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LATE-GLACIAL AND HOLOCENE HISTORY OF VEGETATION AT ROZTOKI AND TARNOWIEC NEAR JASŁO (JASŁO—SANOK DEPRESSION)

Późnoglacjalne i holoceńskie przemiany szaty roślinnej w Roztokach i Tarnowcu koło Jasła (Doły Jasielsko-Sanockie)

ABSTRACT. Palynological studies of two profiles in Roztoki and one in Tarnowiec were carried out. In two of the profiles (Roz. a. and Tar. e) macrofossils were also studied. The studies were supplemented by twelve ^{14}C dates (eight in Tarnowiec). In Roztoki diagrams six pollen assemblage zones (PAZ) were distinguished, providing a basis for reconstruction of the history of vegetation from the Older Dryas to the Boreal period (in Roz. a) or to the Atlantic period (Roz. b). The pollen diagram from Tarnowiec was divided into twelve pollen assemblage zones. They covered period from the Older Dryas to Subatlantic period. Most of the zones defined were confirmed by three numerical methods (CONSLINK, SPLITINF, and SPLITSQ) for spectrum zonation. In Tarnowiec macrofossil diagram seven macrofossil assemblage zones (MAZ) were described. They reflected the changes that took place in the site. The impact of human activities on vegetation started at about 5000 BP. and lasts till now with ever increasing intensity.

INTRODUCTION

The Jasło—Sanok Depression is the largest within the whole range of Polish Carpathians Mts. The region borders with Strzyżów—Dynów Foothills to the north, and with Beskid Niski Mts. to the south. The area consists of a series of flatbottomed valleys separated by series of small hills. The sites studied are located within Jasło—Krosno Valley with Jasiołka River crossing through the middle of it and with a small town of Jasło nearby.

The climate of the area has remarkably continental characteristics with an average annual temperature of 7.5—8.1°C and 530—704 mm of precipitation. Cold and wet bottoms of valleys have mesoclimate with frequent radiation fogs, early and persistent frosts, and frequent air temperature inversions.

The study area is recently covered by fields and meadows that are mainly fresh meadows *(Arrhenatheretum elatioris)*. Much less space is now occupied by wet meadows of *Molinion* or *Calthion alliances*. The area was originally covered partly by swamps and partly occupied by waterlogged or even swamp forests with marsh vegetation along river banks. Now not too much of the original vegetation remained, mainly along drainage ditches and on banks of small ponds. The depression is surrounded by some small, flat hills (300—400 m a.s.l.) where stands of mixed deciduous limehornbeam forests *(Tilio-Carpinetum)* developed; its variety depending on habitat and climate, the East-Carpathian variety with beech is dominating. Patches of mixed acidophilous oak-pine forests *(Pino-Quercetum)* are less frequent. Fir is rare, just single trees, there are some spruces, most of them possibly planted. All the data on the recent vegetation came from unpublished work by K. Towpasz (Towpasz, MS).

The development of human settlements in the area confirmed by archaeological evidence started in the early Neolithic (Machnik 1960, 1962). More significant human influence started in the late Neolithic when the people of the Corded Ware Culture living mainly on animal husbandry spread out. Further intensification of the settlement process took place in the Bronze Age during the rise of the Lusatian Culture (Żaki 1955) while agriculture and cattle breeding were still prevailing occupations. There is no data on the settlements in the early Iron period when an old trade route crossed the region along Wisłoka River Valley. Actually the intensive development of human settlements in the region took place during 13th — 15th centuries. The settlements were located according to the German Law within an area flanked by Wisłok and Wisłoka rivers (Żaki 1969, Kunysz 1970).

The aim of this study was to investigate the Late Glacial and Holocene history of vegetation in the Jasło—Sanok Depression region and to attempt to reconstruct the history of changes in local vegetation within the sedimentation basins under study. This area was an object of paleoecological studies by many authors (Szafer & Jaroń 1935, Szafer 1948, Wołoszyńska 1950, Klimaszewski 1948, Koperowa 1970). The sites described in this paper have been included into the network of reference sites for the International Geological Programme IGCP No 158 B (Berglund & Digerfeldt 1976, Berglund 1979).

METHODS

The main basis for the study is provided by three pollen profiles obtained from wall exposures of two ditches at Roztoki denoted by Wójcik (this volume) as Roz. a, and Roz. b, and one at Tarnowiec denoted Tar. e (Alexandrowicz et al. 1985, Wójcik 1981, Wójcik this volume). All the profiles have been examined by means of pollen analysis, while macrofossils have only been studied in Roz. a, and Tar. e. The samples for the pollen analysis were prepared by standard procedure (Faegri & Iversen 1964). Apart from percentage calculations based on sums of AP and NAP with exclusion of the local species and spores, the pollen concentration was also calculated, using Stockmarr (1971, 1973) method, with *Lycopodium* spore pellets. The profiles discussed in this study have twelve ^{14}C dates, performed at the laboratory of the Silesian Technical University in Gliwice (Pazdur et al. 1985).

Profile	Lab. No.	Depth in m	Type of sample	Radiocarbon age BP
Roztoki a	Gd — 1568	5.15—5.17	brown peat	9920±100
Roztoki a	Gd — 2051	5.72—5.75	brown peat	11740±150
Roztoki b	Gd — 3245	3.73—3.76	brown-black peat	8670± 50
Roztoki b	Gd — 1232	3.90—3.95	brown-black peat	9850±110
	Gd — 1233	duplicate run on same sample		9870±110
	Gd — 766	duplicate run on same sample		9920± 95
Tarnowiec	Gd — 966	0.25—0.30	clayey peat	1950± 60
	Gd — 1483	duplicate run on same sample		2040± 50
Tarnowiec	Gd — 1484	0.56—0.60	brown peat	3930± 60
Tarnowiec	Gd — 964	0.96—1.00	peat with fragments of wood	4240± 90
Tarnowiec	Gd — 1482	1.30	peat with wood fragments	5230± 80
Tarnowiec	Gd — 767	1.40—1.45	peat	7930±100
Tarnowiec	Gd — 1481	1.55	peat	9380± 80
Tarnowiec	Gd — 962	1.80	wood fragments from marl layer	9840±100
Tarnowiec	Gd — 967	2.00	peat with marl and faunal remains	11190±140

The results of pollen analysis are presented in Tab. 1, in percentage diagrams (Figs. 1, 2, 3), and concentration diagram (Fig. 3).

The pollen diagrams have been divided into biostratigraphic units — pollen assemblage zones — PAZ. The names of zones were derived from names of taxa either dominating or characteristic for given section of the diagram. On diagrams the pollen zones are denoted by numbers. The Blytt-Sernander system was introduced in sense of chronostratigraphic units (chronozones — Mangerud et al. 1974).

Percentage pollen diagrams from the cores Roz. a and Roz. b have been divided into 6 local pollen assemblage zones. The diagram from Tarnowiec covering a fuller pollen sequence, the whole Holocene included, has been divided into 12 p.a.z. The zonation of pollen diagrams has been performed by both, traditional and numerical methods. The ZONATION program (Gordon & Birks 1972) by 3 different zonation methods (CONSLINK, SPLITINF and SPLITSQ) has been applied using spectrum computer, and the results have been correlated using SLOTSEQ method (Gordon & Birks 1972). The numerical analysis of data has been performed by dr. A. Walanus.

The macrofossil analysis involved washing large samples (250 ml) i.e. almost five times larger then routine size of 50 ml. 50 ml. samples were collected from

Table 1

Mean and maximum pollen percentage values of selected genera in distinguished pollen assemblage zones.

Zones	Locality 1- Tar.e	mean %	max.%	Locality 2- Roz.a	mean %	max.%	Locality 3- Roz.b	mean %	max.%
1.	Depth: 2,43 - 2,52			Depth: 5,80 - 5,85			Depth: 5,15 - 5,35		
	Pinus	13,6	54,5	Pinus	16,2	32,5	Pinus	7,1	50,2
	Pinus cembra	2,25	9,0	Pinus cembra	1,4	2,8	Pinus cembra	1,2	8,5
	Betula	2,55	10,2	Betula	5,5	11,0	Betula	4,5	32,0
	Larix	0,32	1,3	Larix	0,8	1,6	Larix	0,2	1,5
	Betula nana	1,15	4,6	Betula nana	1,2	2,4	Betula nana	1,7	12,5
	Juniperus	0,7	2,8	Juniperus	0,6	1,2	Juniperus	0,3	2,6
	NAP	10,8	43,3	NAP	29,0	58,0	NAP	4,0	28,0
	Cyperaceae	6,8	27,3	Cyperaceae	10,5	21,0	Cyperaceae	1,2	9,0
	Gramineae	2,6	10,5	Gramineae	18,6	37,2	Gramineae	2,0	14,0
	Artemisia	0,8	3,5	Artemisia	2,0	4,0	Artemisia	0,7	5,5
2.	Depth: 2,17 - 2,43			Depth: 5,75 - 5,80			Depth: 4,95 - 5,15		
	Pinus	9,0	63,0	Pinus		52,2	Pinus	9,0	54,0
	Pinus cembra	1,7	12,5	Pinus cembra		11,5	Pinus cembra	2,8	17,0
	Betula	1,6	11,5	Betula		17,5	Betula	3,1	19,0
	Larix	0,3	2,5	Larix		3,0	Larix	0,4	2,8
	Betula nana	0,5	4,0	Betula nana		4,0	Betula nana	1,8	11,0
	Juniperus	0,1	0,7	Juniperus		0,4	Juniperus	0,1	0,6
	NAP	3,0	21,0	NAP		41,0	NAP	3,5	21,0
	Cyperaceae	0,7	5,0	Cyperaceae		8,0	Cyperaceae	0,4	2,5
	Gramineae	2,2	15,5	Gramineae		15,0	Gramineae	2,0	12,0
	Artemisia	0,4	3,0	Artemisia		4,0	Artemisia	0,8	4,8
3.	Depth: 1,95 - 2,17			Depth: 5,68 - 5,75			Depth: 4,45 - 4,95		
	Pinus	9,8	69,0	Pinus		45,1	Pinus	5,2	63,0
	Pinus cembra	1,7	12,5	Pinus cembra		8,5	Pinus cembra	1,1	14,0
	Betula	2,2	15,5	Betula		23,0	Betula	3,0	36,5
	Larix	0,3	2,5	Larix		2,5	Larix	0,1	2,0
	Betula nana	1,0	7,5	Betula nana		5,0	Betula nana	0,8	10,5
	Juniperus	0,1	0,7	Juniperus		0,1	Juniperus	0,08	0,1
	NAP	4,4	31,0	NAP		40,0	NAP	1,3	16,5
	Cyperaceae	0,7	5,0	Cyperaceae		4,3	Cyperaceae	0,2	3,5
	Gramineae	2,5	17,5	Gramineae		12,0	Gramineae	0,5	6,0
	Artemisia	0,6	4,5	Artemisia		7,5	Artemisia	0,4	5,5
4.	Depth: 1,67 - 1,95			Depth: 5,27 - 5,68			Depth: 4,25 - 4,45		
	Pinus	7,1	64,0	Pinus	6,6	53,0	Pinus	8,5	42,8
	Pinus cembra	1,5	14,0	Pinus cembra	1,6	13,0	Pinus cembra	2,3	11,5
	Betula	1,8	16,5	Betula	2,3	18,5	Betula	6,4	32,0
	Larix	0,2	1,8	Larix	0,3	2,5	Larix	0,2	1,3
	Betula nana	0,8	7,5	Betula nana	0,1	1,0	Betula nana	2,1	10,5
	Juniperus	0,08	0,8	Juniperus	0,03	0,3	Juniperus	0,1	0,6
	NAP	2,7	24,5	NAP	5,0	40,0	NAP	4,3	21,5
	Cyperaceae	0,4	4,0	Cyperaceae	0,3	3,0	Cyperaceae	0,9	2,8
	Gramineae	1,2	11,0	Gramineae	1,2	10,0	Gramineae	1,4	7,0
	Artemisia	0,8	8,0	Artemisia	1,6	13,5	Artemisia	2,0	10,0
5.	Depth: 1,50 - 1,67			Depth: 4,97 - 5,27			Depth: 3,92 - 4,25		
	Pinus	15,0	75,0	Pinus	12,1	73,0	Pinus	3,9	31,5
	Pinus cembra	1,3	6,5	Pinus cembra	3,5	21,5	Pinus cembra	1,0	8,0
	Betula	4,4	22,0	Betula	2,0	12,0	Betula	5,2	41,8
	Larix	0,2	1,2	Larix	0,9	5,5	Larix	0,07	0,6
	Picea	1,3	6,5	Picea	0,1	0,9	Pices	0,3	2,5
	Ulmus	0,2	1,2	Ulmus	0,05	0,3	Ulmus	1,3	10,5
	Betula nana	0,8	4,0	Betula nana	0,6	3,8	Betula nana	2,1	16,8
	NAP	4,8	24,0	NAP	4,3	26,0	NAP	3,0	24,5
	Cyperaceae	0,9	4,5	Cyperaceae	2,3	14,0	Cyperaceae	0,5	4,5
	Gramineae	1,7	8,5	Gramineae	2,3	14,0	Gramineae	1,1	9,5
	Artemisia	2,0	10,0	Artemisia	1,6	10,0	Artemisia	0,8	7,0
5'							Depth: 4,72 - 4,97		
							Pinus	15,2	76,0
							Pinus cembra	0,9	4,5
							Betula	2,3	11,5
							Picea	2,4	12,0
							Ulmus	3,3	16,5
							Tilia	0,4	2,0
							Betula nana	0,6	3,0
							Corylus	1,2	6,0
							NAP	5,2	26,0
							Cyperaceae	0,9	4,8
							Gramineae	4,2	21,0
							Artemisia	0,1	0,5
6.	Depth: 1,20 - 1,50			Depth: 4,72 - 4,62			Depth: 3,40 - 3,92		
	Pinus	7,8	63,0	Pinus	22,0	44,0	Pinus	4,4	48,5
	Betula	2,7	22,0	Betula	0,7	1,5	Betula	3,8	41,8
	Picea	1,5	12,5	Picea	6,7	13,5	Picea	0,7	3,5
	Ulmus	2,0	16,0	Ulmus	7,7	15,5	Ulmus	0,9	10,5
	Tilia	2,0	16,5	Tilia	2,5	5,0	Tilia	1,0	12,0
	Alnus	4,1	33,5	Alnus	4,7	9,5	Alnus	2,7	30,5

	Corylus	2,6	21,5	Corylus	12,3	24,7	Corylus	3,4	37,8
	NAP	2,1	17,0	NAP	9,0	18,0	NAP	1,9	21,0
	Cyperaceae	0,4	3,5	Cyperaceae	0,7	1,4	Cyperaceae	1,5	17,0
	Gramineae	0,5	4,0	Gramineae	6,5	13,0	Gramineae	0,5	6,0
	Artemisia	1,2	10,0	Artemisia	0,2	0,4	Artemisia	0,1	1,3
7.	Depth: 0,97 - 120								
	Pinus	4,0	28,0						
	Betula	0,2	1,4						
	Picea	2,5	18,0						
	Ulmus	0,5	4,0						
	Tilia	1,9	13,5						
	Alnus	5,2	36,5						
	Corylus	2,7	19,0						
	NAP	1,4	9,8						
	Cyperaceae	0,6	4,8						
	Gramineae	0,5	3,5						
	Artemisia	0,4	3,0						
8.	Depth: 0,90 - 0,97								
	Pinus	13,0	26,0						
	Betula	0,1	0,2						
	Picea	8,5	17,0						
	Ulmus	1,4	2,8						
	Tilia	6,0	12,0						
	Alnus	18,2	36,5						
	Corylus	5,5	11,0						
	NAP	2,0	4,0						
	Cyperaceae	0,4	0,8						
	Gramineae	1,0	2,0						
	Artemisia	0,4	0,8						
9.	Depth: 0,72 - 0,97								
	Pinus	6,5	26,0						
	Betula	0,3	1,5						
	Picea	3,2	13,0						
	Ulmus	0,2	0,8						
	Tilia	3,0	12,0						
	Alnus	9,5	38,0						
	Carpinus	1,2	4,8						
	Fagus	1,2	4,8						
	Corylus	2,7	11,0						
	NAP	4,5	18,0						
	Cyperaceae	0,6	2,5						
	Gramineae	1,5	6,0						
	Artemisia	0,6	2,5						
10.	Depth: 0,59 - 0,72								
	Pinus	5,1	31,0						
	Betula	0,5	3,0						
	Picea	2,1	13,0						
	Ulmus	0,4	2,5						
	Tilia	1,7	8,5						
	Alnus	6,3	38,0						
	Carpinus	0,5	3,5						
	Fagus	0,6	4,0						
	Corylus	2,3	14,0						
	NAP	2,3	14,0						
	Cyperaceae	0,4	2,8						
	Gramineae	0,8	5,0						
	Artemisia	0,6	4,0						
11.	Depth: 0,27 - 0,59								
	Pinus	3,4	31,0						
	Betula	0,4	3,8						
	Picea	1,4	13,0						
	Ulmus	0,2	2,2						
	Tilia	0,3	3,0						
	Alnus	3,8	34,5						
	Carpinus	0,5	5,0						
	Fagus	2,7	24,8						
	Abies	1,3	12,0						
	Corylus	0,8	8,0						
	NAP	1,9	17,5						
	Cyperaceae	0,8	8,0						
	Gramineae	0,7	6,5						
	Artemisia	0,1	1,5						
12.	Depth: 0,5 - 0,27								
	Pinus	4,3	30,5						
	Betula	0,08	0,6						
	Picea	2,3	16,5						
	Ulmus	0,1	1,1						
	Tilia	0,2	2,0						
	Alnus	3,2	22,5						
	Carpinus	0,5	4,0						
	Fagus	1,6	11,8						
	Abies	0,4	3,0						
	Corylus	0,8	6,0						
	NAP	7,5	53,0						
	Cyperaceae	2,7	19,0						
	Gramineae	1,8	13,0						
	Artemisia	0,2	1,8						

Roztoki a profile. It was probably the reason, apart from actually less rich sediments there, that no zones could be distinguished on macrofossil diagram from Roztoki. The macrofossil diagram in Tarnowiec was divided into biostratigraphic units (macrofossil assemblage zones — MAZ).

THE DESCRIPTION OF THE POLLEN ASSEMBLAGE ZONES

Zone 1 (Roz. a 1, Roz. b 1, Tar. 1)

The pollen concentration is very low. The zone is distinguished by the high values of NAP, mainly *Cyperaceae* and *Gramineae*. The pollen of heliophilous plant taxa such as *Artemisia*, *Chenopodiaceae*, *Helianthemum nummularium* type, *H. canum* type, *Centaurea scabiosa*, *Anthemis* type, *Sanguisorba officinalis*, *Plantago media*, *Rumex* type, *R. acetosella* and *Selaginella selaginoides* spores (up to 8.2% in profile Tar.) are indicative of the zone. The sum of AP consists mainly of *Betula*, *Larix*, *Pinus sylvestris* and *P. cembra*. In profiles Tar. and Roz. b *Picea* pollen occur up to 0.5%. The sum of shrub pollen attain up to 4.5%, 10% and 15.7% in profiles Roz. a, Tar., Roz. b, respectively. The percentages of *Betula* cf. *nana*, *Juniperus* and *Salix* are high throughout. In profile Tar. *Hippophaë rhamnoides* pollen was found. In profile Roz. b the continuous curve of *Hippophaë* and occurence of *Ephedra fragilis* are remarkable. In profile Roz. a the pollen percentages of aquatic plants such as *Alisma plantago-aquatica*, *Potamogeton*, *Myriophyllum spicatum*, *Sparganium* type, *Batrachium* type, and *Typha angustifolia* are high. Also *Pediastrum* occurs in large amounts in profile Roz. a and in the bottom samples from profile Roz. b.

Zone 2 (Roz. a 2, Roz. b 2, Tar. 2)

The pollen concentration increases, most distinctly in profile Tar. In profile Roz. b the concentration rises in the lowest sample, then declines, but remains higher than in zone 1. In profile Roz. a only one sample with high pollen concentration was included in this zone. The zone is distinguished by rising percentages of AP, the dominant *Pinus cembra* and *Larix* pollen curves, with those of *Betula* and *B.* cf. *nana* being also high. Frequencies of some shrubs (*Salix* and *Juniperus*) decrease. The first single pollen grains of *Alnus*, *Ulmus* and *Prunus* appear, those of *Picea* occur fairly frequently. In the pollen concentration diagram Tar. 2 the curves of *Pinus sylvestris* and *Betula* rise distinctly, but *B.* cf. *nana* pollen concentration declines, while the percentage values increase. The significant reduction in NAP is characteristic in this zone. Percentages of most herbaceous plants, except for *Filipendula* and *Thalictrum*, decrease. In profile Tar. the values of *Selaginella selaginoides* spores are still high (up to 1%) in the lower part of zone, near its top pollen grains of *Pleurospermum* *austriacum* appear. *Saxifraga*, *Knautia arvensis*, *Sanguisorba officinalis* and *Geum* type occur sporadically throughout. There are also numerous aquatic and telmatic plant taxa including *Typha latifolia*, *Nymphea alba*, also *Myriophyllum spicatum*, *Alisma plantago-aquatica*, *Potamogeton* type, *Sparganium* type, *S. erectum* type, *S. emersum* type, *P.* sect. *Coleogeton*, *Sphagnum* and significant amount of *Pediastrum*.

Zone 3 (Roz. a 3, Roz. b 3, Tar. 3)

The sample from the upper part of zone in profile Tar. is dated at 11190±140 B P. The pollen concentration in profiles Roz. a and Roz. b is lower than in zone 2 but higher than in zone 1. The pollen concentration curve in profile Tar. oscillates, but generally it rises in comparison with zone 2. The thickness of this zone is different in different profiles, being fullest in profile Roz. b. Hence the changes taking place in zone 3 are surveyed mainly on that profile. The zone is distinguished by the rising curves of *Betula* in profiles Roz. a and Roz. b, and of *Filipendula* in profile Tar. The NAP curve is low, excluding diagram Roz. a. The considerable sum of trees and shrubs consists apart from *Betula* — of *Pinus sylvestris* and *B.* cf. *nana*. Also *Pinus cembra* has a conspicuous curve, yet much lower than in zone 2. Almost from the base of zone *Picea* has a continuous curve (up to 1%). The percentage of *Juniperus* decrease distinctly, its curve is discontinuous. *Hippophaë* occurs only sporadically. Single pollen grains of *Ephedra fragilis* (2 grains), *E. distachya*, *Prunus* type and *Ulmus* (several pollen grains) appear. Within the herb pollen percentages of *Gramineae*, *Cyperaceae*, *Artemisia*, *Chenopodiaceae*, *Filipendula* and *Thalictrum* are the highest. Their curves are mostly as high as in zone 2, only the *Gramineae* curve has fallen distinctly. The mentioned rise of *Filipendula* curve in profile Tar. is exceptional. Single pollen grains of *Plantago media*, *Rumex acetosella*, *Sanguisorba officinalis*, *Potentilla* type, *Centaurea scabiosa*, *Rubus chamaemorus* and *Pleurospermum austriacum* occur, the latter appearing also in profile Tar. Within aquatic plants pollen the occurence of *Typha latifolia* is remarkable. In addition, *Potamogeton* sect. *Coleogeton*, *Hottonia palustris*, *Caltha*, *Sphagnum* and *Pediastrum* are present. In profile Tar. *Nymphea alba* occurs, as well as large amounts of *Typha latifolia*.

Zone 4 (Roz. a 4, Roz. b 4, Tar. 4)

The sample from the middle part of zone in profile Tar. is dated at 9840±100 B P. However the age is uncertain being obtained from a piece of wood which may be younger than the sediment containing it. The pollen concentration curve in diagrams Tar. and Roz. b is fairly low, whereas in diagram Roz. a is rather high, declining distinctly near the top of zone. Shrub pollen, particularly *Betula* cf. *nana* are of great importance in this zone. *Juniperus* and *Salix* pollen curves show some increase; *Ephedra fragilis* type and *E. di-*

stachya occur. Percentages of the majority of trees decline, excluding *Betula* and *Pinus cembra*. The *Picea* pollen curve is continuous, up to 0.7% throughout. Single pollen grains of *Ulmus*, *Alnus* and *Corylus* appear. The characteristic feature of this zone is the maximum of *Artemisia* and *Chenopodiaceae* pollen curves, as well as a general increase in NAP. *Pleurospermum austriacum* (with the continuous curve in diagram Roz. b), *Plantago maior*, *P. media*, *Rumex*, *R. acetosella* type, *Saussurea*, *Centaurea scabiosa*, *C. scabiosa* cf. *Kotschyana*, *Dianthus* type, *Papaver* type, *Lychnis* type are more frequent than in the other zones. In addition, a single spore of *Dryopteris thelypteris* is found in profile Tar. Generally, the aquatic plants are poorly represented; they do not occur in profile Roz. b, a single grain of *Typha angustifolia* and numerous pollen grains of *Sparganium* are found in Roz. a, whereas a wide variety of aquatic plants appears in profile Tar. including *Nymphea alba*, *Sparganium*, *S. erectum*, *Potamogeton* sect. *Eupotemogeton*, *P. natans*, *Batrachium* type, *Equisetum* and *Pediastrum*.

Zone 5 (Roz. a 5, Roz. b 5, Tar. 5)

In this zone, a change of sediment occurs in all the profiles. The layer of peat has been deposited upon the layer of lake marl with or without a distinct boundary in between. Thus the drastic increase in the already high pollen concentration follows. The sample from profile Roz. a, at the base of zone is dated at 9920±100 BP, the analogous sample from profile Roz. b is dated with three methods between 9920 and 9850 BP (9850±110 — NaOH-SOL I extraction, 9920±95 — NaOH-SOL II extraction, 9870±110 RES). The age of the layer of peat laying slightly higher in profile Tar. is 9380±80 BP. The zone is not quite homogenous within the profiles though the general trends are compatible. *Pinus sylvestris* and *P. cembra* are dominant in profile Roz. a; *Betula* and *B.* cf. *nana* have their peaks in profile Roz. b, whereas *Pinus sylvestris* and *Betula* — in profile Tar. In all diagram the *Larix* curve ends definitely in this zone, and the curves of *Pinus cembra*, *Betula* cf. *nana* and *Juniperus* end- in diagrams Roz. b and Tar. The *Picea* curve is not very high but continuous in all diagrams. It rises near the top of zone in diagram Roz. b, and reaches a distinct maximum in diagram Tar. The *Ulmus* curve takes a similar course in diagrams Roz. b and Tar. This part near the top of zone is probably the residual, or not fully developed form of subzone 5′, distinguished in profile Roz. a, which will be discussed separately. In diagram Tar. the *Corylus* and *Tilia* curves are low but already continuous. The curves of herbaceous plants decline in diagrams Roz. a and Tar., in diagram Roz. b the NAP curve is rather high but falls steeply near the top of zone. The percentages of *Artemisia* and *Chenopodiaceae* are reduced throughout. The values of *Cyperaceae* and *Gramineae* are high; also those of *Filipendula* in profile Roz. b. Such pollen taxa as *Pleurospermum austriacum* (for the last time in Roz. b), *Selaginella selaginoides* (the last microspore in Tar.), *Calluna*, *Empetrum*, *Hypericum*, *Plantago maior*, *Sanguisorba officinalis*, *Stellaria* *holostea* appear sporadically, and the first grain of *Humulus* near the top of zone in Roz. b has been found. Aquatic plants are represented in different ways in the profiles, which is connected with changes of sediment in various parts of zone. In profile Roz. b, where the change takes place only near the top of zone, there is a wide variety of aquatic plants. They are also numerous in profile Tar. The presence of *Typha latifolia*, *Nymphea alba*, *Sparganium erectum*, *Potamogeton* sect. *Coleogeton*, *Sphagnum* and *Pediastrum* (whose curves end in this zone) is stated.

Subzone 5′ (Roz. a 5′)

This subzone is fully recognized only in profile Roz. a, although — as stated above — its residual form appears in the other profiles too. The pollen concentration increases until it attains the maximum values. The subzone is characterized by the dominance of *Picea* and *Ulmus*. The greatest changes in AP take place here, both quantitative and qualitative. At first *Betula* cf. *nana*, then *Pinus cembra* pollen disappear definitively, the *Betula* curve falls, but the *Picea* and *Ulmus* curves rise. The amounts of *Quercus*, *Tilia* and *Alnus* pollen rise gradually. At the top of subzone the percentage of *Pinus* is reduced to 45.5%. In the upper part of subzone the NAP curve shows a rise, caused by an increase in percentages mainly of *Gramineae* and *Cyperaceae*, but also those of *Artemisia*, *Filipendula*, and *Compositae Tubuliflorae*, *Rubiaceae*, *Umbelliferae* and *Rosaceae* reappear. *Cruciferae*, *Thalictrum*, *Pimpinella* type, *Chenopodiaceae*, *Compositae Liguliflorae*, *Geum* type pollen and *Sphagnum* spores occur sporadically.

Zone 6 (Roz. a 6, Roz. b 6, Tar. 6)

The sample from the middle part of zone in profile Roz. b is dated at 8670 ± 50 BP, and two samples from profile Tar. — at 7930 ± 100 and 5230 ± 80 BP respectively. The pollen concentration decrease to quite low values. The zone is distinguished by the dominance of *Alnus*, *Corylus*, *Tilia* and *Quercus*. The percentages of *Pinus sylvestris* and *Betula* decline throughout whereas those of *Ulmus*, *Picea* and *Tilia platyphyllos* rise. New species appear, including *Acer* (with single pollen grains but forming a continuous curve), *Viburnum*, *Sambucus*, and — somewhat later in profile Tar. — *Carpinus*, *Fagus* and a single pollen grain of *Abies* in the upper part of zone. In profile Roz. b, also *Hedera* occur. The NAP curve declines generally but *Gramineae*, *Chenopodiaceae* and *Calluna* in profile Tar. show small increase. Within sporadic species the pollen grains of *Rumex acetosella*, *Plantago maior*, *Humulus-Cannabis* type, *Silene* type and *Symphytum* are remarkable. Within aquatic plants the pollen grains of *Potamogeton*, *P. natans* type, *Typha angustifolia* and *Sparaganium* occur in significant quantities; *Typha latifolia* has a peak in diagram Roz. b.

Zone 7 (Tar. 7)

The sample at the boundary between zones 7 and 8 is dated at 4240±90 BP. The pollen concentration curve has two maxima and remains rather low between them. The zone is distinguished by the dominance of *Picea* pollen whose oscillating curve reaches the highest values (18%). Also *Corylus*, *Alnus*, *Tilia cordata*, *T. platyphyllos* and *Quercus* pollen amounts are remarkable. Single pollen grains of *Fraxinus*, *Acer*, *Fagus* and *Abies* occur. The NAP curve is low, up to 10%, only the pollen values of *Gramineae*, *Cyperaceae* and *Artemisia* are higher. In addition, *Calluna*, *Vaccinium* type, *Saussurea*, *Silene* type are present. The aquatic plants are represented by *Typha latifolia*, *Sparganium*, *Potamogeton*, and *P. natans* type.

Zone 8 (Tar. 8)

The pollen concentration rises slightly. The zone is characterized by the dominance of *Tilia* and *Pinus sylvestris*. *Tilia* percentages remain at 12%, and those of *Pinus sylvestris* rise up to 26%. *Picea* percentages still keep high, the *Carpinus* and *Fagus* curves rise. The NAP curve is very low.

Zone 9 (Tar. 9)

The pollen concentration shows a decrease, then a rise with some maxima. The zone is distinguished by the rise of *Carpinus* and *Alnus*. The *Alnus* pollen curve has the highest peak here (up to 38.5%), and the values of *Carpinus* become significant for the first time (up to 5%). At the same time maxima of *Fagus*, *Betula*, *Sambucus* and *Salix* pollen occur. The *Abies* values become considerable, though not exceeding 1% yet. In the upper part of zone the curves of *Picea*, *Corylus* and *Ulmus* pollen rise. The zone is characterized by a distinct increase in NAP (up to 18%), caused by a rise in *Gramineae*, *Umbelliferae*, *Filipendula*, *Compositae Liguliflorae* and *Tubuliflorae*. The *Plantago lanceolata* pollen curve consisting of single pollen grains, and sporadical pollen grains of *Rumex acetosa* and *Ranunculus acer* type appear, as well as the first, corroded pollen grain of cf. *Secale cereale*. Within aquatic plants the numerous pollen grains of *Typha angustifolia*, and much fewer of *Potamogeton* and *Batrachium* type are found. Between the middle and the top of zone the *Sphagnum* curve is continuous though never rises high.

Zone 10 (Tar. 10)

The pollen concentration is low and rises only in the upper part of zone. The zone is distinguished by the maximum of *Corylus* pollen, with *Picea*, *Alnus* and *Quercus* values remaining high. Near the top of zone the curves of *Tilia* and *Ulmus* fall, whereas those of *Fagus*, *Abies* and *Betula* rise. In the pollen concentration diagram the picture is different, namely the *Corylus* culmination takes place much later (in the next zone), *Ulmus* does not show any decline and a rise of *Betula* curve is less conspicuous. A fall of NAP curve is caused by a reduction in *Gramineae* and *Artemisia*, though *Filipendula*, *Compositae Liguliflorae* and *Tubuliflorae* pollen show some increase. The curve of *Plantago lanceolata* continues up to the older part of zone as well as single grains of *Plantago maior* and *Rumex acctosella*. There are no changes within aquatic plants in comparison with zone 9.

Zone 11 (Tar. 11)

The bottom part of zone is dated at 3930±60 BP. The pollen concentration is high, falling steeply at the top of zone. The zone is distinguished by *Fagus* and *Abies* pollen curves rising up to 24% and 12% respectively. The percentages of *Alnus* (up to 34%), *Picea* (12.5%), *Quercus* (up to 7.5%) and *Carpinus* (up to 5%) still keep high. *Salix*, *Sambucus* and *Viburnum* pollen show their peaks in the middle of zone. The pollen curves of *Ulmus* and *Tilia* do not exceed 2% and the *Tilia platyphyllos* values reach up to 2% only in the upper part of zone. The NAP curve shows a decline to 4% and then a rise to 18%, with the curves of *Gramineae*, *Cyperaceae*, *Filipendula* and *Compositae Liguliflorae* pollen contributing mostly to these changes. Around the middle of zone the *Chenopodiaceae* curve reaches the maximum and the first pollen grain of *Secale cereale*, identified doubtlessly this time, appears. In the upper part of zone the amount of *Secale cereale* exceeds 1%; *Humulus/Cannabis* and single grain of *Hedera* are found. Also *Ranuncuius acer* type, *Lotus* type and *Scleranthus* pollen are identified. A wide variety of aquatic plants occurs including *Typha latifolia*, *T. angustifolia*, *Sparganium erectum*, *S. emersum*, *Potamogeton* type, *P.* sect. *Coleogeton*, *P. natans* type and *Batrachium* type.

Zone 12 (Tar. 12)

The boundary between zones 11 and 12 is dated with two methods at 2040±50 and 1950±60 BP respectively. Pollen concentration is very low. The pollen percentages of almost all tree components decrease, only the *Pinus* pollen curve is high, even rising; also that of *Picea* has a peak in the lower part of zone. Those changes are more prominent in the pollen concentration diagram, with the *Pinus* curve showing a decrease. NAP percentages are the highest of all zones (up to 53.5%), which is caused by an increase mainly in *Gramineae* and *Cyperaceae* and also in *Compositae Liguliflorae*, *C. Tubuliflorae* and *Filipendula* pollen values. The *Hordeum* curve appears for the first time and rises up to 4%; that of *Secale cereale* attains the maximum at 1.2%. *Lychnis* type and, in the upper part of zone, *Rumex acetosa* occur. The variety of aquatic plants is reduced to *Typha latifolia*, *T. angustifolia* and *Batrachium* type pollen.

Profile Tarnowiec e — macrofossil assemblage zones

Zone Tar. I (2.45—2.65)

Selaginella selaginoides is a characteristic species for this zone. Among tree species, macrofossils of *Betula*, *Picea*, *Pinus*, and *Larix* were identified there. Most of the species of mosses found here *Calliergon gigantheum*, *C. trifarium*, *Drepanocladus sendtneri*, *Meesia triquetra* and *Scorpidium scorpioides* — the most frequently occurring species associated with deeper water are decisively calciphilous. Not very numerous although consistently occuring here was an expansive, calciphilous species *Chara contraria*; besides *Carex rostrata*, *C. fusca*, and *Schoenoplectus tabernaemontani* were also present. Later a variety of aquatics and helophytes appeared; such as: *Nymphaea alba*, *Lycopus europaeus*, *Menyanthes trifoliata*, *Hippuris vulgaris* and *Viola palustris*. In the upper part of zone, fruits of *Heleocharis mamillata* and *Comarum palustre* were found.

Zone Tar. II (2.20—2.45)

The only arboreal macrofossil found in this zone was a wood of *Salix*. Apart from dominating *Schenoplectus tabernaemontani* and *Potamogeton filiformis*, *Heleocharis mamillata* occurs more frequently while *Hippuris vulgaris* and *Menyanthes trifoliata* — less frequently. In the upper part of the zone macrospores of *Selaginella selaginoides* were also present.

Zone Tar. III (1.80—2.10)

The occurrence of *Calliergon giganteum* ends in this zone, as it was associated with *Chara contraria* community. Another species connected with the hydroseral processes — *Drepanocladus* revolvens was also found here. *Selaginella selaginoides* spores are present for the last time. The frequencies of *Carex rostrata* and *C. fusca* fruit are still high. *Potamogeton filiformis* fruits are less abundant but still frequent. In contrast to the previous zone there is again an abundance of macrofossils of aquatics and helophytes: *Nymphea alba*, *Hippuris vulgaris*, *Menyanthes trifoliata*, *Heleocharis mamillata*, *Sparganium neglectum*, *Viola palustris* and *Comarum palustre*. In the upper part of the zone, wood of *Alnus* was found; in some samples there were fruits of *Rubus idaeus*.

Zone Tar. IV (1.45—1.90)

Apart from *Menyanthes trifoliata* — the species characteristic for this level — The macrofossils of *Nymphaea alba*, *Potamogeton filiformis*, *Viola palustris*, *Chara contraria* are prominent for the last time. Among mosses *Calliergon trifarium*, *Drepanocladus lycopodioides* (restricted to this level alone), *D. revolvens*, and *Scorpidium scorpioides* were identified. By the end of zone the sediment changes into peat.

Zone Tar. V (1.15—1.45)

Mentha aquatica dominates in this zone. The change of sediment brought about changes in the composition of the macrofossil assemblage. The aquatic plants so abundant in the previous layers now disappeared. Fruits of *Lemna* and *Alisma plantago-aquatica* are found while fruits of *Rubus idaeus* are frequent.

Zone Tar. VI (0.45—1.15)

The level is dominated by seeds of *Sambucus* and fruits of *Rubus idaeus*. *Carex rostrata* nuts reappear. Fruits of *Alnus*, single fruits of *Potamogeton filiformis* and *Lycopus europaeus* were found. Macrofossils of *Batrachium*, *Lemna* and *Ranunculus repens* are frequent, and there were also *Valeriana* and *Mentha aquatica* present.

Zone Tar. VII (0.15—0.45)

In this youngest zone, *Carex rostrata* and *Lychnis flos-cuculi* dominate. *Chenopodium* sp. and *Ch. album* were also found there.

HISTORY OF LOCAL CHANGES IN TARNOWIEC

The vegetational succession recorded in this site started in Older Dryas chronozone. For the oldest macrofossil zone there is no pollen analysis. The lake, from its very beginning was inhabited by *Chara contraria*, *Hippuris vulgaris*, *Menyanthes trifoliata*, *Viola palustris*, and numerous calciphilous mosses. The presence of fruits of *Nymphaea* alba and *Heleocharis mamillata* in the Older Dryas sediments is noteworthy — these species which require rather warm climate have been classified by Samuelsson (1934) as South-Scandinavian-Atlantic species.

In Allerød chronozone apart from dominating *Schoenoplectus tabernaemontani*, *S. lacustris* appeared — a species which, according to Samuelsson (1934), has its range limited by a July isotherm of 13°C. It does not occur in the Alps above the timberline (Iversen 1954). *Selaginella selaginoides* megaspores occur in the Tarnowiec profile only till the end of Allerød period, but its microspores continue to appear in the pollen diagrams still much later.

In the Younger Dryas chronozone *Hippuris vulgaris* and *Viola palustris* occur together. The first change of sediment in Allerød (the peat has been deposited upon the layer of lake marl) was associated with the appearance of *Calliergon giganteum* and with increase in representation of *Carex* species. The second, similar change of sediment caused the disappearance of most species of mosses, with *Chara* occurring only sporadically, a gradual with drawal of *Carex rostrata* and *C. fusca*, and the beginning of decline of aquatic species.

Wet alderwoods with some ponds developed and the vegetation there was quite different (cf. Zone V).

The most recent history of the site is associated with progressing man-made drainage the effect that produced the water-logged meadows with Lychnis flos-cuculi.

CHANGES IN VEGETATION RECORDED IN SEDIMENTS OF LATE-GLACIAL LAKE NEAR JASŁO

Zone 1

The low pollen concentration of the basal samples is caused by the high content of mineral matter in the sediments. Apart from Roz. b profile, this zone has been distinguished on the basis of the pollen analysis of 2—3 samples only. In the sediment from Tarnowiec it was not possible to calculate spectrum for six lowermost samples due to their very low pollen concentration although the macrofossils were identified there. The pollen and macrofossil analysis anabled to define the zone as Older Dryas chronozone. In this period around Roztoki and Tarnowiec site a park-woodland landscape prevailed. Despite high frequencies of shrubs and herbs including heliophilous species there were also trees present, what is confirmed by macrofossils. Apart from birch nutlets (*Betula pubescens*), needles of *Larix*, and seeds of *Pinus* there were also five seeds of *Picea* found in the sample below the basal sample of the pollen profile, and three seeds in the sample corresponding to the basal pollen spectrum. However the curve for *Picea* pollen did not exceed 0.5%.

In the waterlogged depressions of the site the following plants were growing: *Nymphaea alba*, *Hippuris vulgaris*, *Menyanthes trifoliata*, *Lycopus europaeus*, *Potamogeton filiformis*, and also *Chara vulgaris* and *Ch. contraria*. When the list is supplemented by aquatic species determined by pollen analysis, high frequency of calciphilous species becomes evident. Also mosses represented in this zone by *Scorpidium scorpioides*, *Meesia triquetra*, *Calliergon trifarium*, *C. giganteum*, *Calliergonella cuspidata* are mostly calciphilous. The reed-swamp communities were formed by *Carex rostrata*, *C. fusca*, *Schoenoplectus tabernaemontani*, *Viola palustris*, *Heleocharis mamillata*, and *Schoenoplectus lacustris*, the last two species found only in the uppermost layer. The most characteristic feature of this zone was *Selaginella selaginoides* occuring in all profiles, as microspores and megaspores.

Zone 2

This zone spanned over 26 cm in Tarnowiec, 20 cm in Roz. b and only 5 cm in Roz. a. It is treated as an older part of Allerød chronozone. The composition of tree stands did not change much but the area occupied by them significantly extended, partly at expense of shrubs but mainly by spread of woodland on areas previously occupied by grasses, sedges and heliophilous vegetation. *Pinus cembra* became abundant, *P. sylvestris* and *Larix* occurred frequently (seeds of *Pinus* and needles of *Larix*). Birch has also occurred in the forest stands. The biometric analysis of the birch nutlets revealed that apart from *Betula humilis*, *B. carpatica*, or *B. tortuosa* were present, and in Roz. a, also *B. pubescens*. The species composition of aquatic plants did not change significantly; but their macrofossils were more numerous in profile Roz. b and in the upper part of Tar. profile. In the older part of zone in the Tar. profile the curve of *Selaginella* microspores was still present, and in the younger part of this zone 58 macrospores were found.

Zone 3

This zone, unevenly represented in the profiles studied, was treated as a younger part of Allerød chronozone. It was marked by significant increase or maxima of Betula pollen and decreases in *Pinus cembra* and *Larix*. The abundance of birch within this zone was also confirmed by macrofossil analysis; nuts and a fruit scale were found. The nuts were identified as belonging to *Betula pubescens*, *B. carpatica*, and *B. humilis*, and the fruit scale as belonging to *B. pubescens* group. *Pinus sylvestris* was common (apart from high percentages of pollen more evidence is provided by numerous seeds found within the zone), and spruce (two seeds in Tar.), and larch (needles) were also present. Among the aquatic species, the macrofossil analysis confirmed presence of *Nymphaea alba*, *Hippuris vulgaris*, *Lycopus europaeus*, *Potamogeton filiformis*, *Menyanthes trifoliata*, *Sparganium neglectum*, and *Heleocharis mamillata*, as well as oospores of *Chara vulgaris* in Roz. b, and *Chara* contraria in Tarnowiec.

Zone 4

The results of pollen analysis allowed assumption that this zone represented the Younger Dryas chronozone. Hence the wood found in the middle section of the level and dated as about 9840$\pm$100 BP must be much younger than the sediments surrounding it. During the Younger Dryas the forest limits shifted southward and a park landscape prevailed again. In the older part of the period groups of trees occupied much larger spaces than in the younger part. It is indicated by higher percentages of tree pollen (*Pinus sylvestris*, *P. cembra*, *Larix*, and *Picea*), and also by more numerous tree macrofossils. Seeds of *Picea* were found only in the bottom samples of this zone. From the middle sample some fragments of *Alnus* wood were identified. Biometric studies revealed that besides *Betula humilis* there was also *B. pubescens* in Roz. a, and *B. carpatica* in Tar. In the younger part of Younger Dryas, *Juniperus*, *Betula* cf. *nana* and *Salix* became abundant and *Ephedra fragilis* t. and *E. distachya* t. also appeared.

The aquatic vegetation did not change much compared with Allerød. In the older part, the fruits of *Nymphaea alba* were more numerous; a fruit of

Cladium mariscus identified in Roz. a also came from the older part. All this together with a prominent pollen curve of *Filipendula* proves that during the older stage of this period climate was much milder than in the Older Dryas. *Dryopteris thelypteris* spore found in Tar. profile provides additional evidence to it. A change towards more severe continental climate took place presumably in the younger stage of this period. This supposition is supported by a significant increase of *Juniperus* curve and its culmination in Tar. profile.

Zone 5

The lower limit of this zone was marked by the beginning of decline in *Artemisia* and *Chenopodiaceae* pollen curves. For its most part it was concurrent with percentage increases of *Pinus* and *Betula* with only *Pinus sylvestris* curve dropping in Roz. b profile. It was mentioned in the PAZ description that this zone had been dated in all profiles. Bearing in mind that in Tar. profile the dated sample did not come from the base of peat but from upper sample, it could be inferred that the change of sediments was more or less synchronous but occurred in various stages of the zone 5 development. In Tar. the change took place at the beginning of the zone, in Roz. b in its middle, while in Roz. a at the end of zone. This could support hypothesis put forward by Wójcik (MS) that at the beginning of holocene when the lake become shallow or partly dried out, a part of the lake sediments might have been eroded. This period can be treated as slightly restricted Preboreal period. The forest communities were dominated by *Pinus sylvestris*, *Betula*, *P. cembra*, *Larix*, and *Picea*. Their presence in situ was confirmed by two seeds found at the bottom of this zone in Roz. a, larch needles, wood and many birch nutlets, pine wood and numerous pine seeds. The presence of *Picea* is interesting since its pollen values in Roz. a are quite low (in the corresponding pollen sample it did not exceed 0.3%). Wood of *Alnus* was also identified in this zone. When compared with Bieszczady Mts. (Ralska-Jasiewiczowa 1980), or Besko in Jasło—Sanok Depression (Koperowa 1970) it represents extremely early appearance of alder. The contribution of shrubs was quite significant (*Betula* cf. *nana*, *Juniperus*, *Salix*, and, in Tarnowiec, the first appearance of *Corylus*). At Roztoki aquatic species were represented by abundant fruits of *Potamogeton filiformis* seeds of *Menyanthes trifoliata* and oospores of *Chara vulgaris*, and telmatophytes, by numerous sedges. At Tarnowiec sedges were less frequent than in the previous zone. It was associated with the change of sediment from the lake marl into the peat at the beginning of the zone.

Subzone 5′

The description of the subzone given above cannot be much supplemented apart from mentioning that in Roz. b and Tar. profiles it occurs in the upper parts of zone 5, in shortened form. It is presumably the younger part of the

Pre-Boreal chronozone when, similarly as in Bieszczady Mts. Ralska-Jasiewiczowa 1980), pine forest with spruce and elm spread in the area. According to the criteria used by Koperowa (1970) at Besko, this zone should be included into the Boreal period, characterized there by maxima of *Picea* und *Ulmus* with permanent high contribution of *Pinus sylvestris*. However, a comparison between the diagrams for Roz. a, Roz. b and Tar. profiles together with the corresponding dates shows that this subzone belongs rather to the younger Preboreal period. The macrofossil analysis proved presence of pines (in the upper part of this subzone both seeds and wood of *Pinus* were found), birch (nuts) and *Salix* (wood) in situ. The presence of *Filipendula* in local tall herb communities was confirmed by its fruit, though its pollen curve was not very prominent. Aquatic plants and telmatophytes virtually absent from the pollen spectrum, turned out in macrofossil analysis. The fruits of *Lycopus europaeus, Viola palustris, Cladium mariscus*, as well as the oospores of *Chara vulgaris* were found.

Zone 6

This zone covers two, much shortened chronozones: Boreal and Atlantic. The beginning of the Boreal chronozone was indicated by the end of birch culmination concurrent with a maximum peak of *Pinus* curve, rapid increase of hazel and of elm. The surrounding hills were probably covered with elm forests while the less fertile habitats were occupied by pine woods. The forest understory was represented by *Sambucus* (seeds) and *Rubus idaeus* (numerous fruits). The amounts of spruce pollen in the pollen spectra indicate that this species played a significant role in the forest stands occupying the lower parts of the depression. It probably co-existed with alder (*Alnus* wood was found in the sediment). A rapid increase in the *Alnus* pollen curve is indicative of wide expansion of this species into damp habitats so common in the Depression region. Small ponds were overgrown with *Lemna*, with *Alisma plantago-aquatica, Heleocharis mamillata*, and *Mentha aquatica* growing in them.

It was difficult to determine precisely the boundaries between Boreal and Atlantic chronozones in both Roz. b and Tar. diagrams, particularly because these parts of profiles were very shortened and all the changes in diagrams seemed to happen simultaneously. Dates from both diagrams were obviously very helpful nevertheless the pollen criteria did not provide any solid base for separation of the above periods.

In the Atlantic period some indistinct traces of human activity were found. They were reflected by presence of *Plantago maior, Ranunculaceae, Artemisia, Compositae Liguliflorae, Rubiaceae* pollen, and increase in *Chenopodiaceae* pollen curve. *Gramineae* and *Cyperaceae* pollen had their maxima a little higher in the diagram. In these samples *Humulus-Cannabis* pollen was found.

Zone 7

It is again difficult to find a boundary between Atlantic and Sub-Boreal chronozones. The beginning of zone 7 was marked by spruce domination, continuous curve for *Carpinus* and a new increase of *Corylus* pollen values. A continuous *Fagus* pollen curve starts much later, just after the date of 4240$\pm$90 BP. There is no change in the components of *Quercetum*-mixtum apart from the decrease of *Ulmus* pollen. In the understory *Sambucus* played the most prominent role (maximum in the pollen diagram and seeds). Fruits of *Rubus idaeus* were again numerous. Among aquatic species, the macrofossils of *Lemna*, *Batrachium*, *Potamogeton filiformis*, and *Eupatorium cannabinum* were found.

Zone 8

This is a very episodic zone within the Sub-Boreal chronozone, separated from the zone 7 by 4240$\pm$90 BP date. Among trees, *Pinus* and *Tilia* extended their ranges; *Fagus* had already a continuous although low pollen curve. In the close vicinity of Tarnowiec site *Alnus glutinosa*, *Betula humilis*, *Sambucus*, and *Rubus idaeus* were growing. *Carex rostrata*, *Lemna* and *Batrachium* occurred in the pond.

Zone 9

This zone is remarkable for the highest pollen values of *Alnus*, and very numerous nuts of *A. glutinosa* — what indicates that the alderwood grew on the peat bog. Traces of human activity are evident in this zone. The pollen curves for *Plantago lanceolata*, *Rumex acetosa* started there, while those for *Compositae Liguliflorae*, *C. Tubuliflorae*, *Umbelliferae*, *Chenopodiaceae*, *Artemisia*, and *Gramineae* increased. It was presumably the Neolithic settlement. The changes in forest cover were still not profound although some could be reflected by decreasing curves for *Quercus*, *Ulmus*, and *Tilia*. The first pollen grain of *Cerealia* was found there although the identification was uncertain.

Zone 10

This zone is distinguished by the increase of *Corylus* pollen values. Pollen grains of *Plantago lanceolata*, *P. maior*, *Rumex acetosella* are present, in addition to high pollen curves for *Compositae Liguliflorae*, *C. Tubuliflorae*, *Umbelliferae*, *Artemisia*, and *Gramineae*, therefore it cannot be excluded that the increase of *Corylus*, has been brought about by human activity. Having cleared the land, the Neolithic man was leaving behind open areas convenient for the development of hazel shrubs. Large numbers of *Rubus idaeus* fruit may be associated with the man-made habitats suitable for spread of this species.

Zone 11

This zone distinguished only in Tarnowiec reflects, to large extent, the man-made changes in vegetation. Fir and beech forests expanded as a combined result of deforestation and climate changes. *Abies* appeared in the pollen spectra much earlier, but in very low percentage values. During zone 11 it spread beyond any doubt on the nearby high grounds together with beech. Firs might also grow in valley communities together with spruce still rather common in the Depression region. The appearance of fir just preceded 3930$\pm$60 BP. date. The traces of Neolithic herdsmen (possibly of the Corded Ware Culture) continue, and are supplemented by more macrofossil findings: fruits of *Chenopodium*, *Rubus idaeus*, and numerous fruits of *Lychnis flos-cuculi*.

Zone 12

This zone records the period of devastation of forest cover. It occurred at the beginning of the Sub-Atlantic period. Its lower limit is marked by decline of *Alnus*, and rise of NAP curve. Aldertrees were probably felled, and alder-woods thinned, giving way to swamp communities (high pollen values of *Cyperaceae*, nuts of *Carex rostrata*, fruits of *Ranunculus repens*, *Lycopus europaeus*, *Comarum palustre*, *Valeriana*) and wet meadows with *Lychnis flos-cuculi* (pollen grain, fruits). On suitable places cereals (*Secale cereale* and *Hordeum*) were already cultivated on large scale. In the older part of this zone numerous fruits of *Chenopodium album* were found.

SUMMARY OF THE RESULTS

The presented study is based upon the analysis of paleobotanical material obtained from two sites: Roztoki (two profiles Roz. a, and Roz. b), and Tarnowiec. Roz. a profile made possible the reconstruction of the history of vegetation in the area from the Older Dryas till the Boreal period, while Roz. b profile included moreover the Atlantic period. Tar. profile allowed to study vegetational history over the time span from the Older Dryas to the Sub-Atlantic. In pollen diagrams from Roztoki six pollen assemblage zones (PAZ) were identified while pollen diagram from Tarnowiec — includes twelve pollen assemblage zones, and seven macrofossil assemblage zones (MAZ). These data form the base for the reconstruction of vegetational succession in the region studied.

In the Older Dryas the area was occupied by a park-type landscape. Very early appearance of spruce in situ (indicated by presence of numerous seeds) is noteworthy. The data obtained so far from Nowy Targ Basin, West Bieszczady Mts., and Jasło—Sanok Depression reveal the earliest traces of spruce coming from Allerød (Koperowa 1962, Gerlach et al. 1972, Środoń 1967, 1977, Ralska-Jasiewiczowa 1980).

Allerød was the period when forests were much more extended than in the Older Dryas. Larch-stone pine forests with common pine and spruce dominated. Alder was probably present.

The Younger Dryas witnessed the progressing shrinking and thinning of the forested areas and reversion of park landscape. In this period *Alnus* was present in the area with no doubt (fragments of wood were found). The presence of alder during this period was also stated at Besko (Koperowa 1970). In Bieszczady Mts. alder-tree appeared much later (*Alnus viridis* present since Allerød). Nevertheless in the pollen diagrams only single pollen grains of *Alnus* were found.

The climate during the Younger Dryas must have been milder than in the Older Dryas although some authors suggest that it could be the coolest period within the Late Glacial (Coope & Joachim 1980, Watts 1980). It is however contradicted by the presence of *Nymphaea alba*, *Cladium mariscus* and *Dryopteris thelypteris* at Roztoki and Tarnowiec, and also by a prominent pollen curve of *Filipendula*. A significant cooling of the climate occurred not earlier than in the younger part of this period. Studying the palaeotemperatures by means of ^{18}O and ^{13}C isotopes (Fritz et al. 1975, Wcisło 1985, Różański et al., in press) has yielded the difference between the summer temperatures in Allerød and the Younger Dryas in Roz. b profile reaching 5°C. It is a suprisingly large difference. The pollen analysis did not allowed conclusions about such remarkable alterations in climate. Next warming of the climate in the Pre-Boreal period estimated by ^{18}O method indicate increase of summer temperature by 3°C (Różański et al. in press, Różański, this volume). Small number of sites that have been studied so far do not permit any generalized conclusions or interpretations.

During the Preboreal period the lacustrine sediment in both sites changed into peat. This happened more or less synchronously although it could not be excluded that some sediments might have been eroded. This change was probably caused by climatic reasonsdrier climate.

The Boreal period was marked by quick spread of *Ulmus* and *Corylus* and later of the other components of thermophilous deciduous forests. Forests with spruce and alder developed in the depressions of the area. In Tarnowiec diagram the Atlantic period was difficult to distinguish, as it was represented by very short sediment series; in Roztoki b the diagram just ended during that period. All that means strong water level oscillations during the time in question (see Szczepanek, this volume). Since the end of Atlantic period the effects of human activities assumed a significant role (apart from climatic changes) in shaping the vegetation cover.

In the Sub-Boreal period, similarly as in other parts of Carpathians areas, forests with beech and hornbeam expanded. In the older part of the period (about 3900 BP) fir appeared. It was in the Jasło—Sanok Depression later than in Beskid Niski Mts. (Szczepanek, this volume) but earlier than in Bieszczady Mts (Ralska-Jasiewiczowa 1980).

The beginning of Sub-Atlantic period witnessed the onset of progressive devastation of forest communities caused by human activities.

Roztoki site was investigated by means of pollen and macrofossil analysis more than 50 years ago by Szafer & Jaroń (1935). When the present results are compared with his work the far-reaching similarities in the courses of most pollen curves reveal, mostly in those for *Pinus*, *Betula*, *Larix*, *Ulmus*, and *Corylus*. Only the *Salix* pollen curve is many times higher in Szafer's diagram. The error in willow pollen identification could have easily been committed there, remembering the low magnification objective used then.

The computer zonation obtained by A. Walanus for all 3 pollen diagrams after this paper has been already completed, confirmed the correctness of zones distinguished in this study. The correlation between profiles made by SLOTSEQ method (Gordon & Birks 1972, Birks & Gordon 1985) showed the highest similarity between Roz. a and Tar. diagrams, lower similarity between Roz. b and Tar., and the least similarity between the two diagrams for Roztoki site. However, these results have to be discused in more detail in another paper.

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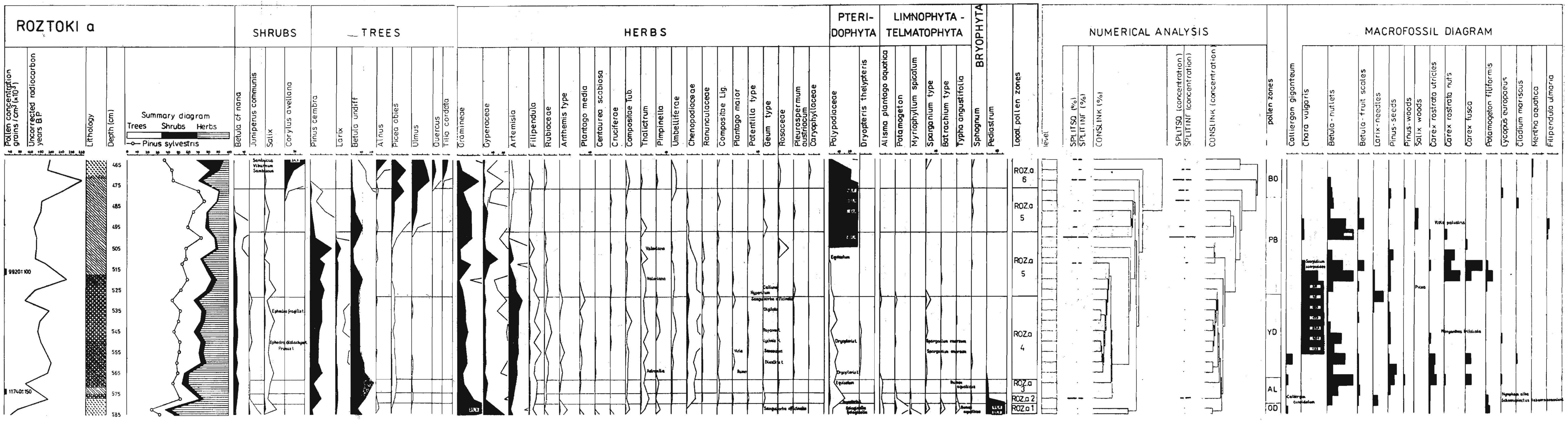

Fig. 1. Percentage pollen diagram and macrofossil diagram from the Roztoki, profile a. Symbol, used in the lithology column follow Faegri & Iversen (1975) system. Percentages of all tree, shrub and herb pollen taxa are calculated from the total P sum, excluding *Pteridophyta*, *Limnophyta*, *Telmatophyta*, *Sphagnum* and *Pediastrum*

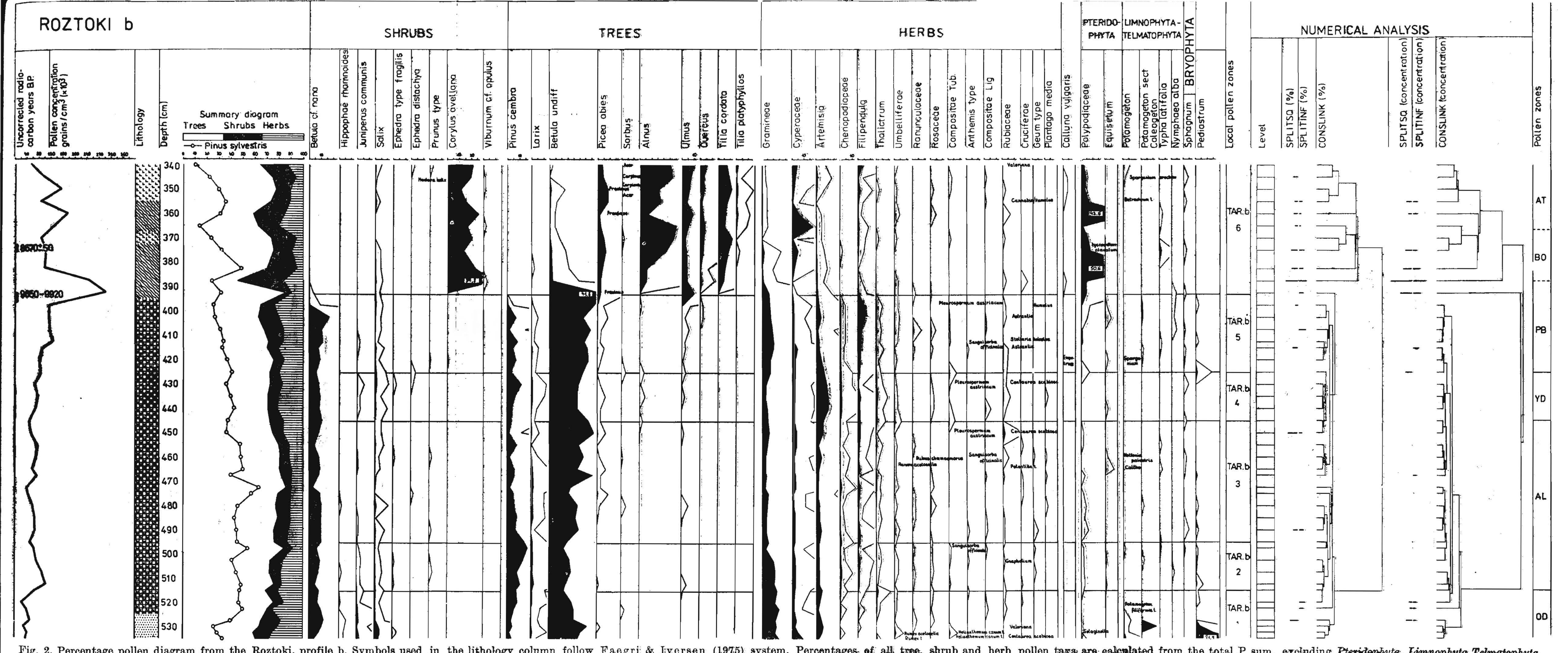

Fig. 2. Percentage pollen diagram from the Roztoki, profile b. Symbols used in the lithology column follow Faegri & Iversen (1975) system. Percentages of all tree, shrub and herb pollen taxa are calculated from the total P sum, excluding *Pteridophyta*, *Limnophyta*, *Telmatophyta*, *Sphagnum* and *Pediastrum*.

Fig. 3. Percentage pollen diagram, pollen concentration diagram and macrofossil diagram from Tarnowiec, profile e. Symbols used in the lithology column follow Faegri & Iversen (1975) system. Percentages of all tree, shrub and herb pollen taxa are calculated from the total P sum, excluding *Pteridophyta*, *Limnophyta*, *Telmatophyta*, *Sphagnum* and *Pediastrum*