies decrease. The *Fagus* curves are, as a rule, much higher and indicate the essential role of this tree in the communities of the lower mountain forest zone in the young Holocene. The beginning of the continuous *Carpinus* and *Fagus* pollen curves precedes somewhat the date of 4500 years B. P. and usually precedes also the first traces of human activity. In a majority of the localities the continuous *Abies* curve begins much later, and attains significant values what corresponds with the role of this tree in the forests. The continuous *Abies* curve seems to coincide of ten with the first appearance of the culture pollen indicators. Human husbandry may have exerted a decisive influence upon the role of the hornbeam in the forest communities of lower situations, for these places were most convenient for settlement. In consequence, the percentage values of *Carpinus* pollen in pollen diagram were lower than these of *Fagus* or *Abies*, which occupied the higher lying areas, less suitable for farming. Starting from this stage, the increasingly large areas brought into cultivation by man as well as the type of forest exploitation had a great influence upon the vegetation. In the author's opinion however, human husbandry was not the decisive factor influencing the transformation of the plant communities in this region (Środoń 1985). The climatic changes constituted the primary factor.

The early appearance of *Carpinus* and *Fagus*, considerably preceding that of *Abies* and the very distinct dominance of *Fagus* indicate the closer connection of forest communities in the Low Beskid with those of the East than those of the West Carpathians. Also because of the minor role of Picea in the younger

Holocene the vegetation of the Low Beskids more resembles the plant cover of the Bieszczady Mts. than that of the West Beskids.

The herb curves in the pollen diagrams reflect clearly the local vegetation. The relatively low curves for synanthropic and cultivated plants in all the pollen diagram result not so much from the late penetration of these areas by human husbandry as rather from its pastoral-agricultural nature and the still existing large wooded areas (present forestation: ca 35—50%).

The noticeable differences in the sediment accumulation rate at some localities are possibly connected with the fluctuations of humidity. In the profile from Jasiel there are at least two distinct layers of loam separated by a several-centimetre-thick layer of peat.

The age of the first of them is determined by the date of the floor sample of the overlying peat, i.e. 9270±116 years B. P. The other loam layer is comprised between this date and that of 4960±90 years B. P. The second silty sediment layer, 35 cm thick, covers a time interval of nearly 4000 years and includes 3 local pollen zones (*Salix-Betula-Artemisia*, *Pinus-Betula-Polypodiaceae* and *Corylus-Ulmus*). The floor of this layer is palynologically refered to the Boreal period. The period following 8500 B. P. known in the Carpathians and their foreland as a period of active hydrological processes resulting in the arising of landslips (e.g. Szymbark—Kamionka), inundation of depressions (e.g. Besko, Roztoki), intercalations of flood mud in the sediments of peatbogs on river terraces e.g. Tarnawa in the Bieszczady Mts. (Ralska-Jasiewiczowa 1980; Starkel 1975). A slower rate of sediment accumulation in peatbogs in this time interval can also be found outside the Carpathians (e.g. Słopiec in the Świętokrzyskie (Holy Cross) Mts. — Szczepanek 1982). In particular cases this slackening may have been connected with the movements of ground-water. In the mountains, especially on the slopes, we should also take into account the processes of solifluction which are closely associated with humid climatic phases.

ACKNOWLEDGMENTS

I wish to express my heartfelt thanks in the first place to Dr. R. Soja for suggesting the peatbog and helping me with boring in the field, Assist. Prof. M. Ralska-Jasiewiczowa for valuable remarks and discussions, Ms Z. Tomczyńska for the identification of wood samples, Ms D. Nalepka for the identification of plant tissues from several layers and Ms B. Nowaczyńska for the preparation of samples for palynological analyses and another technical help.

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REFERENCES

Gerlach T., Koszarski L., Koperowa W. & Koster E. 1972. Sediments lacustres postglaciaires dans la depression de Jasło-Sanok. Studia Geomorph. Carpat. — Balcan, 6: 37—61.

Gil E., Kotarba A. & Szczepanek K. 1972. The site II-3 the landslide at Szymbark-Kamionka. Exc. Guide — Book. INQUA Holocene Symp. 1, Poland: 42—45.
Gil E., Gilot E., Kotarba A., Starkel L. & Szczepanek K. 1974. An early Holocene landsliche in the Beskid Niski and its significance for palaeogeographical reconstructions. Studia Geomorph. Carpat. — Balcan, 8: 69—83.
Grodzińska K. & Pancer-Kotejowa E. 1965. Zbiorowiska leśne Pasma Bukowicy w Beskidzie Niskim. (summary: Forest communities of the Bukowica Range (Low Beskids, Polish Western Carpathians). Fragm. Flor. Geobot., 11 (4): 563—599.
Grodzińska K. 1968. Rośliny naczyniowe Pasma Bukowicy (Beskid Niski). (summary: The vascular plants of the Bukowica Range (Low Beskids, Polish Western Carpathians). Fragm. Flor. Geobot., 14 (1): 3—82.
Gumiński R. 1950. Ważniejsze elementy klimatu rolniczego Polski Południowo-Wschodniej. Wiad. Służby Hydrol. Meteorol., 3 (1): 57—113.
Harmata K. 1987. Late — Glacial and Holocene history of vegetation at Roztoki and Tarnowiec near Jasło (Jasło — Sanok Depression). Acta Palaeobot., 27 (1):
Hess M. 1965. Piętra klimatyczne w polskich Karpatach Zachodnich. (summary: Vertical climatic zones in the Polish Western Carpathians). Zesz. Nauk. UJ, 115, Prace Geogr., 11, Prace Inst. Geogr., 33: 1—267.
Hess M., Niedźwiedź T. & Obrębska-Starklowa B. 1976. Stosunki termiczne Beskidu Niskiego (metodyka charakterystyki reżimu termicznego gór). Inst. Geogr. i Przestrzennego Zagosp. PAN. Prac. Geogr., 123: 1—101.
Klimaszewski M. 1935. Z fizjografii Beskidu Niskiego. Wierchy, 13: 89—93.
— 1946. Podział morfologiczny Południowej Polski. Czas. Geogr., 17 (3—4): 133—182.
Koperowa W. 1962. Późnoglacjalna i holoceńska historia roślinności Kotliny Nowotarskiej (summary: The history of the Late Glacial and Holocene vegetation in Nowy Targ Basin). Acta Palaeobot., 2 (3): 1—57.
— 1970. Późnoglacjalna i holoceńska historia roślinności wschodniej części Dołów Jasielsko-Sanockich (summary: Late Glacial and Holocene history of the vegetation of the eastern part of the "Jasło-Sanok Doły" Flysch Carpathians). Acta Palaeobot. 11 (2): 1—42.
Machnik J. 1960. Ze studiów nad kulturą ceramiki sznurowej w Karpatach Polskich (summary: From studies on the Corded-Ware Culture in the Polish Carpathians). Acta Archaeol. Carp., 2 (1—2): 55—86.
— 1962. Uwagi o związkach i chronologii niektórych znalezisk kultury ceramiki sznurowej w Karpatach (résume: Observations sur les connezitis et la chronologie de certaines trouvialles de la civilization de la céramique coroleé dans les Carpates). Acta Archaeol. Carp., 4 (1—2): 91—107.
Obidowicz A. (MS). Postglaziale Vegetations, Klima- und Besidlungsgeschichte der Westkarpaten.
Pawlikowa B. 1965. Materiały do postglacjalnej historii roślinności Karpat Zachodnich. Torfowisko na Bryjarce (summary: Materials for the Postglacial history of vegetation of the West Carpathians. Peat-bog on the Bryjarka). Folia Quatern., 18: 1—9.
Pawłowski B. 1972. Szata roślinna Gór Polskich. In: Szafer W. Zarzycki K. (eds.). Szata Roślinna Polski, 2. PWN, Warszawa.
Ralska-Jasiewiczowa M. & Starkel L. 1975. The leading problems of palaeogeography at the Holocene in the Polish Carpathians. Biul. Geolog., 19: 27—44.
Ralska-Jasiewiczowa M. 1980. Late-Glacial and Holocene vegetation of the Bieszczady Mts. (Polish Eastern Carpathians). Inst. Bot. PAN, Warszawa—Kraków.
Starkel L. 1960. Rozwój rzeźby Karpat fliszowych w holocenie. Prace Geogr. IG PAN, 22: 1—239.
— 1972. Charakterystyka rzeźby polskich Karpat i jej znaczenie dla gospodarki ludzkiej. Komitet Zagosp. Ziem Górskich PAN, 10: 71—148.
— 1977. Paleogeografia holocenu. PWN, Warszawa.

Stockmarr J. 1971. Tablets with spores used in absolute pollen analysis. Pollen et Spores. 13 (4): 615—621.
Szafer W. & Jaroń B. 1935. Plejstoceńskie jezioro pod Jasłem (summary: Pleistocene Lake near Jasło in Poland). Starunia, 1: 1—20.
Szafer W. 1948. Późny glacjał w Roztokach pod Jasłem (summary: Late — Glacial in Roztoki near Jasło — West Carpathian Mountains). Starunia, 26: 1—29.
Szczepanek K. 1982. Development of the peat-bog at Słopiec and the vegetational history of the Świętokrzyskie (Holy Cross) Mts. in the last 10000 years. Acta Palaeobot., 22 (1): 117—130.
Sulimirski T. 1955. Polska przedhistoryczna. Cz. 1. Gryf Printers, London.
— 1957—1959. Polska przedhistoryczna. Cz. 2. Gryf Printers, London.
Środoń A. 1967. Świerk pospolity w czwartorzędzie Polski (summary: The common spruce in the Quaternary of Poland). Acta Palaeobot., 8 (2): 1—59.
— 1985. *Fagus* in the Forest History of Poland. Acta Palaeobot., 25 (1, 2): 119—137.
Świdziński H. 1953. Karpaty fliszowe między Dunajcem a Sanem. Reg. Geol. Polski. Karpaty. Tektonika, 1 (2): 362—422.
Święs F. 1980. Zarys porównawczej geobotanicznej charakterystyki Beskidu Niskiego z Bieszczadami i Beskidem Sądeckim. Ann. Univ. Mariae Curie-Skłodowska, sec. C, 35 (8): 77—103.
— 1982. Charakterystyka geobotaniczna lasów Beskidu Niskiego. Analiza i synteza (summary: Geobotanical characterization of the Lower Beskid forests. Analysis and synthesis). UMCS Wydz. Biol. i Nauk o Ziemi, Lublin.
Troels-Smith J. 1955. Characterization of unconsolidated sediments. Danm. Geol. Unders., IV, 3 (10): 1—73.
Więckowski S. & Szczepanek K. 1963. Assimilatory pigments from subfossil fir needles (*Abies alba* Mid.). Acta Soc. Bot. Pol., 32: 101—111.
Żaki A. 1955. Początki osadnictwa w Karpatach Polskich. Wierchy, 24: 99—116.

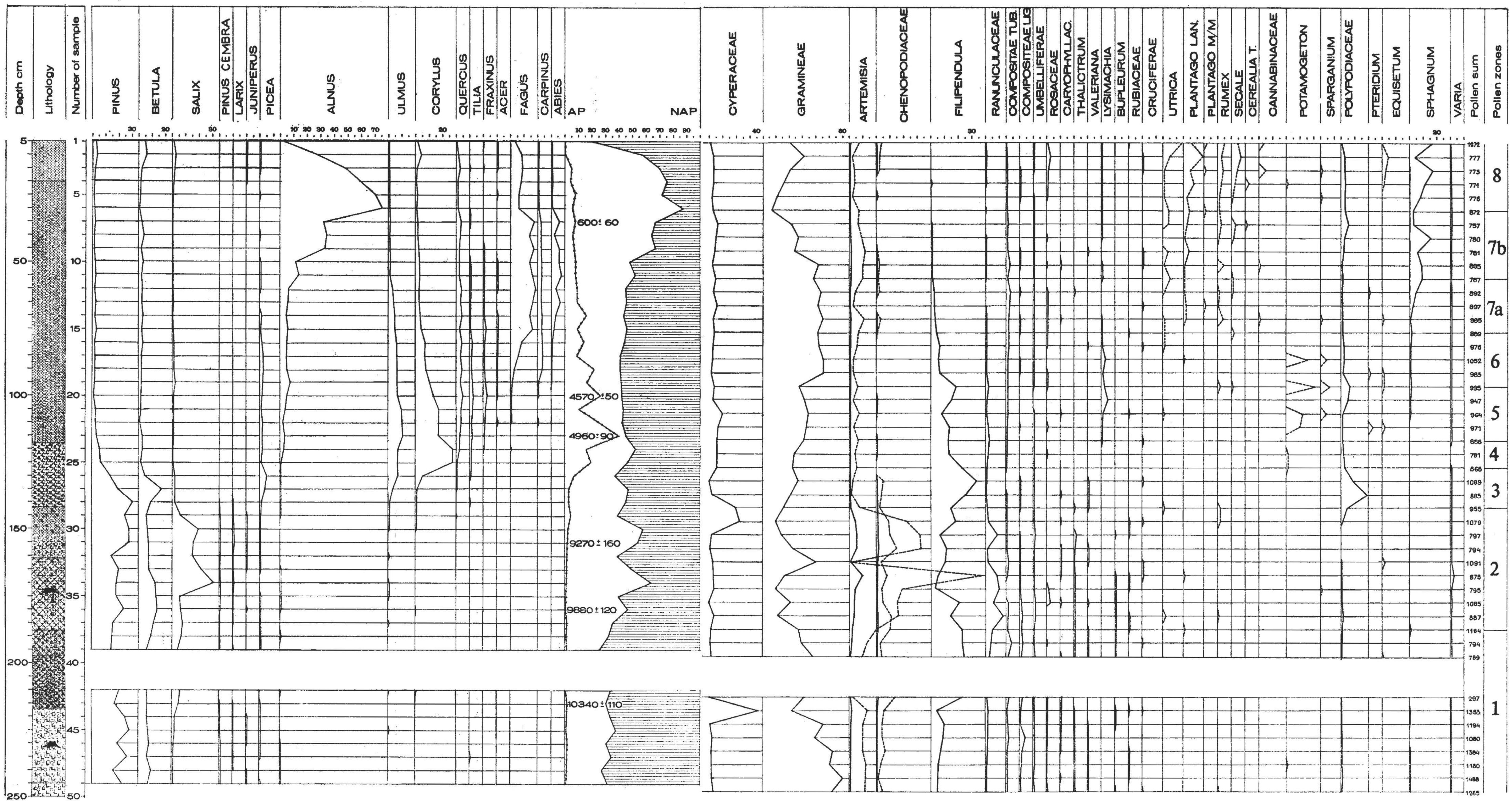

Fig. 2. Percentage pollen diagram from Jasiel mire (1981). Sume of trees, shrubs, dwarf shrubs and herbs pollen (P = 100%), excluding pollen of aquatics and swamp plants and spores, is a calculation base. The percentage values of excluded pollens have been calculated from P + taxon. Stratigraphic symbols according to Troels-Smith (1955) ------ percentage values of taxa multiplied by 10. -x-x-x values of general pollen frequency reduced 100 times

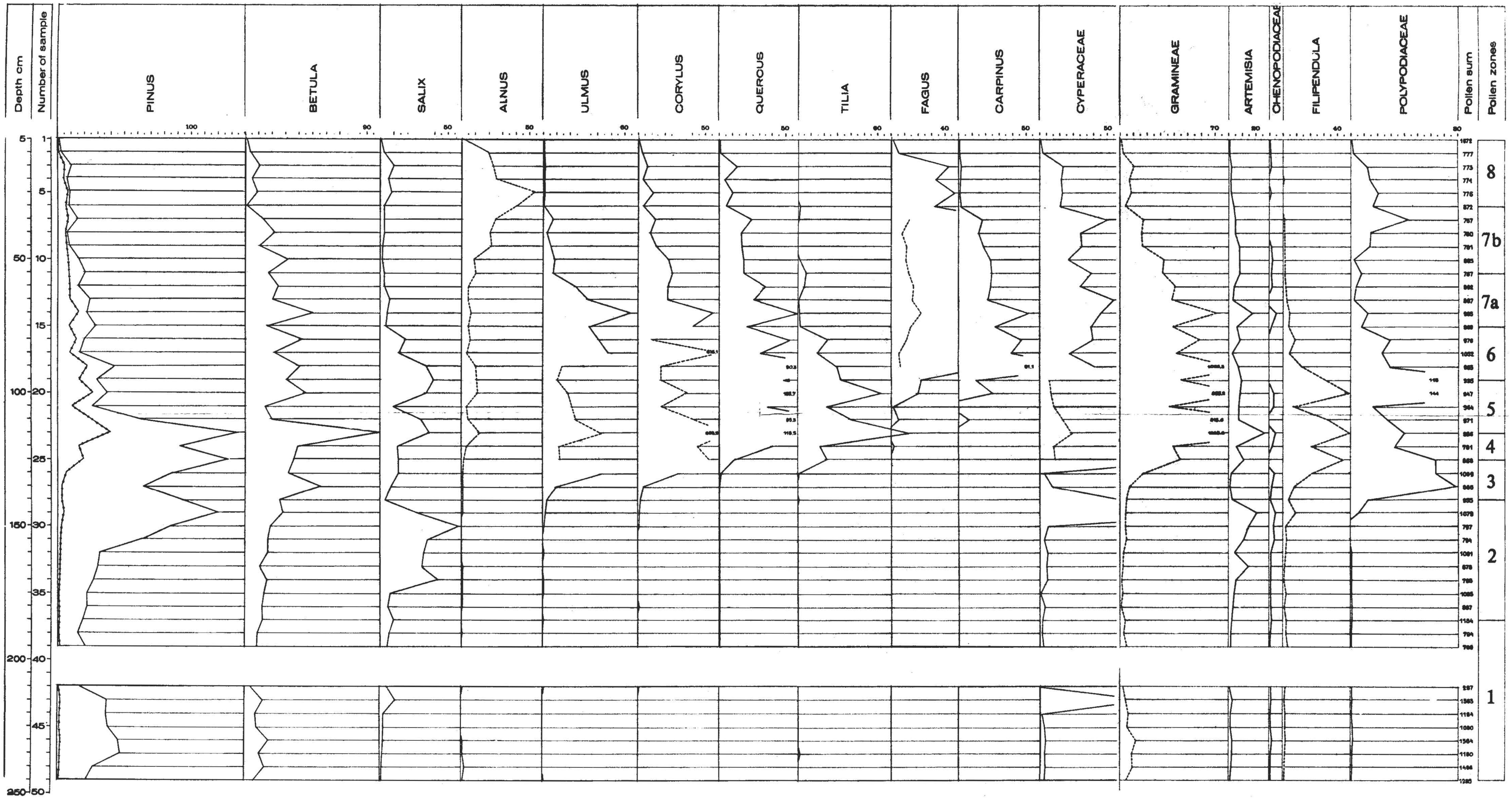

Fig. 3. Pollen concentration diagram from Jasiel mire (1981). ------ values of pollen concentration reduced 10 times. -x-x- values of general pollen frequency reduced 100 times

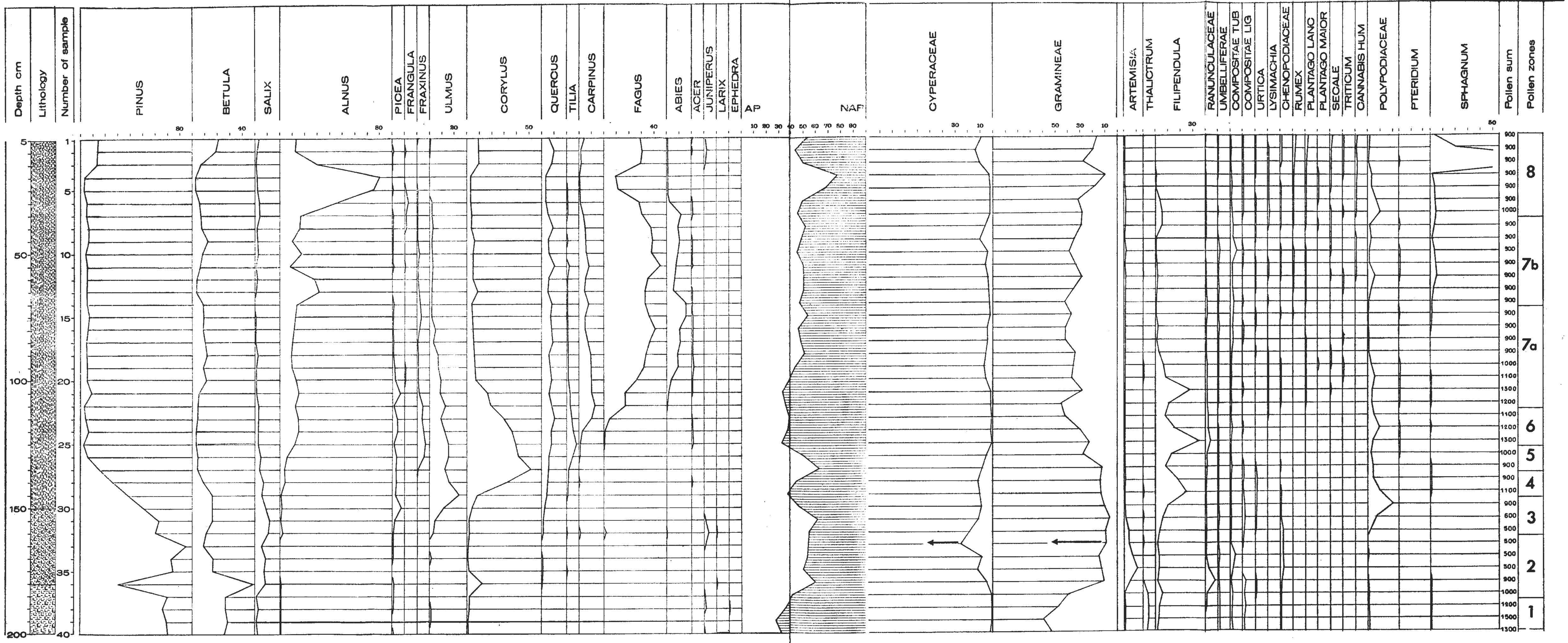

Fig. 4. Percentage pollen diagram from Jasiel mire (1972). Percentage values of trees, shrubs and dwarf shrubs have been calculated from the sum of their pollen (AP). Calculation base for NAP and *Sphagnum* is the sum of AP and NAP (exluding *Sphagnum*)