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LATE-GLACIAL AND EARLY-HOLOCENE VEGETATION FROM THE TERRITORY OF KRAKÓW (POLAND)

Późnoglacjalna i wczesnoholoceńska flora z terenu Krakowa

INTRODUCTION

Pollen diagrams presented in this report come from the town of Cracow which lies on the border of three physiographic units: the Cracow Upland, the Sandomierz Basin, and the Sub-Carpathian Foothills. Two of these units penetrate into the boundaries of the town — the Cracow Upland from the north-west and the Sandomierz Basin from the east. The Sub-Carpathian Foothills border it from the south (Fig. 1).

The Cracow Upland is represented in the town area by horsts built chiefly of Upper Jurassic limestones and partly of Cretaceous rocks. These horsts are separated by narrow grabens formed during the Miocene orogenic movements. The Sub-Carpathian foredeep was also formed during this period. The bottoms of all these tectonic grabens are covered with sediments of the Miocene sea. The investigated terrain lies in the area of the Cracovian Glaciation (Mindel) and outside the maximum range of the Middle-Polish Glaciation (Riss).

On this diversified bed-rock quaternary processes formed a much differentiated contemporaneous relief. The wide valley of the Vistula was cut out in deposits of the Cracovian Glaciation and in Miocene clays underlying them. During the maximum range of the Middle-Polish Glaciation the appearance of this channel was that of an Old Valley. Deposits from this period underlie both the higher and lower terraces of the Vistula (Tyczyńska 1968).

The investigated sites permitted the determination of the age of one of the lower (3—6 m in height) terraces, i. e. Rendzina terrace. According

to earlier interpretations, the age of this terrace was related to the Middle-Polish Glaciation. Up till now no flora from this area has been elaborated by the pollen analysis method. Rich Dryas-macroflora, occurring at the bottom of the Rendzina terrace on the right bank of the Vistula, was elaborated by Żmuda (1914). Its age was related to the

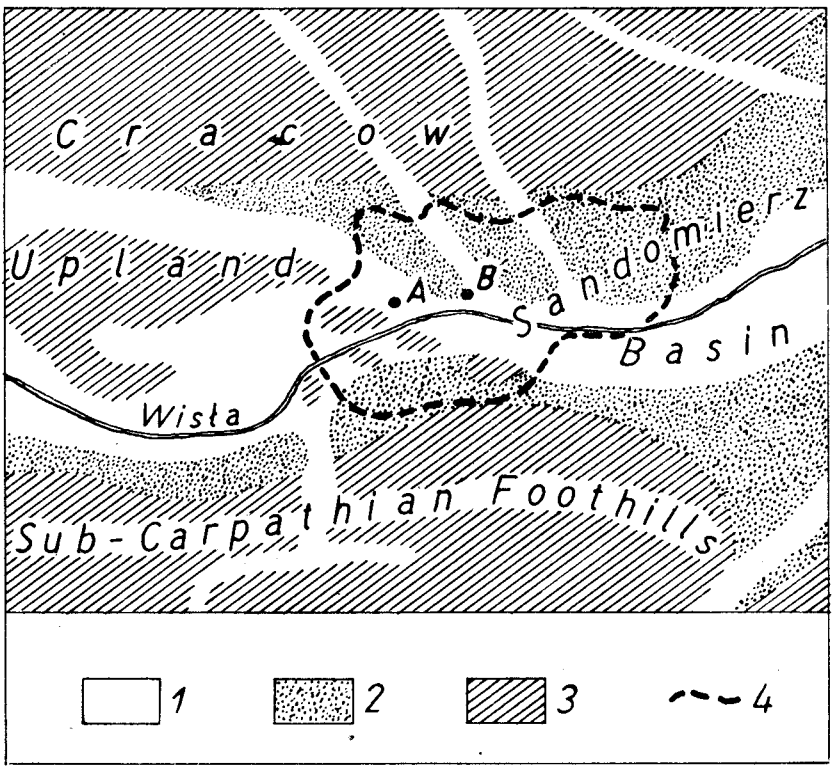

Fig. 1. The situation of Cracow on the background of physiographic units (according to Tyczyńska 1968), 1 — bottoms of basins, grabens and larger valleys, 2 — high terraces and plateaux, 3 — uplands, 4 — boundary of the town, A — the site in Piastowska street, B — the site at the Rondo

Ryc. 1. Położenie Krakowa na tle jednostek fizjograficznych (według Tyczyńskiej 1968), 1 — dna kotlin, rowów tektonicznych i większych dolin, 2 — wysokie terasy i płaskowzgórza, 3 — wyżyny, 4 — granica miasta, A — stanowisko przy ulicy Piastowskiej, B — stanowisko przy Rondzie

Middle-Polish or even Cracovian Glaciations. It was Środoń (1952) who made a critical review of Pleistocene floras from the Sub-Carpathian Region, and related it to the younger part of the Last Glaciation (Pomeranian Stadial) and to the Late Glacial period. For various reasons this flora requires modern paleobotanical elaboration as well as a detailed radiocarbon dating.

DESCRIPTION OF THE PROFILES

The two profiles presented in this report come from the left bank of the Vistula. The site at the Rondo (Fig. 2) lies within a terrace of this river, in a place where its valley begins to widen to the east. At the sampling point the following sequence of layers was established:

0·00—1·30 m embankment
1·30—3·00 m silty sand
3·00—3·60 m sandy clay
3·60—3·70 m sandy clay with a high content of plant detritus
3·70—4·15 m peat with traces of clay
4·15—4·50 m clayey silt with plant detritus.

The site in Piastowska street (Fig. 3) lies within a terrace of the Rudawa river, a left-bank tributary of the Vistula. Both the valley of the Vistula and that of the Rudawa, are already relatively narrow there, and continue to narrow towards the west, as they there enter the narrow grabens of the Cracow Upland. The material for research was taken from a fen-peatbog, which is now built over.

The highly differentiated geomorphological situation in this not very large area is to some extent reflected in the investigated profiles, although the sites are only about 5 km apart. Since there are no profiles elaborated by the pollen analysis method either from the Cracow area or from the whole western part of the Sandomierz Basin, the comparison and synchronization of some more general changes in the diagrams was based on the pollen diagrams from the eastern part of this Basin (M a m a k o w a 1962) and on those from the southern part of the Święty Krzyż (Holy Cross) Mountains (S z c z e p a n e k 1961).

In both diagrams, the distinction of the Younger Dryas period arouses no doubt. In the pollen diagram from Piastowska street the bottom samples with a small quantity of *Salix* and *Betula nana* and a slightly larger proportion of *Alnus* pollen may belong to the Allerød period, although, in principle, there is no certain reason to mark out the Allerød/Younger Dryas boundary. The data mentioned above enable us to state that the organogenic sedimentation in the investigated area began only towards the close of the Late Glacial. Ś r o d o ń (1965) also accepted a similar age for this terrace in the valleys of Carpathian rivers.

DESCRIPTION OF THE VEGETATION

On the basis of results obtained by pollen analysis it can be assumed that in the Younger Dryas period the humid sands and organogenic sediments which had already filled up the depressions, were overgrown by a loose pine-forest with an admixture of larch and arolla pine.

Arctostaphylos uva-ursi, whose fruit-stones were found in both profiles, probably occurred in its herb layer.

Large quantities of *Salix* pollen grains, among which the morphological type of *Salix pentandra (S. alba* and *S. pentandra)* prevailed in many samples, probably reflect the development of willow thickets as well as willow-poplar riverside forests. Apart from the poplar and birch, the alder also occurred in these riverside forests. In the pollen spectra there appeared very small quantities of *Betula* and *Alnus,* but in the peat from Piastowska street pieces of *Alnus* wood were found in two levels and *Betula* vel *Alnus* in the profile from the Rondo (more probable *Betula).*

The higher situated forestless sandy soils were overgrown by communities including *Juniperus, Ephedra distachya, E.* t. *fragilis, Armeria vulgaris* s. l., *Helianthemum* t. *nummularium, H.* t. *oelandicum, Scleranthus annuus,* and *Rumex acetosella.*

The high *Cyperaceae* curve in both diagrams and that of *Polypodiaceae* in the diagram from Piastowska street, show that wet communities of various type were common on the newly uncovered terrace.

The unusually abundant occurrence of *Selaginella selaginoides* (micro- and macrospores) in the profile from the Rondo, and the indubitable presence of *Betula nana* (leaves) in the material from the Piastowska street, suggest that the patches of tundra vegetation were still developed there in the Younger Dryas period.

The contemporaneous distribution of *Selaginella selaginoides* in the tundra in the western part of the Soviet Union covers areas with a mean July temperature between 10°—14°C (Dobrynin 1956, quoted after R o t n i c k i, T o b o l s k i 1965).

The occurrence of *Ceratophyllum* hairs in the deposit from the Rondo and the continuous *Myriophyllum verticillatum* curve in the Piastowska street profile indicate that the mean July temperature in this area during the Younger Dryas period was at least 13°C.

The transition to the Preboreal period is characterized by a very distinct, sharp rise in the pine curve, matched by a corresponding decrease in *Cyperaceae, Salix,* and *Juniperus* and in the case of the profile from the Rondo a fall in the *Pinus* t. *haploxylon* and *Selaginella* curve. Above this level there is a marked decrease in aquatic pollen grains. The presence of *Cladium mariscus* fruit in the Rondo profile indicates a considerable amelioration of climatic conditions, which justifies the assumption that the mean July temperature in this area had increased by about 3°C in comparison with the Younger Dryas.

At present *Cladium mariscus* (L.) Pohl. occurs mostly in the northern part of Poland and in the province of Lublin (Fig. 4). An isolated locality in Southern Poland is situated at Podgórki near Cracow (Ś w i e b o d a 1968). Fossil fruits of *Cladium mariscus* have so far been reported only from a few stations of interglacial, Brørup, Late-Glacial and Holocene

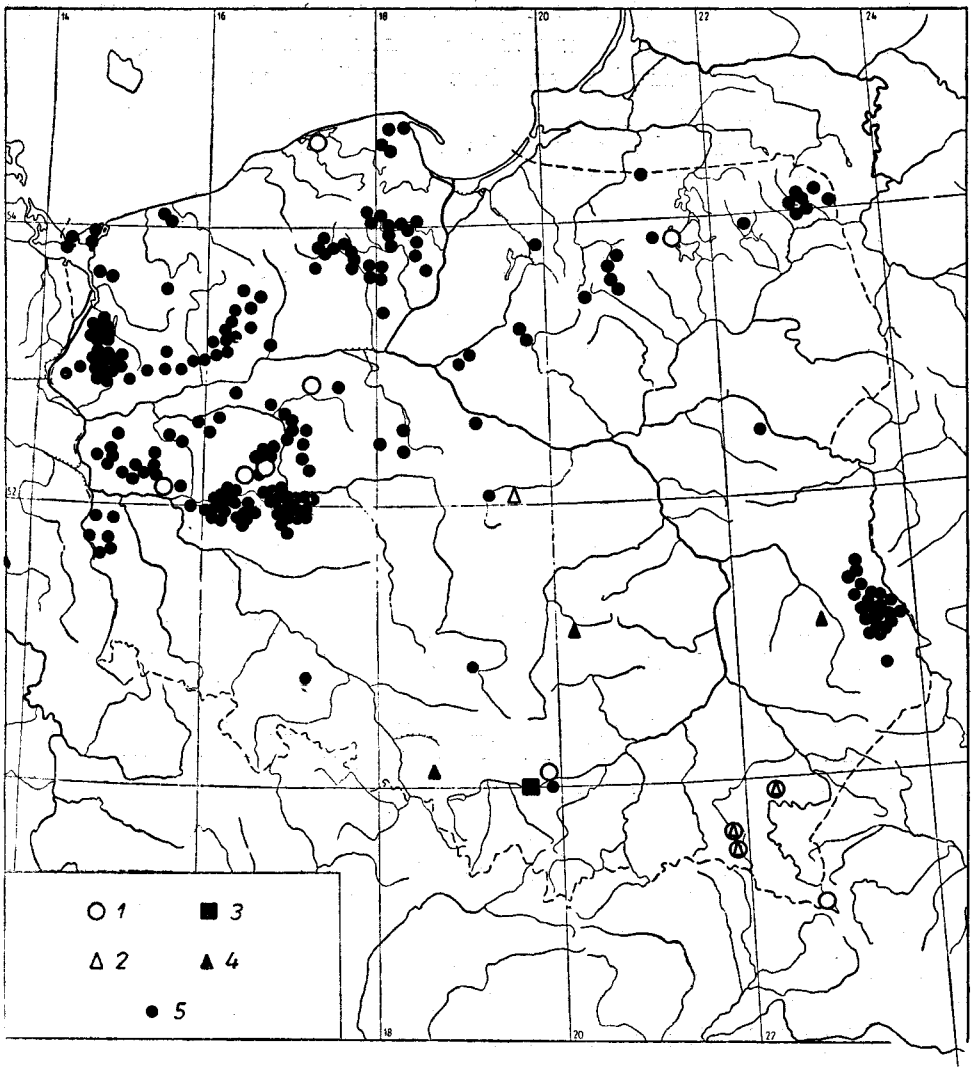

Fig. 4. Present-time distribution of *Cladium mariscus* L. (Pohl.) in Poland (5) as well as its fossil finds: 1 — Holocene, 2 — Late Glacial, 3 — Brørup Interstadial, 4 — interglacial deposits. Contemporary distribution according to Świeboda (1968).

Ryc. 4. Współczesne rozmieszczenie *Cladium mariscus* L. (Pohl.) w Polsce (5) oraz jej stanowiska kopalne: 1 — holocen, 2 — późny glacjał, 3 — interstadiał Brørup, 4 — stanowiska interglacjalne. Rozmieszczenie współczesne według Świebody (1968)

age. Pollen grains of this plant have also been reported from some Holocene and Late-Glacial localities. The Late-Glacial and Holocene records of *Cladium mariscus* indicate that the present station of this plant near Cracow is a relic of a more continuous distribution in Southern Poland in the past.

The changes observed in the pollen diagrams are accompanied by a distinct change in the sediment. In the Rondo profile it is only now that peat has begun to accumulate and in the profile from Piastowska street the strongly decomposed peat with a large admixture of mineral matter is changing into a light, poorly decomposed mossy peat, with fairly common *Camptothecium nitens*.

The marked decrease of mineral matter in the sediment content is probably due to the overgrowth of hitherto uncovered places and to the lowering of the rivers' level, as well as to the less frequent floods. These factors are also responsible for the complete disappearance of rebedded pollen grains whose curve was particularly high in the clayey sediment from the Rondo.

In the Preboreal period the terraced, sandy bottom of the valley, and the flat areas of hills of the Cracow Upland, were covered by pine forest with a rather insignificant proportion of birch. The absence of an initial birch phase was most likely due to a lack of suitable edaphic conditions. This problem was more widely dealt with by T o b o l s k i (1966) who noted that in dune areas pine forests not only started the Holocene succession but also prevailed there during the Bølling and Allerød periods. H. M ü l l e r (1969) also drew attention to the predominance of pine in the majority of diagrams from East Germany from the beginning of the Allerød, and to the lack of birch phase in the Preboreal period. This, in her opinion, does not concern only the north-western part of the investigated territory, owing to the later immigration of pine to this area.

In the diagrams of the Cracow area a difference in the occurrence of heliophilous shrub and herb pollen grains is to be observed. In the profile from Piastowska street *Ephedra* t. *fragilis*, *E. distachya*, *Hippophaë*, *Helianthemum*, and *Saxifraga* t. *oppositifolia* were still noted in the Preboreal period, whereas in the Rondo profile their occurrence is interrupted in the Younger Dryas. It seems very likely that during the Preboreal period, when pine woods became more dense, the diversified relief of the western part of Cracow area (see Fig. 1) provided better conditions for the survival of many light demanding plants.

In the presented diagrams it is very difficult to mark the boundary between the Preboreal and Boreal periods. Similar difficulties were met with in some diagrams from the eastern part of the Sandomierz Basin (M a m a k o w a 1962).

In the Boreal period the whole of this area continued to be occupied chiefly by pine woods. As the climatic conditions grew better, shallow marshes and other humid habitats dried up on the Rendzina terrace and the pine penetrating into these places enlarged its area of distribution. This is evidenced not only by its very high pollen curve, but also by numerous macroscopic remains (wood fragments, cones, seeds) in the profile from the Rondo and wood remains from Piastowska street. The

very high production of pine pollen and its local over-representation makes it difficult to find any uniform criteria for marking the Preboreal/Boreal transition in both the diagrams. It seems that in the diagrams presented the beginning of a continuous elm curve is the only distinct common feature permitting the definite determination of this boundary.

That this criterion ought also to be applied in the further investigations of this area, is evidenced by radiocarbon dating of the profile from the Rondo. The date falls on the close of the Preboreal period, dating the peat layer just immediately below the beginning of the continuous *Ulmus* curve *. In the diagram from the Rondo the beginning of a continuous spruce curve is also indicated at the same time as that of the elm but in the diagram from Piastowska street spruce is represented by small quantities of pollen grains as far back as the Allerød/Younger Dryas transition. However, in both diagrams it seems that the rational limit of the spruce curve occurs in the younger part of the Boreal period. Thus it may be considered that the small admixture of spruce in the forests of the western part of the Sandomierz Basin can be related only to the later part of the Boreal period. The rapid spread of spruce in the West Carpathians (K o p e r o w a 1962), already taking place from the beginning of the Preboreal period, is not reflected at all in the diagrams presented here.

The high *Gramineae* curve in the Boreal period observed in the diagram from the Rondo is also worthy of note. In the diagram from Piastowska street an insignificant increase in *Gramineae* at the 55 cm level corresponds to it. Pine charcoals determined in the material from the Rondo denote a fire in pine forest at that time. That is why it seems most plausible to relate the increase in *Gramineae* and *Polypodiaceae*, and to some degree of *Betula* to this fire. However, the fire was of a local character and affected a rather limited area, since its traces in the Piastowska profile are already less visible.

These large quantities of *Gramineae* in the Boreal period in the Rondo profile are particularly worthy of note in conjunction with investigations in the eastern part of the Sandomierz Basin (M a m a k o w a 1962) and in the Święty Krzyż Mountains (S z c z e p a n e k 1961), where similar large quantities of grasses occurred in profiles from several sites. In some profiles coal-dust was simultaneously observed in the material. It seems that in all cases pine was the tree attacked by fire.

In the present state of research it would be difficult to decide what was the cause of these fires and whether the culmination of the *Gramineae* curve can be in all cases related to the fire. The possibility that in some instances the culmination of grasses was related to an abundant occurrence of *Phragmites* pollen cannot be excluded. On the other hand, in

* Radiocarbon dating was carried out in the C-14 Laboratory at Heidelberg. No. of sample: H 1458—1031; C-14 age: 9390 ±180 B. P.

the diagrams from the Rondo and Piastowska street the majority of grasses at their culmination level belong to the *Festuca* and *Dactylis* types.

The beginning of the Atlantic period determined in the top samples of the profile from the Rondo appears in an already highly clayey material. The development of peatbog was interrupted at that time and its surface was covered with sandy clay and sand.

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STRESZCZENIE

PÓŹNOGLACJALNA I WCZESNOHOLOCEŃSKA FLORA Z TERENU KRAKOWA

Praca zawiera próbę rekonstrukcji przemian w składzie roślinności na obszarze miasta Krakowa od początku młodszego dryasu aż po okres atlantycki. Wnioski oparte są na wynikach analizy pyłkowej i makroskopowej torfów kopalnych występujących na lewym brzegu Wisły. Pokład torfu, odkryty w sąsiedztwie Ronda (Grzegórzki), występuje w spągu terasy rędzinnej wyścielającej dolinę Wisły. Próby torfu ze stanowiska przy ulicy Piastowskiej pochodzą z terasy Rudawy, ze spągu torfowiska niskiego (ryc. 1).

W okresie młodszego dryasu (ryc. 2 i 3) na obszarze Krakowa występował rzadki las sosnowy z domieszką modrzewia i limby. Duże ilości pyłku wierzby z przewagą w wielu próbach ziarn pyłku o typie morfologicznym *Salix pentandra* (*S. alba* i *S. pentandra*) wskazują na obecność nie tylko zarośli wierzbowych, lecz również łęgów wierzbowo-topolowych z olszą, której drewno zachowało się w profilu z ulicy Piastowskiej. Niezalesionym i wyżej położonym terenom piaszczystym charakterystyczne piętno nadawały zbiorowiska z *Juniperus, Ephedra distachya, E.* t. *fragilis, Armeria vulgaris* s. l., *Helianthemum* t. *nummularium, H.* t. *oelandicum, Scleranthus annuus* i *Rumex acetosella.*

Wyjątkowo obfite występowanie *Selaginella selaginoides* (mikrospory i makrospory) w profilu z Ronda oraz obecność *Betula nana* (listki) w materiale z ulicy Piastowskiej sugerują, że w okresie młodszego dryasu płaty roślinności tundrowej były jeszcze dobrze wykształcone. Występowanie kolców *Ceratophyllum* (Rondo) oraz ciągła krzywa pyłku *Myriophyllum verticillatum* (ulica Piastowska) pozwalają przyjąć, że średnia temperatura lipca wynosiła w tym okresie co najmniej 13°C.

Początek okresu preborealnego charakteryzuje gwałtowny wzrost udziału pyłku sosny, zmniejszenie ilości *Cyperaceae, Salix* i *Juniperus*, a w profilu z Ronda ponadto spadek udziału *Pinus* t. *haploxylon* i *Selaginella selaginoides*. Udział brzozy był w tym czasie nieznaczny.

Występowanie w okresie preborealnym owocującego *Cladium mariscus* (Rondo) dowodzi, że średnia temperatura lipca wzrosła w stosunku do młodszego dryasu o około 3°C.

Owoce *Cladium mariscus* zostały podane dotychczas z kilku stanowisk w Polsce, z okresów interglacjalnych, z interstadiału Brørup oraz z późnego glacjału i holocenu (ryc. 4). W późnym glacjale i holocenie notowano ponadto pyłek tej rośliny. Rozmieszczenie późnoglacjalnych i holoceńskich stanowisk jest dowodem, że współczesne stanowisko kłoci w Podgórkach k. Krakowa (Świeboda 1968) jest reliktem ciągłego zasięgu tej rośliny w przeszłości.

W okresie borealnym udział lasów sosnowych na badanym terenie był niewątpliwie duży. Dowodzą tego, obok wysokiej krzywej pyłku sosny, również liczne jej szczątki makroskopowe (w profilu z Ronda drewno, szyszki, nasiona, krótkopędy oraz drewno w profilu z ulicy Piastowskiej).

Wyznaczenie granicy pomiędzy okresem preborealnym i borealnym w diagramach z terenu Krakowa napotyka duże trudności. Jedyną wspólną cechą obydwu diagramów, która pozwala na wyznaczenie tej granicy, jest początek ciągłej krzywej wiązu. Za słusznością przyjęcia tego kryterium również i w przyszłych badaniach na tym obszarze przemawia datowanie radiowęglem profilu z Ronda. Wiek warstwy torfu występującej bezpośrednio poniżej początku ciągłej krzywej wiązu został określony na 9390 ±180 B. P., co wskazuje na przynależność tego poziomu do schyłku okresu preborealnego.

Racjonalna granica krzywej świerka w obydwu diagramach z Krakowa przypada na młodszą część okresu borealnego, co świadczy, że dopiero w tym czasie świerk zaczął się rozprzestrzeniać w zachodniej części Kotliny Sandomierskiej.

Początek okresu atlantyckiego, uchwycony w stropowych próbach profilu z Ronda, zawarty jest już w materiale bardzo silnie zailonym. Rozwój torfowiska został w tym czasie przerwany, a jego powierzchnię pokryły iły piaszczyste i piaski.

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Table 1
Tabela

Kraków - Rondo. Absolute numbers of sporomorphs.
Kraków - Rondo. Bezwzględne ilości sporomorf.

Depth in m - Głębokość w m	3.60	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15	4.20	4.25	4.30	4.35	4.40	4.45	4.50
Trees and shrubs - Drzewa i krzewy																			
Abies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Alnus	24	59	26	3	-	-	-	-	2	1	-	1	4	6	5	1	2	1	4
Betula t. alba	16	55	67	65	35	53	93	41	50	30	80	188	34	11	10	12	10	9	7
Betula t. nana	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	-	1	-	1
Carpinus	-	-	-	1	-	-	-	-	-	-	-	-	1	-	2	-	-	2	3
Corylus	34	134	41	2	2	-	-	-	-	1	-	1	1	3	8	-	2	2	4
Ephedra distachya	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Ephedra t. fragilis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-
Fagus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Fraxinus	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippophae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	1
Juniperus	-	-	-	-	1	-	1	-	1	-	-	-	1	3	8	10	12	32	18	8
Larix	-	-	-	-	-	-	-	1	1	1	4	-	1	-	-	1	1	1	-
Picea	15	51	27	12	19	10	13	3	1	-	1	1	4	-	3	1	1	3	1
Pinus t. haploxylon	-	-	-	-	-	-	-	-	-	-	-	-	4	7	21	5	5	8	13
Pinus t. silvestris	85	617	763	481	535	622	475	151	189	164	711	803	324	150	126	198	222	243	148
Populus	-	1	3	1	1	1	-	1	-	1	-	2	2	-	6	2	1	1	-
Quercus	8	49	30	1	-	-	1	-	-	-	1	-	2	-	-	-	-	-	3
Salix	-	2	6	9	3	4	4	2	6	2	3	3	13	4	6	17	18	9	6
Tilia	11	9	3	1	-	-	1	-	-	-	-	-	-	4	-	-	-	-	-
Ulmus	7	21	31	24	4	10	12	1	-	-	-	-	5	5	-	-	3	1	-
Viburnum	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Herbs - Rośliny zielne																			
Anthemis type	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-
Armeria vulgaris s.l. (A)	1	3	3	1	2	2	5	3	-	4	7	5	5	1	1	1	2	2	-
Artemisia	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	1	1	-
Botrychium	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
Calluna	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caltha type	-	-	-	-	-	1	-	-	1	-	-	-	-	1	1	-	-	2	-
Caryophyllaceae	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Chenopodiaceae	-	-	-	-	1	1	-	-	1	1	2	1	-	1	-	2	3	2	3
Cladium mariscus	-	-	3	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Comarum	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Compositae Liguliflorae	-	1	1	1	-	1	1	-	6	1	-	-	-	1	2	3	1	1	-
Compositae Tubiflorae	5	6	-	1	1	-	3	1	2	1	2	-	1	-	4	8	5	2	-
Cruciferae	-	-	-	1	2	-	-	1	-	-	-	-	-	-	2	-	-	-	3
Cyperaceae	10	34	51	182	46	60	54	25	86	14	31	66	83	76	96	115	87	138	73
Empetrum	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-
Equisetum	-	1	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-
Ericaceae	-	-	-	-	-	-	-	-	-	-	-	-	1	2	2	-	1	-	-
Filipendula	17	4	1	2	2	4	8	4	27	9	2	5	1	1	-	-	-	-	-
Geum	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Gramineae	73	133	143	109	132	376	340	264	99	26	55	80	28	28	37	34	32	47	14
Helianthemum t. nummularium	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-
Helianthemum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Lycopodium complanatum/tristachyum	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Mentha type	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-
Menyanthes	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Ophioglossum	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Papilionaceae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Phegopteris dryopteris	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Plantago lanceolata	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Plantago maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypodium vulgare	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	-	-	-	-
Polypodiaceae	196	81	42	39	124	436	240	356	260	17	7	9	5	4	1	1	1	-	4
Potamogeton sect. Coleogeton	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Potamogeton sect. Eupotamogeton	-	-	1	1	-	-	-	-	-	-	-	1	-	-	1	2	-	-	-
Potentilla type	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Pteridium aquilinum	1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubiaceae	2	-	1	-	1	3	6	3	6	-	2	4	-	1	-	2	3	-	1
Rumex aquaticus/hydrolapathum	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rosaceae	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sanguisorba officinalis	1	1	-	-	-	-	1	1	6	-	-	-	-	1	-	-	-	-	-
Sedum	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Selaginella selaginoides	-	-	-	-	-	-	-	-	-	-	-	-	43	48	12	49	91	57	63
Sparganium type	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Sphagnum	3	3	-	-	1	-	1	-	-	2	10	4	3	4	4	-	1	4	2
Succisa pratensis	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thalictrum	1	-	4	1	-	-	1	-	2	1	-	5	3	1	-	-	-	1	2
Typha latifolia	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Umbelliferae	-	2	-	2	-	-	1	-	1	1	2	2	-	-	1	-	-	-	-
Varia	1	2	1	-	-	-	-	-	-	-	-	-	3	-	4	2	1	1	3
Tertiary sporomorphs - Sporomorfy trzeciorzędowe																			
Carya	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Coniferae indeterminatae	-	-	-	-	-	-	-	-	-	-	-	-	4	18	28	3	9	9	23
Cupressaceae/Taxodiaceae	-	-	-	-	-	-	-	-	-	-	-	-	4	1	4	2	2	2	21
Gleicheniaceae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Juglandaceae	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	1	-
Nyssa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	1
Platycarya	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Pterocarya	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2
Sciadopitys	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
Sequoia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Sporae indeterminatae	-	-	-	-	-	-	-	-	-	-	-	-	1	8	11	2	-	-	19
Hystrix	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	1	-	-	2
Indeterminable pollen grains - Nieoznaczalne ziarna pyłku	12	4	6	3	1	1	1	2	8	7	1	-	4	12	20	5	6	8	21
Slide surface in cm^2 - Przejrzana powierzchnia w cm^2	17.0	6.1	4.4	16.2	8.7	12.8	9.5	8.4	11.6	10.2	9.4	10.8	6.8	24.4	29.6	10.3	16.7	10.8	19.0

Table 2
Tabela

Kraków - Piastowska street. Absolute numbers of sporomorphs.
Kraków - ulica Piastowska. Bezwzględne ilości sporomorf.

Depth in cm - Głębokość w cm	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
Trees and shrubs - Drzewa i krzewy																		
Abies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Alnus	2	1	1	1	10	10	2	-	2	2	12	7	6	8	5	8	13	15
Betula t. alba	33	172	270	130	109	85	98	134	90	55	73	101	92	96	78	67	78	69
Betula t. nana	-	1	7	18	11	2	6	9	6	13	17	2	9	9	4	1	4	7
Corylus	5	-	-	1	-	1	1	1	1	2	-	-	-	1	-	1	-	5
Ephedra distachya	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-
Ephedra t. fragilis	-	-	1	1	-	1	-	-	-	1	-	-	-	-	-	-	-	-
Hippophaë	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1	2	-
Juniperus	1	5	15	10	3	10	8	3	9	9	17	12	4	9	7	16	12	5
Larix	-	2	2	-	1	4	2	2	1	3	1	2	1	-	-	1	1	-
Picea	18	4	8	8	20	5	6	3	-	3	5	8	11	6	5	4	9	15
Pinus t. haploxylon	-	-	2	-	2	2	3	-	-	-	-	1	1	1	1	7	2	4
Pinus t. silvestris	436	304	357	515	833	867	1051	834	566	385	351	304	345	333	361	375	363	350
Populus	-	-	5	-	1	2	5	2	7	5	1	2	3	4	5	3	-	4
Quercus	-	-	2	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-
Salix	-	9	30	15	6	9	17	11	13	21	22	58	23	30	33	17	13	25
Sorbus cf. aucuparia	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Tilia	1	-	1	-	2	-	-	-	2	-	1	1	1	1	-	-	-	1
Ulmus	4	2	1	1	1	1	-	-	-	-	-	1	3	2	-	-	1	-
Herbs - Rośliny zielne																		
Anthemis type	1	-	3	1	-	-	1	1	-	-	-	1	1	-	-	1	-	-
Armeria vulgaris s.l. (B.)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Artemisia	1	14	18	19	11	18	25	23	13	16	13	10	13	18	15	12	10	4
Batrachium type	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1
Botrychium	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	2	-	-
Bupleurum	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Calluna	-	-	1	-	1	-	-	-	-	-	-	-	1	1	-	-	-	-
Caltha type	-	-	-	-	3	1	-	-	-	1	-	-	2	-	1	-	-	-
Caryophyllaceae	-	-	-	-	1	-	-	-	-	3	2	-	1	-	1	-	-	-
Centaurea t. montana	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Cerastium type	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodiaceae	1	3	3	2	6	6	9	1	4	7	1	2	2	6	2	4	2	2
Comarum	-	5	1	1	-	1	-	-	-	-	-	-	-	2	2	-	2	-
Compositae Liguliflorae	1	-	-	-	3	2	2	3	-	-	1	1	1	3	2	-	2	-
Compositae Tubiflorae	-	-	1	1	8	2	1	3	1	1	1	5	2	-	-	-	2	2
Cruciferae	-	2	5	4	-	3	3	4	-	11	2	4	3	5	3	-	1	1
Cyperaceae	65	247	231	246	307	662	396	281	393	315	342	468	284	289	521	387	309	310
Empetrum	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Epilobium	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ericaceae	-	-	-	-	-	1	-	1	-	-	1	1	1	-	-	1	-	1
Equisetum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
Filipendula	2	1	-	2	1	4	5	4	1	-	3	-	7	1	3	3	5	5
Geum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Gramineae	29	52	167	93	56	53	71	54	58	68	88	115	89	104	121	109	93	76
Gypsophila fastigiata	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Helianthemum t. nummularium	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Helianthemum t. oelandicum	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Helianthemum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Lemna	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Lycopodium complanatum/tristachyum	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
cf. Malachium	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-
Mentha type	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-
Myriophyllum verticillatum	-	-	-	-	-	-	-	-	-	-	15	20	11	4	3	6	1	2
Papaver	-	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Phegopteris dryopteris	-	1	-	-	2	-	1	2	-	-	-	-	-	-	-	-	-	-
Phragmites	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantago lanceolata	-	-	-	-	-	1	-	1	-	-	-	-	1	1	-	-	-	-
Plantago maior	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Plantago media	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-
Polygonum bistorta/viviparum	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-
Polygonum t. lapathifolium	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Polypodiaceae	1256	163	122	180	496	168	91	12	42	39	169	132	318	349	246	119	368	397
Potamogeton sect. Coleogeton	-	-	-	-	-	-	1	1	1	-	-	5	1	-	5	3	3	-
Potamogeton sect. Eupotamogeton	-	-	-	-	-	-	1	-	-	-	-	2	1	-	-	-	-	-
Potentilla type	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-
Prunella type	-	-	1	-	-	-	1	-	-	-	-	-	1	-	-	-	1	-
Pteridium aquilinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculaceae	-	-	2	6	2	1	1	2	1	4	-	-	3	2	1	-	-	-
Rhynchospora alba	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-
Rosaceae	-	2	-	2	2	3	3	3	1	1	1	1	3	-	1	-	-	-
Rubiaceae	2	7	11	10	7	4	7	5	5	6	3	8	4	6	5	4	2	8
Rumex acetosa	-	1	1	-	1	1	-	1	1	-	2	1	-	-	-	-	-	-
Rumex acetosella	-	-	-	-	-	1	-	-	1	-	1	-	-	-	-	-	-	-
Rumex aquaticus/hydrolapathum	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Sanguisorba officinalis	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Saxifraga t. oppositifolia	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Scleranthus annuus	-	-	-	1	-	-	-	1	-	1	1	-	1	-	1	-	3	-
Selaginella selaginoides	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-
Sparganium type	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-
Sphagnum	-	1	2	5	19	9	33	41	14	-	4	6	3	11	7	6	9	10
Thalictrum	1	2	2	1	4	2	6	1	4	3	4	5	-	2	8	3	1	-
Typha latifolia	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	1
Umbelliferae	-	-	4	1	1	2	2	1	2	2	2	2	1	5	11	2	3	2
Urtica cf. dioica	-	-	-	-	1	-	2	1	-	-	-	-	-	-	-	-	-	1
Varia	1	1	-	5	4	2	2	-	2	-	1	-	-	1	-	1	4	-
Tertiary sporomorphs - Sporomorfy trzeciorzędowe																		
Cupressaceae/Taxodiaceae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Nyssa	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
Sequoia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sporae indeterminatae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2
Indeterminable pollen grains - Nieoznaczalne ziarna pyłku	4	6	8	14	11	13	9	17	1	5	2	-	3	4	3	1	6	10
Slide surface in cm^2 - Przejrzana powierzchnia w cm^2	3.6	4.6	3.3	2.7	2.4	2.2	3.1	2.1	3.0	7.5	5.8	6.7	6.4	8.6	11.2	14.8	11.4	8.7

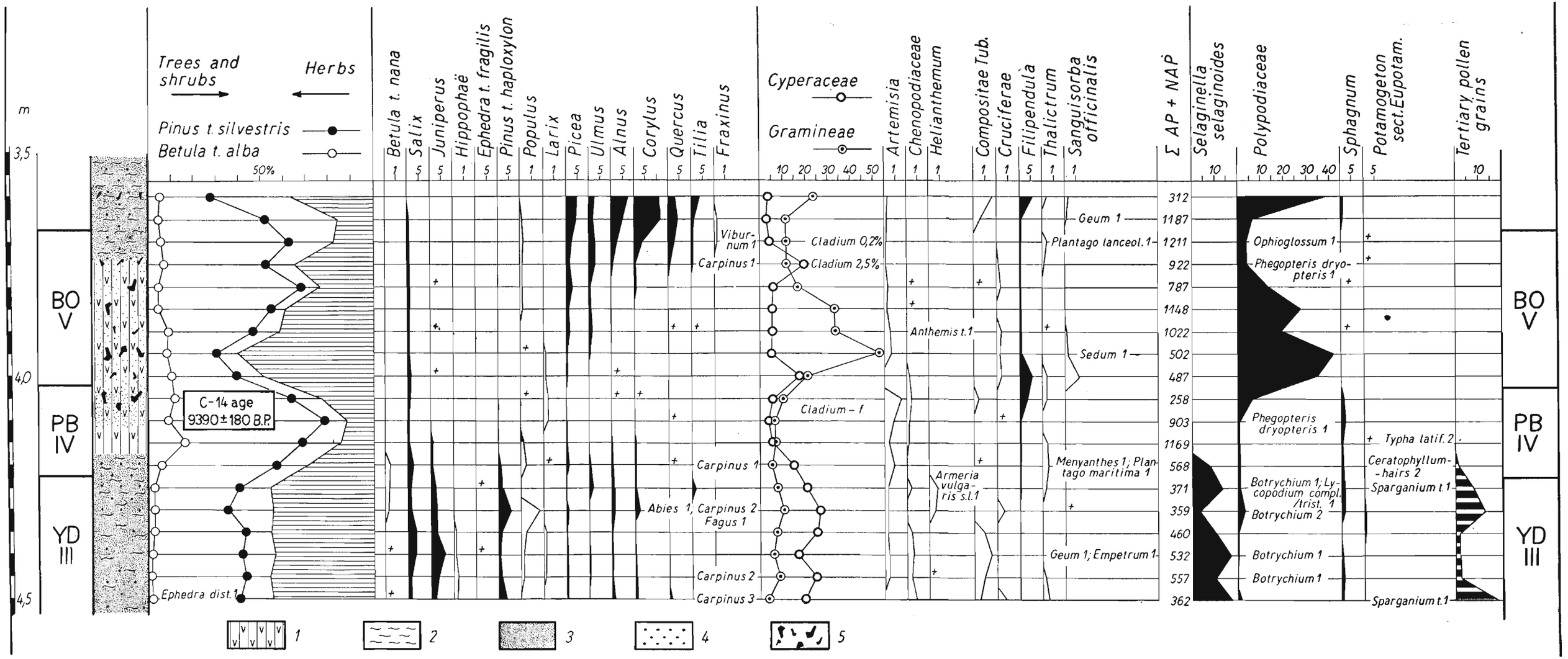

Fig. 2. Cracow — Rondo. The basis of calculation for the pollen curves is the total pollen and spore sum except aquatics, *Polypodiaceae*, *Sphagnum* and tertiary plants. The latter are calculated on the basis of the total sum + the respective type of pollen or spore. Types occurring in small frequencies are given in 5× enlarged scale (white silhouettes) or their absolute quantities have been marked.

Sediment signatures: 1 — sedge-wood peat, 2 — plant detritus, 3 — clay, 4 — sand, 5 — charcoals

Ryc. 2. Kraków — Rondo. Podstawą obliczenia poszczególnych krzywych jest suma wszystkich ziarn pyłku i spor, z wyjątkiem roślin wodnych, *Polypodiaceae*, *Sphagnum* i roślin trzeciorzędowych. Procentowy udział roślin wyłączonych obliczono w stosunku do sumy totalnej + dany typ pyłku czy spory. Typy pyłku występujące w małych ilościach są wrysowane w skali 5× przewiększonej (białe sylwetki) albo podano ich bezwzględne wartości.

Oznaczenia osadów: 1 — torf turzycowo-drzewny, 2 — detritus roślinny, 3 — ił, 4 — piasek, 5 — węgle drzewne

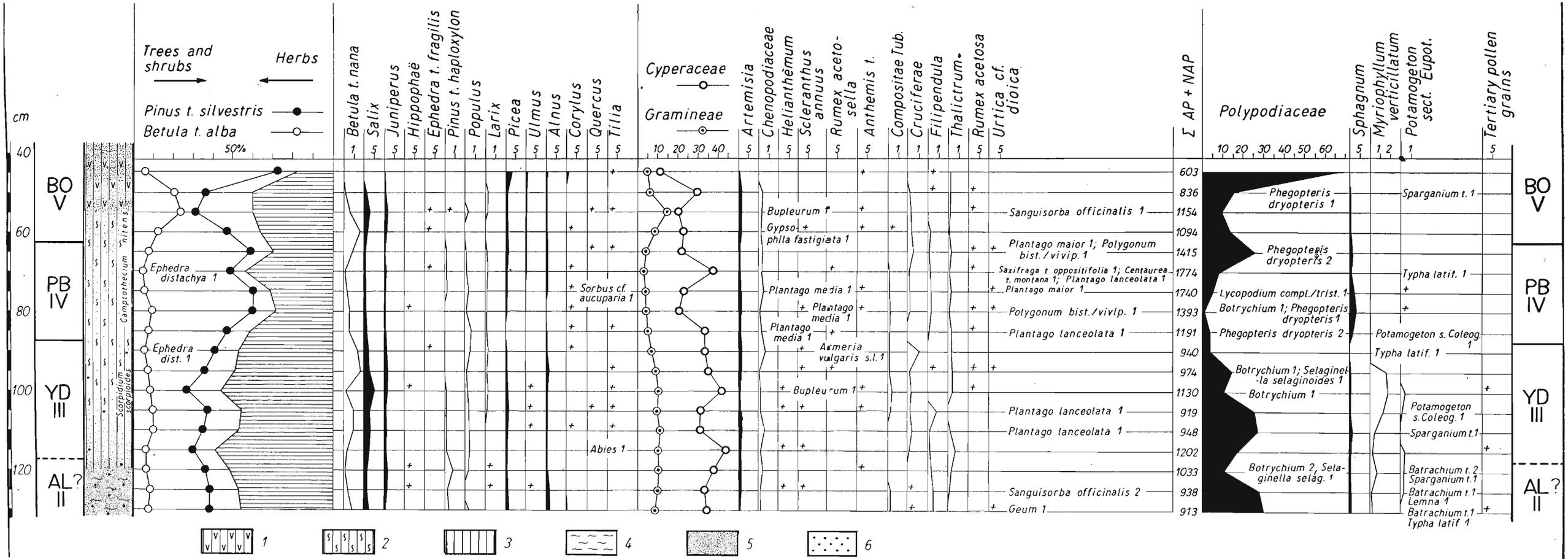

Fig. 3. Cracow — Piastowska street. The basis of calculation for the pollen curves see fig. 2.
Sediment signatures: 1 — sedge-wood peat, 2 — sedge-mossy peat, 3 — sedge peat, 4 — plant detritus, 5 — clay, 6 — sand

Ryc. 3. Kraków — ul. Piastowska. Sposób obliczenia poszczególnych krzywych jest podany przy ryc. 2.
Oznaczenia osadów: 1 — torf turzycowo-drzewny, 2 — torf turzycowo-mszysty, 3 — torf turzycowy, 4 — detritus roślinny, 5 — ił, 6 — piasek