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From plant finds present in peat to subfossil communities – importance and possibilities of plant macrofossil remains analysis

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Abstract: This paper presents possibilities of palaeobotanical method – analysis of macrofossil remains. Plant findings, present in peat, can be divided into vegetative and carpological (generative). Their identification delivers information about past vegetation because botanical composition of peat samples is reflection of plants really growing in investigated area in the past. However distribution of subfossil communities is sometimes different than at present, what is the result of climate changes in the Late Glacial and the Holocene.

Key Words: mire, peat, plant macrofossils, vegetative and carpological remains, subfossil plant community

Introduction

Peat is kind of biogenic sediment. Humidity of substratum and surface of any area conditions its origin. This hydrological factor induces insufficient oxygen circulation in ground layers. Because of that access of oxygen to plant remains is impeded. Organic matter conserves this way.

Analysis of macrofossil remains is a method based on possibilities of recognizing of plant findings forming biogenic sediments, like peat. This way it allows reconstructing succession of mire vegetation in investigated territory, and delivers, indirectly, information about climate changes, and human activity in the past.

Peat cores with not disturbed structure are collected using a Russian sampler („Instorf"), mainly. After special preparation, peat is analysed using a light microscope (vegetative remains), and a stereoscopic microscope (generative findings).

Polish researches based on plant macrofossil remains analysis – beginnings

In Poland, very important researches based on method of plant macrofossil remains analysis were conducted in fifties and sixties. Tołpa (1958) was first who wrote about using of phytosociological methods in reconstruction of subfossil plant communities. This idea was applied in genetic classification of peat, published in 1967 by Tołpa, Jasnowski and Pałczyński.

One of its author - Jasnowski (1957), already in fifties researched moss flora occurring in Pleistocene and Holocene peat collected in some areas of Poland. The effect of that was study of moss peats genesis and their classification (Jasnowski 1959).

Marek (1965) investigated biology and stratigraphy of alder mires. He evidenced peat-forming role of communities known as *Carici elongatae-Alnetum* sensu lato.

Whereas Pałczyński (1975) marked out new peat-forming communities: alder-birch forest *Betuletum pubescentis-verrucosae* and pinewood *Carici chordorrhizae-Pinetum*. He pointed also that reconstruction of subfossil vegetation should be based on „species combination recognized during analysis of macrofossil remains."

Plant remains

Macrofossil remains are divided into some groups (Tobolski 2000):

I. Leaves and leaf-like structures.
II. One- or multilayer flat remains, some of them with coloured inside of cells (epiderm, rizoderm, periderm).
III. Elongated forms, cylindrical, branched or without branches (rhizomes and roots of vascular plants, stems and branches of mosses).
IV. Lump forms with distinct (wood) or indistinct cell structure (charcoals).
V. Regular forms (seeds, fruits, sporangia, macrospores, oogonia).

Leaves of bryophytes (peatmosses and brown mosses) are very important kind of remains. Among peatmosses findings, branch leaves predominate. The stem leaves, more important for correct identification of species, are very sporadic and often incomplete in peat masses because of their gentle structure. This problem was discussed by Grosse-Brauckmann (1974). Species identification of peatmosses is especially important if representatives of the same section prefer different water and nutritional conditions. It refers to *Palustria* section, for example. *Sphagnum magellanicum* is characteristic for extreme poor and dry habitats, where it forms hummocks. *Sphagnum palustre* (Pl. 1, Fig. 1) occurs in floating matt covering the area of water bodies and on mesotrophic mires. Ecological significance of *Subsecunda* (Pl. 1, Fig. 2) and *Squarrosa* (Pl. 1, Fig. 3) sections is more uniform. Both are connected with meso- or even euthrophic mires (cf. Dickson 1986). *Acutifolia* section species (Pl. 1, Fig. 4) occurr mainly in raised bogs. Lack of their stem leaves is especially unfavourable for possibility of species identification, because their hyaline cells can be 1 – 4-divided, what is very important species feature (cf. Frahm and Frey 1987). Among representatives of *Cuspidata* section, *Sphagnum fallax* (= *Sphagnum recurvum*, *Sphagnum apiculatum*) (Pl. 1, Fig. 5), could be quite easy recognized in highmoor peat. If identification of peatmosses species is impossible, sections are defined only, what is unfortunately frequent practice (cf. Barber 1981, Tobolski 2000).

Recognition of brown mosses remains (named Bryales) is easy, in opposite to definition of their genus and species. Damage of leaves caused by strong decomposition of peat is an often reason of that. However, it is possible to identify *Calliergon giganteum* (Pl. 1, Figs 6-7), *Scorpidium scorpioides* (Pl. 1, Fig. 8), *Camptothecium nitens* (Pl. 1,

Fig. 9), *Helodium lanatum* (Pl. 2, Fig. 1), *Campylium stellatum* (Pl. 2, Fig. 2), *Meesia triquetra* (Pl. 2, Fig. 3), *Polytrichum strictum* (Pl. 2, Fig. 4).

The other important problem is recognition of Poaceae and Cyperaceae epiderm. In both families, belonging to monocotyledonous (the class Liliopsida), epiderm consists of rectangular cells with waved walls. Guard cells are usually dog-bone-shaped. Grasses epiderm was identified basing on presence of ring cells (Tobolski 2000). Kidney-shaped ring cells are characteristic for *Phragmites australis* tissue (Pl. 2, Fig. 5). Whereas lack of ring cells and presence of sclerenchyma fibres is common for cyperaceous epiderm, e.g. leaf epiderm of *Eriophorum vaginatum* (Pl. 2, Fig. 6).

Interesting but rare kind of findings is rhizoderm of Nymphaeaceae (Pl. 2, Fig. 7) present sometimes in lacustrine sediments. Remains of *Equisetum limosum* are more often recognized (in peat) (Pl. 2, Figs 8-9).

Between tissues, fragments of needle epiderm of pine and spruce can be found. Cells are narrow, small, usually coloured (Pl. 3, Fig. 1). Shape of stomatal apparatus decides about classification of epiderm. Pine apparatus is bigger and more elongated.

Using the comparative specimens allows to recognize subfossil periderm of *Pinus sylvestris* (Pl. 3, Fig. 2), *Picea abies* (Pl. 3, Fig. 3), and deciduous trees/shrubs, identified only as a genus: birch (Pl. 3, Fig. 4), alder (Pl. 3, Fig. 5) and willow (Pl. 3, Fig. 6).

One of the most important challenges is an identification of sedge radicles. This problem was discussed and critical appreciated (Tołpa 1958, Tobolski 2000). But there are studies which results base on species determination of sedge radicles (Oświt 1973, 1991, Pałczyński 1975). According to Obidowicz (1975), it is possible to identify radicles of *Carex limosa*, *Carex rostrata* and *Carex fusca* (= *Carex nigra*). But most of sedge roots could be named only as *Carex* sp. (Pl. 3, Fig. 7). The author recognized radicles of *Carex* cf. *limosa* - with characteristic bulb root-hairs (Pl. 3, Fig. 8), *Carex* cf. *rostrata* – with surface swellings (Pl. 3, Fig. 9) and *Carex* cf. *elata* (= *Carex stricta*, *Carex Hudsonii*) – with hammer-shaped appendixes (Pl. 4, Fig. 1). It is important that slight proportion of any sedge species radicles do not exclude possibility of their much more percentage in peat mass. It is connected with intraspecific variability of radicles (ca. Katz et. al. 1977, Tobolski 2000). Therefore species identifications should be treated as advices upon species combination of reconstructed communities. They do not inform about abundance of any sedge species in phytocoenosis. But it corresponds to criteria of contemporary phytosociology, used also in palaeobotanical studies (ca. Oświt 1973, Pałczyński 1975).

Among radicles, roots of *Cladium mariscus* are quite characteristic. Some of their surface cells are dark coloured (Pl. 4, Fig. 2).

During identification of wood, elementary division into deciduous and coniferous is made. Wood of alder (Pl. 4, Fig. 3), pine (Pl. 4, Fig. 4) and spruce (Pl. 4, Fig. 5) can be recognized. In alder wood, size of ladder vessels and quantity of thickenings of their secondary cell walls (in long section) is a distinctive feature. Whereas, coniferous wood was identified basing on size and quantity of pits in cross-section, in the place where tracheids and vascular rays are crossed.

Subfossil sedge nutlets were identified basing on their preserved utricles (*utriculus*) mainly, like *Carex rostrata* (Pl. 4, Fig. 6). Many of nuts is indeterminable and divided into 2-sided and 3-sided, only (Velichkevich, personal information).

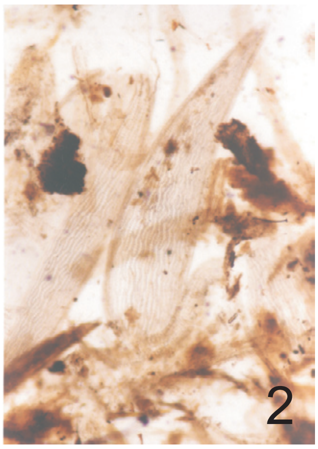
Important and interesting findings are nuts of birches. They can be classified generally into fruits of woody and shrubby birches: *Betula sec. Albae* (Pl. 4, Fig. 7) (*Betula pubescens*, *Betula pendula*) and *Betula sec. Nanae* (*Betula nana*, Pl. 4, Fig. 8), *Betula humilis*, Pl. 4, Fig. 9), respectively.

Depth [cm]	*Carex* cf. *elata* - radicles **A**	*Phragmites australis* - epiderm	*Equisetum limosum* – epiderm,rhizoderm	*Menyanthes trifoliata* - epiderm	*Sphagnum* cf. sec. *Subsecunda*	*Calliergon giganteum*	*Meesea triquetra*	*Drepanocladus* cf. *sendtneri*	*Drepanocladus* sp.	cf. *Thelypteris palustris* - tissues	*Thelypteris palustris* - tissues	*Sphagnum magellanicum*	*Pinus sylvestris* – periderm, needle epiderm	cf. *Picea excelsa* - periderm	coniferous wood	*Betula* sp. - periderm	*Alnus* sp. - periderm	*Salix* sp. - periderm	deciduous wood	*Carex* sp. - radicles	Cyperaceae - epiderm	*Sphagnum palustre*	*Sphagnum* sec. *Squarrosa*	*Climacium dendroides*	Bryales	indeterminable	*Menyanthes trifoliata* – seed **B**	*Betula* sec. *Albae* - nut	Peat unit	Subfossil plant community	^{14}C dating BP
15 - 0			5	+						+			+		5	5		+	5	60	+	+			5	15			*Cariceti*	forest-brushwood+ *Carex-Sphagna*	
25 – 15											+		15	+	+	+	+		5	30	+			+	45	5			*Cariceto-Bryaleti*	*Scheuchzerio-Caricetea nigrae*	
35 – 25	+					20	5		5	+	+				+	10				30					30	+		1	*Bryaleti*		
45 – 35	+						+	5		+				+	+	5				70					10	10			*Cariceti*		1560±90
55 – 45	+																			100					+	++					
65 – 55				+	+						+	+	10		5	+	+	+		55		15	5			10		2	cf. Alnioni	*Sphagno squarrosi-Alnetum*-type	
75 – 65	+															+			+	100						+					
85 – 75	+															+				100						+					
95 – 85	+	+	+										+			+				100						+			*Cariceti*		
105 – 95	+	5	+										+		+	+				90					+	5				*Magnocaricion*	
115 – 105	+	15											+			5		+	+	75						5	1				
125 – 115		5	+													+				95						+					2430±70
135 – 125		+	+													+				90						10	1				

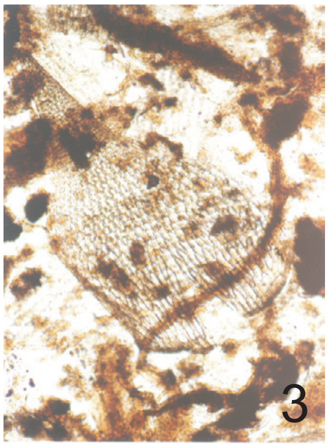
Tab. 1 Results of macrofossil plant remains analysis of peat samples from BII core (Borki mire, the Puszcza Knyszyńska Forest), A – vegetative finds, B – generative remains

Plate 1

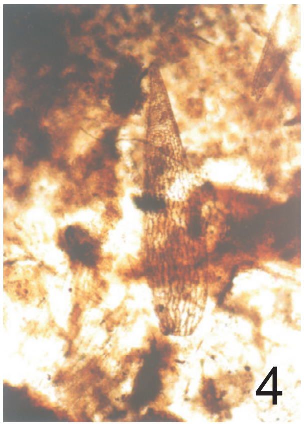
Sphagnum palustre
branch leaf, x 74



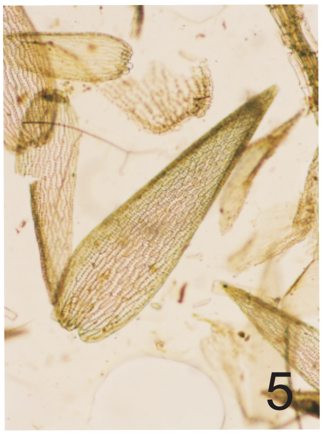
Sphagnum cf. contortum
(*sectio Subsecunda*)
branch leaf, x 74



Sphagnum teres
(*sectio Squarrosa*)
branch leaf, x 74



Sphagnum sec. Acutifolia
branch leaf, x 74



Sphagnum fallax
branch leaf, x 74

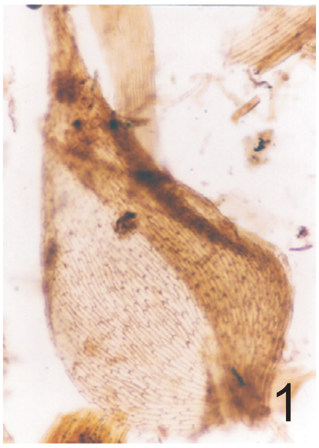
Calliergon giganteum
stem leaf, x 74

Calliergon giganteum
branch leaf, x 74

Scorpidium scorpioides
leaf, x 74

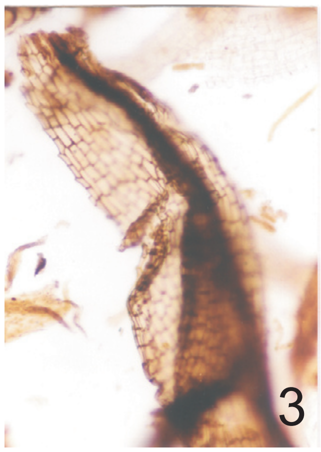
Camptothecium nitens
leaf, x 74

Plate 2



Helodium blandowii
leaf, x 185

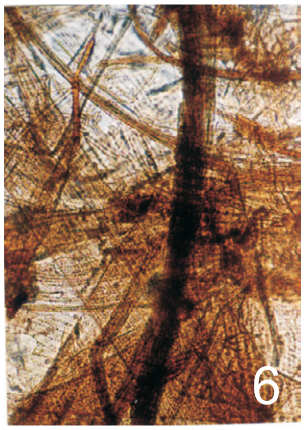
Campylium stellatum
leaf, x 74



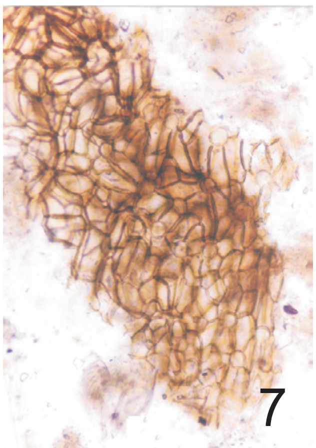
Meesia triquetra
fragment of leaf, 185

Polytrichum sp.
fragment of leaf , x 74

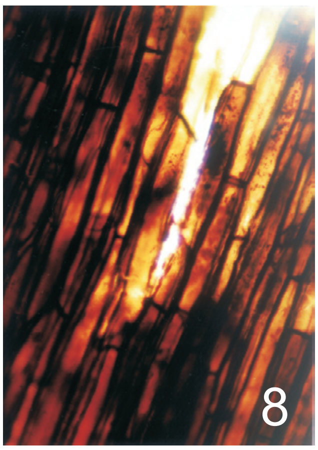
Phragmites australis
epiderm of rhizome, x 370



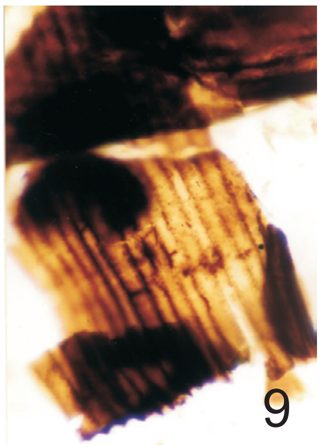
Eriophorum vaginatum
epiderm of leaf, 185



Nymphaeaceae
rizoderm, x 185

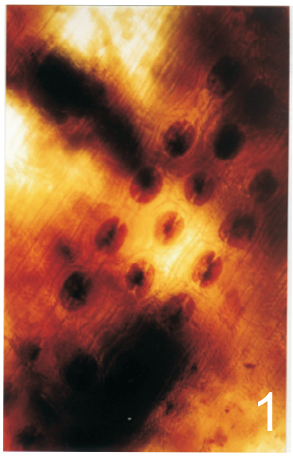


Equisetum limosum
rizoderm, x 185

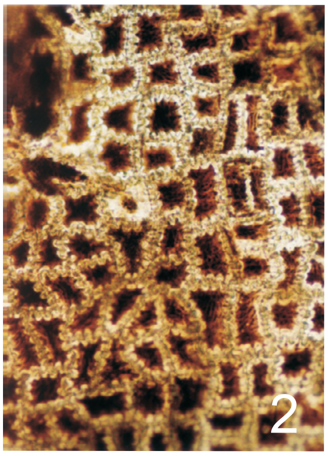


Equisetum limosum
- epiderm of
rhizome, x 185

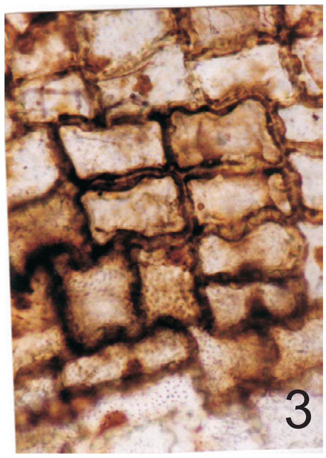
Plate 3



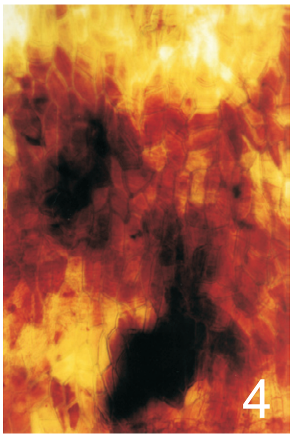
Picea abies
epiderm of
needle, x 185



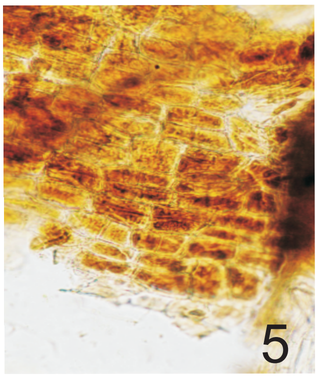
Pinus sylvestris
peryderm, x 370



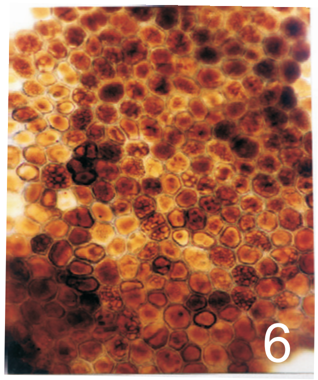
Picea abies
periderm, x 185



Betula sp.
periderm, x 185

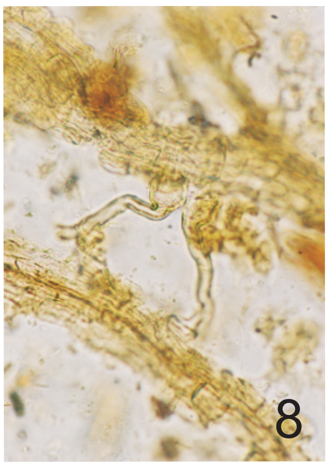


Alnus sp.
periderm, x 370

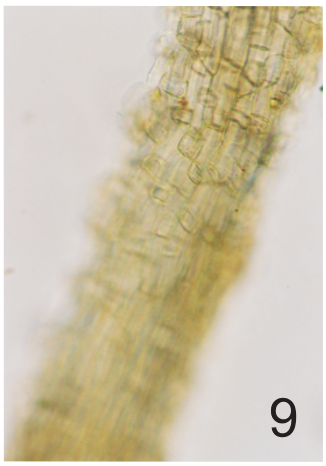


Salix sp.
periderm, x 370

Carex sp.
radicles, x 185

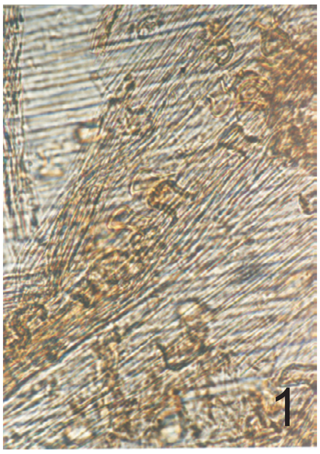


Carex cf. *limosa*
radicles, x 370



Carex cf. *rostrata*
radicle, x 370

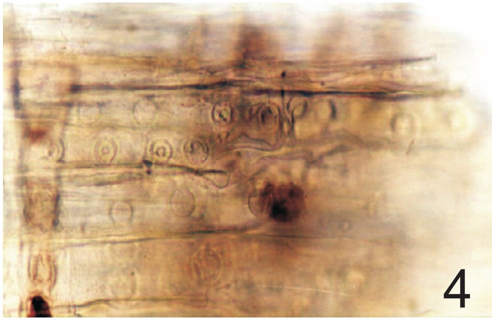
Plate 4



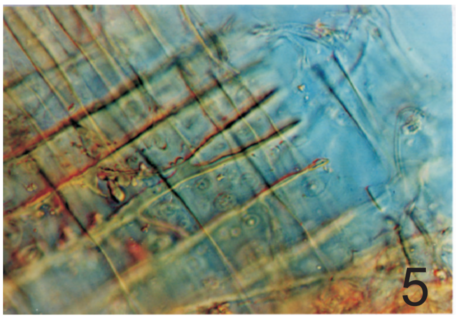
Carex cf. *elata* radicles, x 370

Cladium mariscus - radicle, x 370

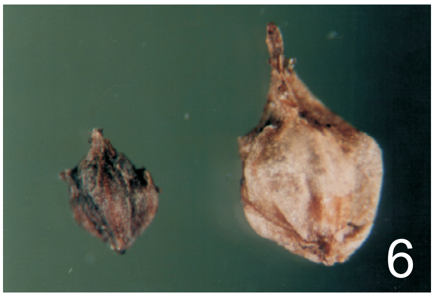
Alnus sp. wood, x 370



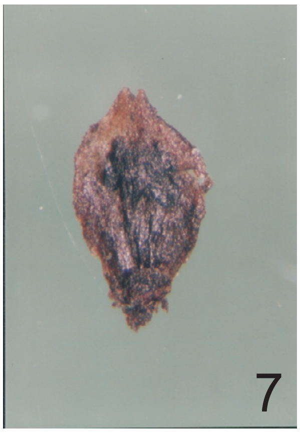
Pinus sylvestris wood, x 370



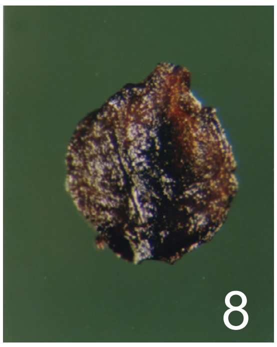
Picea abies wood, x 740 (Nomarsky contrast)



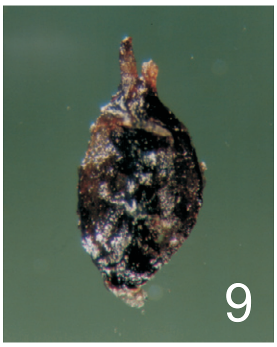
Carex rostrata nutlet (left) and utricle, x 36



Betula sec. Albae nutlet, 72



Betula nana nutlet, x 72



Betula humilis nutlet, x 72

Reconstruction of subfossil vegetation

Fixing of botanical composition of peat samples let to define peat unit. After that reconstruction of plant subfossil communities could be possible. Sometimes remains of plants that are not present in studied territory nowadays are recognized. In sediments from the Puszcza Knyszyńska Forest mires sixteen taxa are not found there at the present time, e.g.: *Betula nana*, *Ranunculus reptans*, *Myriophyllum alternifolium*, *Scheuchzeria palustris*, *Potamogeton filiformis*, *Cladium mariscus*, *Sphagnum platyphyllum*, *Meesea triquetra*, *Scorpidium scorpioides*.

Some of communities, functioned in the territory of the Puszcza Knyszyńska Forest in the Holocene, occur at present e.g. in Northeast Russia (*Sphagnetum betulo-pinosum eriophoreto fruticuletosum*) or in Northwest Europe (*Menyantho trifoliatae-Sphagnetum teretis*). It proves climate changes in the past.

Table 1 presents results of above-mentioned analyses. Peat samples were collected in Borki mire (the Puszcza Knyszyńska Forest, Northeast Poland). Altogether four peat units were described in this peat core: *Cariceti*, *Cariceto-Bryaleti*, *Bryaleti* and cf. Alnioni. All of them are connected with Tołpa's classification, but the last one is little problematic. Basing on this fixing subfossil plant communities were reconstructed. There are phytocoenoses of two categories. The first one - described by Matuszkiewicz (2001), like *Magnocariocion*, *Scheuchzerio-Caricetea nigrae* and, problematically, *Sphagno squarrosi-Alnetum*-type. In the second group (with uncertain systematic position) there is only one community - forest-brushwood+*Carex-Sphagna*. Peat-forming vegetation occurred in this region of the Borki mire in Subatlantic (2430±70 BP).

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Streszczenie

Od znalezisk roślinnych obecnych w torfie do zbiorowisk subfosylnych - znaczenie i możliwości analizy roślinnych szczątków makroskopowych

Analiza szczątków makroskopowych polega na identyfikacji znalezisk roślinnych obecnych w próbach torfowych. Znaleziska dzielone są na wegetatywne: liście, korzonki, łodyżki, epiderma, peryderma, ryzoderma, drewno oraz generatywne (karpologiczne): owoce, nasiona, oogonia ramienic. Szczątki subfosylne znalezione w późnoglacjalych i holoceńskich próbach torfu prezentują fotografie (Plates 1-4).

Identyfikacja znalezisk roślinnych umożliwia określenie jednostek torfu w danym rdzeniu, a następnie podjęcie próby rekonstrukcji subfosylnych zbiorowisk roślinnych występujących na danym obszarze w przeszłości (Tab. 1).