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ZOFIA BALWIERZ and S. ŻUREK

THE LATE-GLACIAL AND HOLOCENE VEGETATIONAL HISTORY AND PALEOHYDROLOGICAL CHANGES AT THE WIZNA SITE (PODLASIE LOWLAND)

Późnoglacjalna i holoceńska historia roślinności i zmiany paleohydrologiczne na stanowisku Wizna (Nizina Podlaska)

ABSTRACT. On the Wizna peatland which was selected as an experimental site for the IGCP-158B program, 5 bores (drillings) were carried out at various stratigraphic points of the deposit. The article contains detailed palynological materials concerning the lake profile of Maliszewo I. After examining the history of research of the Wizna site, the geomorphology of the peatland's surroundings were characterized. Next, the stratigraphy of the lacustrine deposits of the Maliszewo I profile was described on the ground of its physical properties (bulk density) and chemical properties (ash content, SiO_2, Ca, Mg). The stratigraphic analysis of the peat deposits of Wizna and a few datings of ^{14}C served as the basis for presenting the hydrological changes (the rise and lowering in the water level) which occurred in the Late Glacial period (13.000 years ago) and the Holocene. On the basis of the pollen analysis 10 pollen zones correlated with the Blytt-Sernander scheme were distinguished and characterized beginning from the Alleröd.

INTRODUCTION

The north-eastern part of Poland did not posses upto the present moment any reliable palynological materials based on modern research methods. In the winter of 1982, at the suggestion of Mr. Żurek and Mrs. Ralska-Jasiewiczowa the Wizna peatland was selected as an experimental site for the IGCP — 158B program since the place fulfills the requirements of the program (Berglund 1979). The Wizna site is located in the southern part of the Biebrza Urstromtal in the region where the Biebrza River flows into the Narwia River (Fig. 1). In the sediment of this vast (9000 ha) and deep (upto 6—7 m) peatland one can find all the basic types of low peats, and in its north-eastern part there is the overgrowing shallow Lake Maliszewskie (80 ha) with a very specific thickness of the gyttja layer; in the central part it can be upto 22.5 m.

In the summer of 1982 a group of researches (Balwierz, Więckowski, Żurek) made 5 borings on the peatland with a piston sampler and collected monoliths

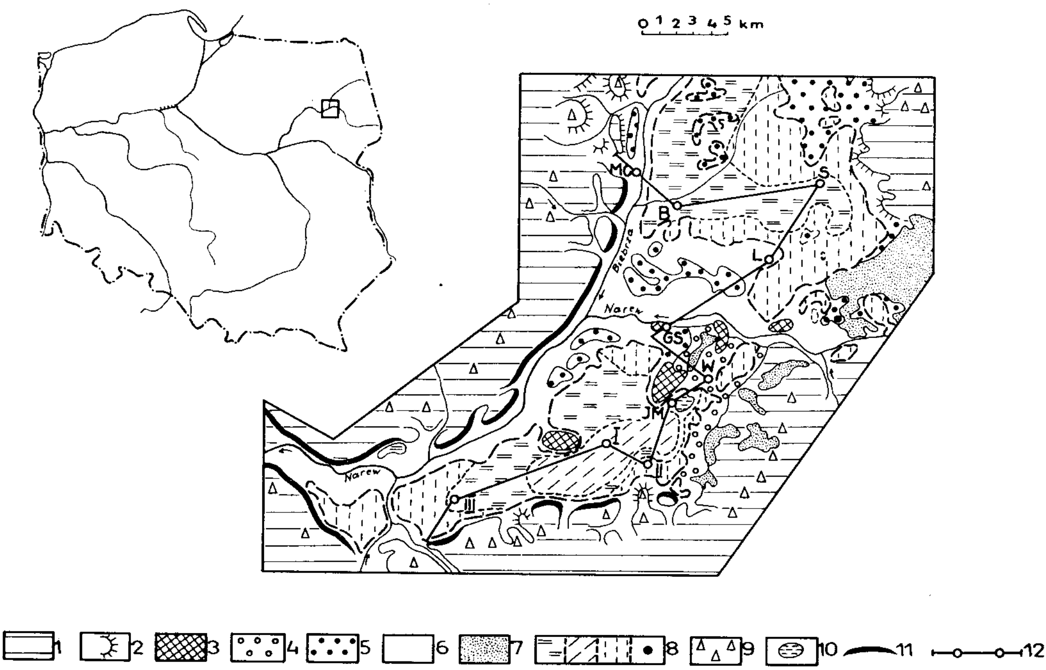

Fig. 1. The geomorphology of the Wizna site: 1 — old-glacial upland, 2 — upland slopes, 3 — uplant relic, 4 — higher outwash plain, 5 — urstromtal terrace, 6 — flood terrace, 7 — dunes, 8 — peatlands: a — reed and sedge deposits, b — moss fen deposits, c — forest and shrub fen deposit, d — raised bogs, 9 — kames, 10 — lake, 11 — slope, 10—20 m, 12 — the crossection of Koty-Mocarze. Profiles of cros-section: I (Wizna I), II (Wizna II), III (Wizna III), JM (Maliszewo I and II), W (Wieczorki), GS (Strękowa Mt.), L (Laskowiec), S (Stójka), B (Burzyn), Mc (Mocarze)

of moss fen peats (Wizna I), alder peats (Wizna II), reed-swamp peats (Wizna III), moss fen-reed-swamp peats (Maliszewo II) and lake gyttjas (Maliszewo I). In the IMUZ Laboratory samples were prepared for pollen analysis, for ^{14}C dating and for the analysis of the bulk density. The first results of this research were presented in 1983 during the 6th meeting of thee IGCP — 158B working team at Szymbark. Here Balwierz presented the first results of the pollen analysis of the bed of the Wizna I pıofile and Żurek characterized the rate of peat and gyttja accumulation in the radiocarbon dated profiles of the Polish peatlands, including the 5 profiles of Wizna (Żurek 1986d). The present paper contains mainly materials referring to the inshore Maliszewo I profile. Z. Balwierz wrote the chapter concerning the results of the pollen analysis, and S. Żurek wrote the remaining chapters.

THE HISTORY OF RESEARCH OF THE WIZNA SITE

The first researches on the Wizna peatlands were carried out in the late 1940's by Professor Tołpa's team (1951). A special identification of brown-mosses at some points of the deposit was made by Jasnowski. On the bank of

Lake Maliszewskie he distinguished lacustrine facies of Meesea triquetra in the *Caricetum diandrae* association (Jasnowski 1959) and in the brown-moss peat layer in the calcareous gyttja he found remains of *Calliergon trifarium* Kindb (Jasnowski 1957). In 1953 during special probings of the Wizna deposits, a 17 m bore was made in the gyttja of central part of Lake Maliszewskie. Simultaneously hydrological and geotechnical research was carried out (Kollis 1957). In the 1960's before the drainage of the peatland, the plant associations of Wizna were characterized (Pałczyński 1966); likewise Żurek wrote a monograph of the site based on a special identification of the stratigraphy of the deposits in 3 cross-sections (Żurek 1968). The stratigraphic research was extended over the entire Wizna area in the years 1969—1971 by the IMUZ Peatland Research Laboratory. In 1970 special research was carried out in the region of Lake Maliszewskie. In the winter 22-meter gyttja monolith was taken from the central part of the lake and in the summer a series of borings were made in the marginal zone by means of the Instorf sampler. Macroscopic, microscopic researches and chemical analysis showed that the gyttja in the central part of the lake has an identical stratigraphy as the gyttja from the western bank of the basin taken from a depth of 4.5 m (Maliszewo IX a and b profile). Here also the lacustrine sediments clearly show changes of the water level (Żurek 1975). The profile from the center of the lake was presented during the International Symposium of the Holocene Committee INQUA (Żurek & Więckowski 1972); whereas the problem concerning the development of fossil layes in the Biebrza Urstromtal shown in relation with the sediments of the Lake Maliszewskie was discussed during the II International Paleolimnological Symposium in Mikołajki (Żurek 1978). The first, though not complete materials concerning the pollen analysis of the Maliszewo and Wizna profiles were published by Stasiak (1979). The peats and gyttjas of Wizna already have a series of ^{14}C datings made mainly in the Politechnic Laboratory in Gliwice by M. Pazdur within the MRI-25 problem. "The changes of the natural environment in Poland". There are yet some investigations that are still being conducted — they concern chemical analysis of the gyttja of the Maliszewo IXb profile, and ion analysis of the waters of the lakes and peat bogs. In the 1980's a new phase of research began within the IGCP program which will be presented in the following chapter.

THE GEOMORPHOLOGY OF THE WIZNA SITE

The Wizna peatland lies in the north-eastern part of Poland, in the great slack of the Urstromtal, where once the glacial and river waters flowed to the west during the successive phase of the last glaciation. In the Wizna basin the axis of the Urstromtal runs in the south-west direction, and the depression becomes narrow till it becomes a narrow gap in the Łomża region (Fig. 1). This gap connects the Biebrza Urstromtal with the vast Kurpiowska Basin.

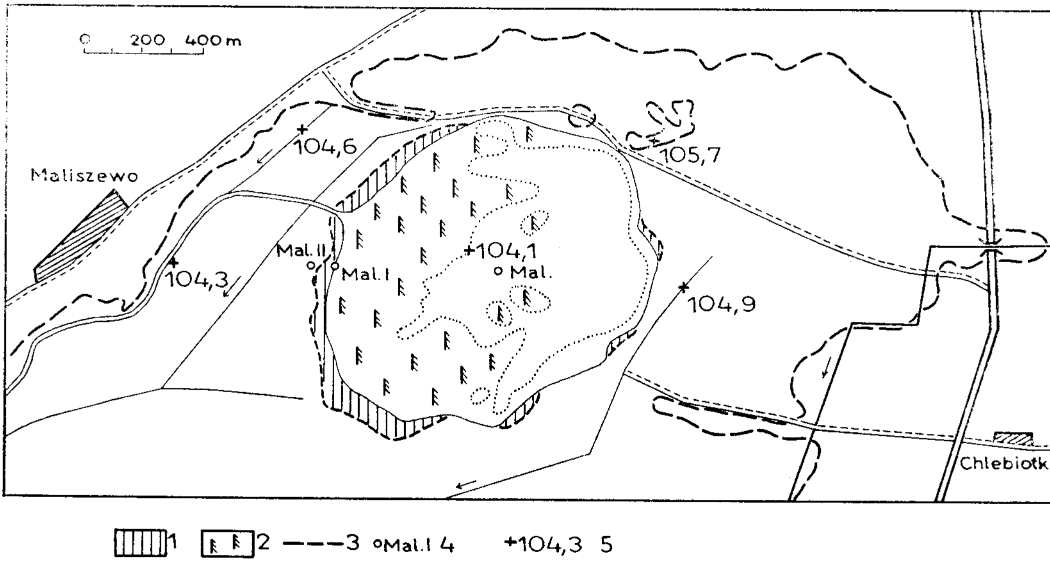

Fig. 2. A site skech of Lake Maliszewskie region: 1 — sedge-moss peatlands (floating vegetation mat), 2 — reed assocciations growing in water, 3 — the peatland boundary, 4 — bores (drillings), 5 — height in meters above sea level

The Wizna Basin is covered by a vast peatland with a longer axis (20 km long) which in its western part borders (2 km) onto a sandy belt of river alluvial silt found in the Narew River. On the west and south side a steep hill, several meters high, divides the basin from the old glacial upland (120—130 m a.s.l.) which is cut by the river valleys and covered by kame hills. On the eastern side the peatland passes almost imperceptibly into a higher sandy level (110—108 m a.s.l.) and latter into a flat but strongly duned morainic plateau. On the north side the Wizna peatland borders onto the flood terrace of the Narew River and onto certain parts of the Urstromtal supra-flood terrace (104—106 m a.s.l.). The terrace of the Narew joins in the north with the peat basin of Lower Biebrza, the longitudinal, 30 km long depression.

The Wizna peatland has a clear 1—1.1% slope from the upland in the direction of the Narew River. The difference in height between the highest point in the south-eastern part of the peatland (108 m a.s.l.) and the outlet of the Gać River in the south-western part (100 m a.s.l.) in 8 m. Along the longest axis of the peatland a deep depression (4—6 m below the present surface) extends under the peat, which first underwent peat formation (Żurek 1968). In the north-eastern part of the peatland, in its bay which is between the Maliszewo moraine relic and the higher outwash level, lies the shallow (0.2—0.8 m of water) Lake Maliszewskie. As a result of the drainage of the surrounding peatlands and the lowering of the water level in the lake, the half of it is almost covered with reed communities and floating islands and the process of overgroving is progressing rapidly (Fig. 2).

DESCRIPTION OF THE MALISZEWO I PROFILE

Along the western bank of the lake there extends a 20—80 m belt of thicketing moss-fen. This is the floating mat of vegetation that is weighed down by a 30—60 cm layer of peat which covers the gyttja. The site of the Maliszewo I coring was located about 180 m south of the outflowing river, and 60 m east of the peatland boundary and the mat of floating vegetation of the lake (Fig. 2). Several meters farther eat there is an area of open water covered with reed. In the region of the drillings there appear sedge-moss plant communities with *Carex lasiocarpa*, *C. rostrata*, *Eriophorum angustifolium*, *Calamagrostis neglecta*, *Menyanthes trifoliata* and mosses *Acrocladium cuspidatum*, *Drepanocladus aduncus* and *Bryum ventricosum*. The mat of floating vegetation of the lake is at present undergoing a thicketing process; here one can note the occurrence of *Salix cinerea*, *Betula pubescens*, and even individual trees of *Pinus sylvestris*. In the near vicinity of the Maliszewo I profile (a few meters away) samples

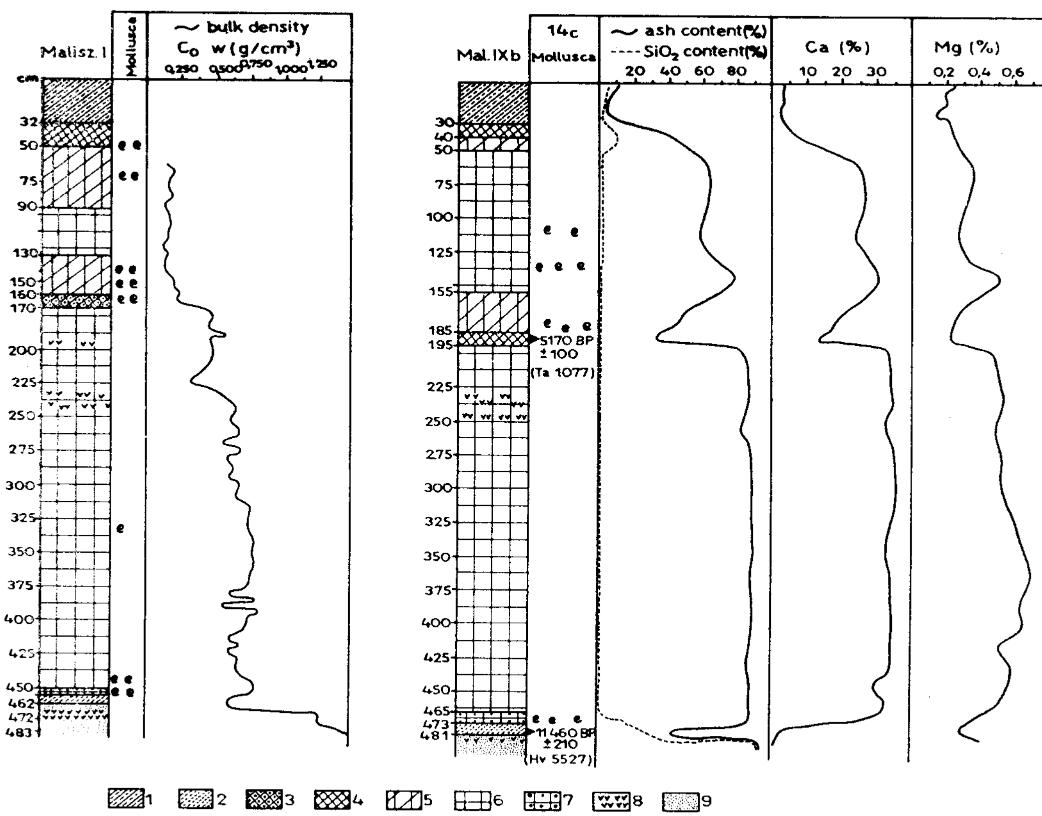

Fig. 3. Some physical and chemical properties of the coastal deposits of Lake Maliszewskie: 1 — sedge-moss peat, 2 — moss fenpeat, 3 — detrital gyttja mixed with peat, 4 — detrital gyttja, 5 — detrital-calcareous gyttja, 6 — calcareous gyttja, 7 — sandy calcareous gyttja, 8 — organic remains, 9 — fine-grained sand

were taken in the second half of the 1970's (Maliszewo IXb profile); the samples were dated by the ^{14}C method and in the entire monoliths of the lake sediment — ash, the contents of SiO_2 and a series of macro- and micro-elements were determined. In the Maliszewo I profile detailed analysis has not yet been carried out, so that in order to determine correctly the stratigraphic layers we had to make use of the data from profile IXb.

The method of determining the physical and chemical properties of the sediments of profiles I and IXb presented in Fig. 3 is the following: Bulk density for 84 levels — the samples were taken by the Więckowski sampler every 5 cm in cylinders of 100 cm^3 capacity. The bulk density was estimated as being the difference in weight of the sample dried at the temperature of 105°C and the weight of the wet sample. The content of $CaCO_3$ (Scheibler's method) and the content of ^{18}O was determined at 28 levels for 20 cm layers. The values for $CaCO_3$ and ^{18}O were made by Dr. K. Różański in the Laboratory at the Institute of Physics and Nuclear Technics of the Academy of Mining and Metallurgy in Kraków. The analyses of ash, content of SiO_2, Ca, Mg, and a number of other elements (Na, K, Fe, Mn, Zn, Cu, P_2O_2) were made for 24 levels (Maliszewo IXb profile) by Dr. D. Choromańska at the IMUZ Laboratory. Ash content was determined by burning samples at a temperature of 550°C, and SiO_2 by the method of double dissolution in HCl and burning the remainder at a temperature 550°C. The entire content of calcium and magnesium was determined by atomic absorption spectrometry on the UNICAM SP — 2900 equipment. The type of gyttja was defined on the basis of the Markowski division (1976) which differentiates 3 components: detritus, the mineral elements and $CaCO_3$. The stratigraphic differentiation of the Maliszewo I profile is the following:

0.00—0.32 m sedge-moss peat layers alternating with layers of brown-moss peat of decomposition degree 5—15% and a spongy structure; with dominant *Drepanocladus aduncus*, *D. sendtheri*, *Calliergon giganteum*, and a constant admixture of *Carex diandra*, *C. lasiocarpa* and *Menyanthes trifoliata*. In the upper part there appear more oligotropic elements such as *Carex limosa*, *Ericaceae* and *Pinus*. The contents of ash 4—10% with Ca ranging from 1.56 to 2.83% and Mg from 0.14 to 0.25%. In the 0—5 cm layer there is an exceptionally large amount of Cu (22.7 ppm) and Zn (120 ppm).

0.32—0.50 m fine detritus gyttja, dark brown, ash — 32%, containing Ca — 6.3% and Mg — 0.24%.

0.50—0.90 m calcareous-detritus gyttja, brown-gray, elastic, showing great shrinkage, ash — 60%, containg $CaCO_3$ from 25 to 35%, Co (bulk density) from 0.138—0.170 g/cm^3.

0.90—1.30 m calcareous gyttja, light gray, showing great shrinkage, ash from 58 to 66%, $CaCO_3$ from 47 to 58%, Co from 0.117 to 0.156 g/cm^3.

1.30—1.60 m detritus-calcareous gyttja, gray-brown, elastic, showing great shrinkage, many shells, ash from 42 to 78 %, $CaCO_3$ from 49 to 72 %, Co from 0.118 to 0.244 g/cm³.

1.60—1.70 m detritus gyttja, brown with a contribution of sedge-moss peat at 1.66—1.69 m, ash 32 %, Ca — 12.8 % and Mg — 0.22 %.

1.70—2.45 m calcareous gyttja, grey, plastic, showing very weak shrinkage with mixed layers of organic remains 195 cm and 225—245 cm. Ash about 80 %, $CaCO_3$ from 60 to 71 %, Co rises from 0.470 to 0.590 g/cm³.

2.45—4.50 m calcareous gyttja, light bluish-gray, plastic, of a very weak shrinkage, ash from 80 to 90 %, $CaCO_3$ from 60 to 92 % (Ca from 32 to 34 %), Co from 0.60 to 0.79 g/cm³. In the 3.8—4.4 m layer there are hardly visible micro-layers.

4.50—4.55 m sandy calcareous gyttja, gray with many shells.

4.55—4.62 m brown-moss peat, with gyttja, ash from 42 % (in this SiO_2 — 2.6 %) with dominance of *Scorpidium scorpioides* and some *Salix* and *Betula* woods.

4.62—4.83 m fine grey sand, loose with brown organic matter at 4.67—4.68 m and 4.70—4.71 m. Co rises rapidly to 1.25—1.44 g/cm³ and $CaCO_3$ drops to 2.9—2.5 %.

From the present description of the profile one can conclude that Lake Maliszewskie underwent various significant changes in water-level. The sandy-calcareous gyttja with brown-moss peat in the bottom, detritus gyttja and detritus calcareous gyttja in the layer 1.30—1.70 m, and detritus gyttja with peat in its upper part, characterize the phases of the shallow lake which is being slowly overgrown along its banks. The calcareous gyttja in the lower and upper part of the profile sedimented in the lake at a considerably greater depth. Two clear drainings of the lake at the beginning of accumulation of carbonate deposits are presumably connected with the Holocene suffosion, the character of which (karstic or termal) has been defined yet. Undoubtedly the changes in the water-level are also connected with the climatic conditions especially with temperature and rainfall (the curve of changes ^{18}O was worked out by Różański & Weisło (1986); representing the temperature variations of the water in the lake. The interpretation to the whole curve can by achieved; and as the author K. Różański claims "only by comparing the results from other lakes" can we obtain positive results. Here, however, we can only state that the passage from the Older Dryas to the Alleröd was connected with the change of temperature by (4°C) of the shallow water of the lake. The variations in the water temperature of the 140—160 cm level can point to the beginning of cooling in the Neoholocene period.

THE RESULTS OF THE POLLEN ANALYSIS

The samples for the pollen analysis were taken by a volumetric container of 1 cm³. The samples were prepared with standard methods: KOH-HF-Erdtman's acetolysis (Faegri & Iversen 1964); the prepared materials were next kept in glycerine. In order to count the concentration of pollen in a volume of 1 cm^3, *Lycopodium* pellets were added to the samples (Stockmarr 1971). The samples were analysed and counted upto 1000 pollen grains of trees. Only in sample of low frequencies is this number smaller. The basis for calculating the percentage of participation of various taxa was the sum of trees and shrubs (AP) and herbs (NAP) — excluding the sporomorphs of aquatic and swamp plants, the spores of moss and ferns, and unidentified sporomorphs. The diagram (Fig. 6) presentes the pollen assemblage zones correlated with the Blytt-Sernander division.

Pollen assemblage zones

Mal. I-1 *Pinus-Betula-Cyperaceae* PAZ (454—470 cm)

The AP curve ranges from 21.1% to 63.9%. In the upper part of the zone pine pollen dominates, reaching the value 54.5%. Among the herbs *Cyperaceae* (28.6—72.5%) constitute the greatest amount, whereas *Gramineae* do not exceed 6%. Also, one notes the appearance of individual sporomorphs of heliophilous plants *(Hippophaë, Helianthemum, Selaginella)*.

Mal. I-2 *Juniperus-Artemisia* PAZ (433—454 cm)

The AP curve increases to 84.6% but the curve of pine pollen drops to 30%. The amount of birch pollen increases upto 40.3%. There appear maximum of *Juniperus* pollen (6.4%) and *Artemisia* (8.6%). Small amounts of *Betula nana* pollen have been noted; similary in the level Mal. I-1 individual pollen grains of heliophytes appear.

Mal. I-3 *Betula-Pinus* PAZ (368—433 cm)

The AP curve reaches 97.6%. It contains mainly pine and birch pollen. As a result of the changing participation of both of these trees — this level was divided into three subzones. In subzone Mal. I-3b the *Betula* pollen curve increases to 66.7% whereas the *Pinus* pollen drops to 24.9%. The occurrence of *Populus* pollen has been noted. In the upper subzone of Mal. I-3c both curves again reach values approximating to 50%. The continuous curve of *Ulmus* pollen also begins. Small quantities of NAP are represented almost entirely by *Cyperaceae* and *Gramineae* pollen.

Mal. I-4 *Pinus-Corylus-Ulmus* PAZ (288—368 cm)

The boundary with the previous pollen level is the beginning of the continuous *Corylus* pollen curve which does not exceed 2.5%. The *Ulmus* pollen curve reaches a maximum of 1.7%. The *Pinus* values oscillate around 55% and the *Betula* around 30%. The continuous *Quercus* pollen curve also appears.

Mal. I-5 *Corylus-Pinus* PAZ (258—288 cm)

The *Pinus*, *Betula* and *Ulmus* pollen curves maintain the same level as in Mal. I-4. The *Corylus* reaches its first maximum — 10.1%. The continuous curves of *Alnus*, *Tilia* and *Fraxinus* pollen begin.

Mal. I-6 *Corylus-Ulmus-Fraxinus* (173—258 cm)

The maximum values of *Corylus* (16.9%), *Ulmus* (7.9%) and *Fraxinus* (3.8%) pollen appear.

Mal. I-7 *Pinus-Cerealia* (163—173 cm)

The curves of thermophilous tree pollen drastically change — *Corylus*, *Ulmus*, *Alnus*, *Quercus*, *Fraxinus*, *Tilia* show a declining tendency. The curve of *Pinus* pollen rises to 52.6%. Also the culture indicators appear, including *Secale*, and the curve of *Rumex acetosa/acetosella* pollen. The curve of *Cerealia* pollen together with rye attains the value of 2%. The curve of *Picea*, *Fagus* and *Carpinus* pollen also begins.

Mal. I-8 *Corylus-Quercus* PAZ (138—163 cm)

After a considerable decline the curve of *Corylus* pollen begins to rise to 10.2% The curve of *Quercus* pollen achieves its absolute maximum (9.4%). Also the curve of *Fraxinus* pollen reaches its former value, whereas *Ulmus* and *Tilia* do not regain the earlier value.

Mal. I-9 *Carpinus-Betula* PAZ (53—138 cm)

The curves of *Ulmus*, *Tilia* and *Fraxinus* pollen do not exceed the value of 1%. The amount of *Corylus* pollen declines from 5.3% to 1.5%. As a result of the variations of *Betula*, *Alnus*, *Quercus*, *Picea* and *Carpinus* curves, 3 subzones were differentiated: Mal. I-9a *Alnus-Carpinus*, with the absolute maximum of *Alnus* (26.9%) and first maximum of *Carpinus* (8.9%). One can note single pollen grains of cereals and *Plantago lanceolata*. The amount of *Rumex acetosa/acetosella* pollen rises to 0.9%. Mal. I-9b *Betula*, where the curve of birch pollen rises to 40.6% and dominates over the pine. The amount of pollen taxa connected with man's activity decreases. Mal. I-9c *Quercus-Picea-Carpinus* with maximum values of the following trees: *Quercus* — 8.5%, *Picea* — 5.5%, *Carpinus* — 10.2%. The continuous curve of *Cerealia* and *Plantago lanceolata* pollen appears and the curve of *Rumex acetosa/acetosella* pollen rises to 0.8%.

Mal. I-10 *Pinus-Juniperus*-NAP (0—53 cm)

The AP pollen curve falls to 41.6%. Also the curve of *Betula* pollen declines. Once again *Juniperus* pollen appears. *Cerealia* pollen appears at its maximum amount (4.5% together with rye), sorrell (3.9%) and other plants connected with human activity *(Plantago lanceolata, Polygonum aviculare, Centaurea cyanus, Cannabis).*

THE HISTORY OF VEGETATION

The profile examined palinologically still has not been ^{14}C dated. The 5 samples are still being worked on. The ^{14}C date comes from the closely neighbouring core. The layer of brown-moss peat, at a depth of 477—481 cm with a considerable admixture of sand was dated in the laboratory in Hannover (Żurek 1975), at 11.460±210 BP (Hv-5527), whereas the second sample taken at a depth of 186—191 cm from detritus gyttja was dated in Tallinn at 5170±100 BP (Ta-1077). The first date could be correlated with the layer of brown-moss peat from the depth of 455—462 cm in profile I and with the *Pinus-Betula-Cyperaceae* pollen layer. In the region of Wizna at that time there existed open pine-birch woods what explains the appearance of individual pollen grains of heliophilous plants *(Hippophaë, Helianthemum, Selaginella).* This level ought to be linked with the Alleröd period.

In the next *Juniperus-Artemisia* zone the vegetational cover underwent further thinning. Apart from the fact that the amount of tree pollen rises one observes a smaller participation of pines to the advantage of birches. Near the lake there were presumably dwarf birches and open plant associations with juniper shrubs. Severer climatic conditions which occurred at this time also led to the decrease of pollen concentration. This level can be correlated with the Younger Dryas period.

The increase in the amount of tree pollen upto 97.6% determines the boundary of the next pollen zone (Mal. I-3) which is also the boundary of the Holocene onset. This level possesses a threefold character. At the beginning and end of this period there were woodlands in the Wizna region where pine and birch occurred to the same extent. In the middle of the period birch dominated. At this time maximum amounts of *Populus* appeared. A permanent feature, though not so evident, of this pine-birch woodland was the elm. The entire *Betula-Pinus* level is correlated with the Pre-Boreal period.

The *Pinus-Corylus-Ulmus* and *Corylus-Pinus* pollen zones presumably correspond with the Boreal period. In its older part, corresponding with the pollen zone Mal. I-4, the proportion of elm in the pine-birch woodland increases and also hazel appears, which in the second half of the Boreal, corresponding with the pollen level Mal. I-5, spreads, limiting the renewal of the heliophilous pine and birch.

The increasing importance of *Quercus* and the appearance of the consecutive elements of the thermophilous mixed woodland (*Tilia*, *Fraxinus*) is the boundary of the next pollen zone (Mal. I-6) and probably the beginning of the Atlantic period. The great amounts of the alder which appear at the beginning of the zone ought to be associated with the local conditions. It surely grew in the vicinity of the peatland. The nearest site where the alder expansion was dated is Woryty (Pawlikowski et al. 1982) in the Olsztyńskie Lake District. The date provided here was 8440±110 BP. The Atlantic period ends with the mixture of peat which was dated in the neighbouring Maliszewo IXb profile at 5170±100 BP. The detritus gyttja layer is linked with a clear lowering of the water level in the lake and the beginning of the peatland formation. It corresponds with the level of the *Pinus-Cerealia* pollen. At this time a rapid decline in the frequency of elm takes place accompanied by a rise in culture indicators including cereals. Such a rapid decline of the elm is commonly observed also in Central Europe as well as in Poland (Hjelmroos-Ericsson 1981, Pawlikowski et al. 1982), but it is hardly connected with the appearance of a greater amount of culture indicators. The higher frequencies of *Cerealia* pollen which serves as evidence of man's quite intensive activity, are never observed in the pollen diagrams from Poland in connection with elm decline. One should carry out further research in order to find out if the phase of man's activity coincident with the lowering of water level of the lake really took place at the end of the Atlantic period or perhaps some type of sediment diesplacement or contamination has happened *.

The beginning of the continuous curves of *Carpinus* and *Fagus* pollen is indicative of the beginning of the following pollen zone Mal. I-8 which is correlated with the beginning of the Sub-Boreal period. In the next pollen zone (Mal. I-9) which is also included in this period, one observe the development of the *Querco-Carpinetum* type of woods.

The reoccurrence of the indicators reflecting man's activity provides the lower boundary of the last pollen zone Mal. I-10. The zone certainly represents the Sub-Atlantic period; however, its lower boundary is difficult to define without dating it. At this time there occured a considerable deforestation of the area connected with the advanced cultivation phase. The pine and juniper find their way onto the deforested area. Next the herb associations begin developing. Here one encounters plants which are characteristic for open grassland (*Plantago lanceolata*, *Rumex acetosa/acetosella*), plants cultivated by man as corn or hemp as well as plants which are associated with cultivation (*Polygonum aviculare*, *Centaurea cyanus*).

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* The date of the detritus gyttja sample of 165—175 cm level recently carried out in the laboratory in Gliwice is 3.340±120 BP. Due to the fact that the level with cereal pollen occurs in the upper parts of two different gyttja monoliths taken from this bed one should consider the possibility of sediment contamination and the too young age of the sample dated ^{14}C. In this light the age of the first traces of settlement still remains an open question and requires further research.

THE LATE-GLACIAL HOLOCENE PALEOHYDROLOGICAL CHANGES AT THE WIZNA SITE

The paleohydrological changes in the Biebrza Urstromtal (based on the peat science research) were presented earlier (Żurek 1975, 1985) whereas a closer location of these changes in time took place after the age of the deposits had been established by the radiocarbon method (Żurek 1986a, 1986b; Żurek et al. 1984). All the dates for the Wizna are shown on the Koty-Mocarze section (Fig. 4).

The oldest deposits date back to the beginning of the Late-Glacial period and serve as evidence that the urstromtal flood terrace was formed earlier, that is, in the final glacial phase. The Late Glacial dune-forming processes, and the processes giving rise to kettle holes (permafrost degradation) caused the formation of local depressions in the bed of the flood terrace, separated by shallow silts. The processes leading to peat bogs formation which began about 13.000 years ago was not continuous; at certain periods intense, covering a greater area.

In the cool water reservoir of the deepest parts of the flood terrace, blue plastic clays or clayey gyttja with a small admixture of detritus were sedimented. Due to the fact that the age of the upper part of the lake deposits in the Wizna I profile (the detritus-clayelgyttja level 5.35—5.42 cm) was 12710$\pm$240 BP, it may be assumed that clayey gyttja derives from the beginning of the Bölling or even the end of the Glacial period. The sedge-moss peat on the gyttja in the Wizna I profile (5.25—5.35 cm) is dated at 12610$\pm$190 BP (Fig. 4). From that moment in the central part of the Wizna peatland the accumulation of the peat moss lasts upto the sixties of our century. In the clearly warmer phase of Alleröd (^{18}O data), in the area of Lake Maliszewskie thin layers of peat moss (11.460$\pm$210 BP) were being sedimented on permafrost. The degradation of the permafrost and the melting of the buried blocks of ice caused, at the end of the Alleröd and in the Younger Dryas, the covering of peat by gyttja, and a steady increase in the depth of the lakes.

During the Eoholocene (Starkel 1977) dated 10000—8000 years ago acording to the Scandinavian radiocarbon scale (Mangerud et al. 1974) lakes with accumulating gyttja are quite drequent in the Wizna basin. On the banks of the lakes moss peatlands are developing and steadily advancing on the water of the lakes. In the middle of the Pre-Boreal period the level of ground water starts rising; in the south-eastern part of the basin the accumulation of osier peats begins (9450$\pm$90 BP). At the end of the Pre-Boreal period the water level on the peatlands becomes lower and the moss-grown spots become covered by trees (9270$\pm$120 BP). At the beginning of the Boreal period an increase of the inlets of ground water takes place. The trees disappear and the weakly decomposed peat from *Carex lasiocarpa*, which occupied the banks of the Lake Maliszewskie (8940$\pm$120 BP), is being rapidly sedimented (1.13 mm per year) until the beginning of the Atlantic period.

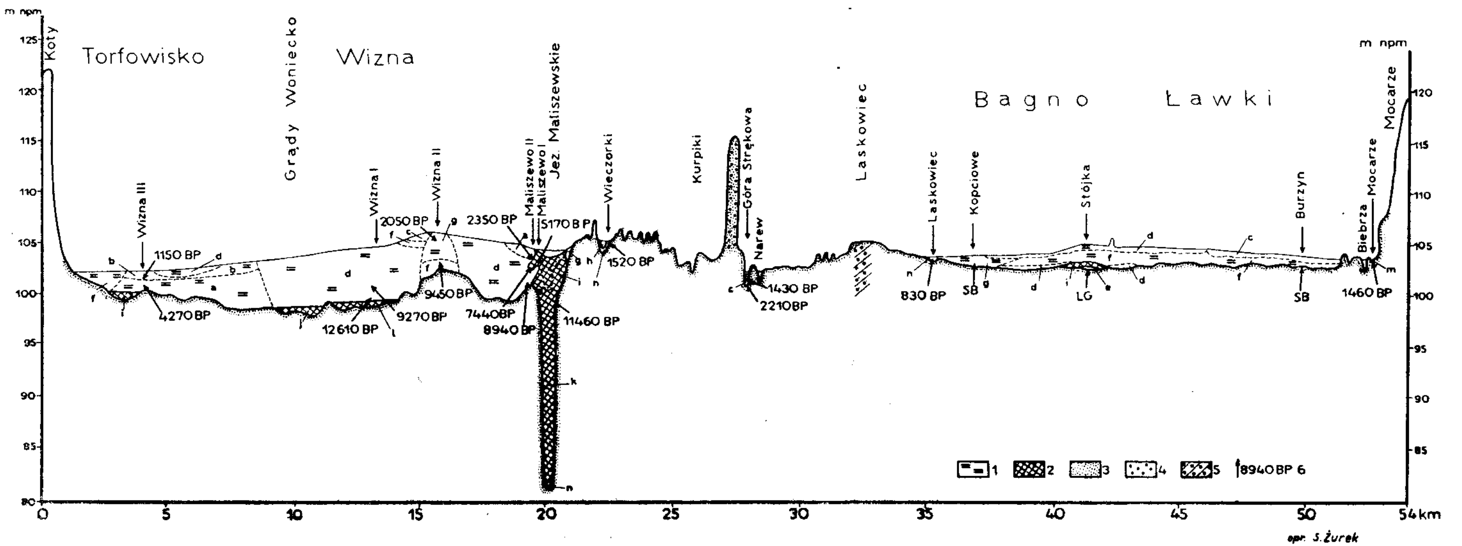

Fig. 4. A geological-stratigraphic cross-section of Koty-Mocarze through the peatlands of the Wizna region: 1 — peat, 2 — gyttja, 3 — fine-grained sand, 4 — gravel with sand, 5 — till, 6 — datings of ^{14}C, LG — Late Glacial, SB — Sub-Boreal period a — reed peat, b — reedsedge peat, c — tall-sedge peat, d — parvocaricetum peat (sedge-moss and sedge), e — moss peat, f — willow peat, g — alder peat, h — raised bog peat, i — detritus gyttja, j — detrital-calcareous gyttja, k — calcareous gyttja, i — clay gyttja, m — mud, n — peat formation

In the Mesoholocene (8000—5000 years ago) the lakes slowly disappear and are replaced by expanding peatlands. At the beginning of the phase the level of water rises, and the inshore peats of the lakes are flooded (7440±150 BP). Because of the increase of underground and surface water inflow not only the low sedges but also high sedges such as *Carex stricta* began to dominate over the area. At the end of the Atlantic period a clear decline in the water level took place and on the calcareous gyttja of Lake Maliszewskie thin layers of sedge-moss peat and fine-detritus gyttja (5170±100 BP) are accumulated.

If the results of the recent ^{14}C dating of the detritus gyttja from the level 165—170 cm (3340±120 BP), carried out in Gliwice, do not show too young age as a result of contamination, than the greatest reduction in the water level in the region occurred not at the end of the Atlantic period, but at the end of the Sub-Boreal period. Thus would correlate with the reduction of water level in the peatlands of Biebrza Urstromtal.

In the Neoholocene phase which began 5000 years ago the climate became somewhat colder and moist. On the moss fen peatlands-peats of other kinds are deposited; and on the non-boggy areas of the flood terrace situated a little higher — reed and alder swamp occur. The beginning of the reed swamp peat accumulation in the south-western part of Wizna (profile of Wizna III) is dated at 4270±70 BP). As the palinological data show in the great peatland Bagno Ławki in the Biebrza Valley basin peat formation advanced. The eastern part of Ławki was dominated by *Carici elongatae-Alnetum* community (profile Kopciowe, Marek 1965), whereas the central and western parts were covered by *Salicetum pentandro-cinereae* shrubs, with *Phragmites communis* prevailing (profile Stójka and Burzyn, Oświt 1973). In the Sub-Boreal period, or rather in its younger part, there occurred a drop in the water level in the peatlands, recorded by a layer a strongly decomposed peat (Oświt 1973).

At the beginning of the Sub-Atlantic period an increase of humidity occurred. Tall sedge reeds (2350±100 BP) begin covering the gyttjas of the lakes, and the abandoned Narew Channel in the Mt. Strękowa region was filled with peat (2210±70 BP). The lateral and bottom erosion of Narew, which caused the covering of peats by a one-meter thick layer of sandy silt, took place 1430±60 years ago. The river incision and a better river diversion reduced the long-lasting floods and caused a change from reed peatlands into sedge peatlands (1150±40 BP). In the alluvial Biebrza zone in the Mocarze village the river erosion bad a direct effect on the accumulation processes. From 1460±100 BP organic muds began to accumulate on the sandy-alluvium river formations. The historical phase connected with the strong activity of man and a permanent settlement in this region begins in the early medieval period (XII—XIVth century). The beginning of this phase could be coincident with the accumulation of peat formations in the Laskowiec village (830±80 BP) and peat-mud formations in the small valley of the Białostocka Upland such as Horodnianka (670±90 BP). The acidification of accumulating peats increased at a consi-

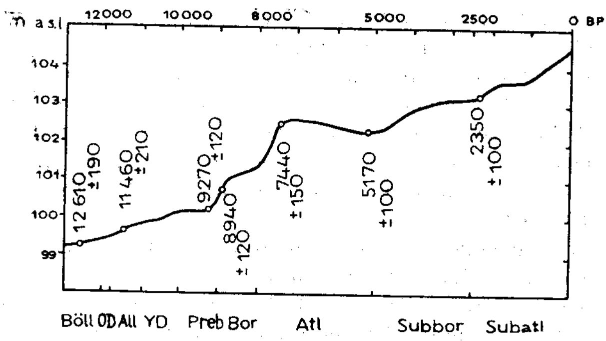

Fig. 5. The curves of water level changes in the Wizna peatland: Böll — Bölling, OD — Older Dryas, All — Alleröd, YO — Younger Dryas, Pr — Pre-Boreal period, Bor — Boreal period, Atl — Atlantic period, Subatl — Sub-Atlantic period, Subbor — Sub-Boreal period

derable rate in the Sub-Atlantic period. Their accumulation was interrupted in the 1960's as a result of the drainage of the Wizna peat deposits.

The changes in the water level in the Wizna basin in the last 13000 years are presented schematically in Fig. 5. The curve of changes, based on the results of ^{14}C datings of Wizna I, Maliszewo I and II profile, point to various fluctuations of the water level, connected with the rythm of climatic changes. A clear rise in the water level occurred at the beginning of the Boreal, Atlantic, Sub-Boreal and Sub-Atlantic periods. The lowering of the water level was noted in the second half of the Preboreal period, at the end of the Atlantic period or in the Sub-Boreal period (mainly in the second half) and at the present time.

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Z. B. — *Department of Geomorphology Institute of Geography, Łódź University, al. Kościuszki 21, 90-418 Łódź*
Zakład Geomorfologii Instytutu Geografii Uniwersytetu Łódzkiego
S. Ż. — *Institute of Land Reclamation and Grassland Farming, Falenty, 05-550 Raszyn*
Instytut Melioracji i Użytków Zielonych

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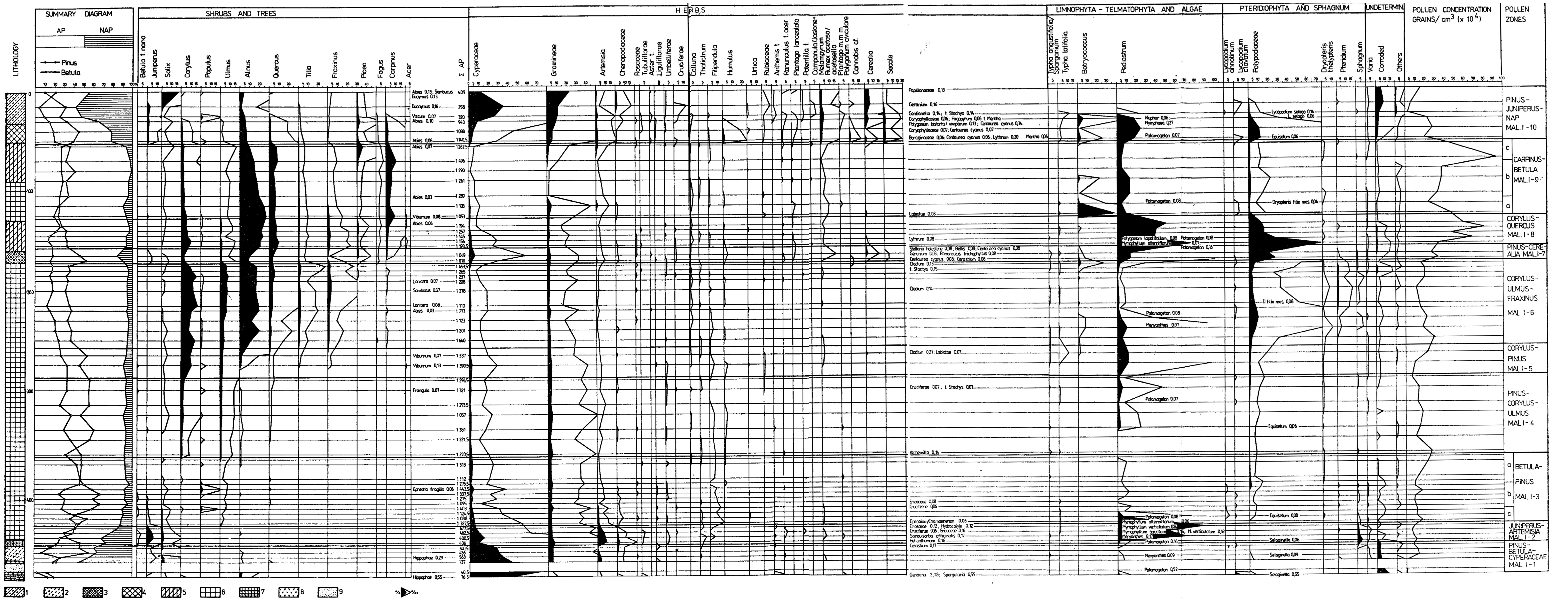

Fig. 6. Pollen diagram of the Maliszewo I profile: 1 — sedge-moss peat, 2 — moss fen peat, 3 — detritus gyttja mixed with peat, 4 — detritus gyttja, 5 — detrital-calcareous gyttja, 6 — calcareous gyttja, 7 — sand-calcareous gyttja, 8 — organic remains, 9 — fine-grained sand