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DEVELOPMENT OF PLANT COMMUNITIES IN THE UROCZYSKO JĘZOR PEATBOG INDICATED BY ANALYSIS OF MACROFOSSIL PLANT REMAINS

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Summary. The investigations were carried out in the „Uroczysko Język" transitional mire located north-east of Józefów. Four 150–200 cm thick peat cores were sampled with an Instorf bore for paleobotanical analyses. Samples of plant macrofossils were collected for the analysis at 10-cm intervals. Additionally, the reaction (pH in 1M KCl and H_2O) and the ash content were determined.

The analysis of the mascroscopic plant remains have revealed that the bottom is formed by clayey gyttja containing scarce plant detritus, primarily roots of the beaked (*Carex rostrata*) and slender (*Carex lasiocarpa*) sedges. The upper layer was composed of sedge-moss fen peat and was covered by transitional sphagnum peat. The 85–35 cm (UJ III) and 80–100 cm (UJ IV) layers comprised strongly hydrated gyttja, and the roof of the analysed deposit was formed by almost entirely undecomposed transitional sphagnum peat.

Currently, the big basin of „Uroczysko Jęzor", filled with organic sediments and having an open water surface, is surrounded by huge arc-shaped dunes. The analysis of the present plant cover showed occurrence of aquatic communities from the class *Potametea*, such as *Nupharo-Nymphaetum* and *Hottonietum palustre*, in the water pool. Rush communities from the class *Phragmitetea* have developed in the northern part of the object, and the other part of the basin is covered by a floating bog, which comprises transitional peatbog communities from the class *Scheuchzerio-Caricetea nigrae* (associations: *Sphagno-Caricetum rostratae, Caricetum limosae,* and *Rhynchosporetum albae*).

Key words: analysis of macrofossil plant remains, reconstruction of plant communities, transitional mire, Roztocze

INTRODUCTION

Peatlands play an essential role in ecosystem and species diversity and, concurrently, they are one of the most threatened Earth's ecosystems. In peatlands, accumulation of plant organic matter proceeds in anaerobic conditions, and the hydrological factor influences the process. Sediments derived thereby preserve the structure of plant tissues and analysis of macrofossil plant remains facilitates identification of vegetation forming subfossil communities. Plant cover can be reconstructed quite accurately, primarily thanks to local deposition of subfossil plant remains and the possibility of identification of their taxon and even species [Amman *et al*. 2007]. The method is based on identification of plant remains using an optical microscope (diaspores: spores, seeds, fruits; vegetative parts of seed plants and cryptogams: tissues, bark, leaves, cones, etc.) [Birks and Birks 1980, Birks 2001, 2003]. The method is important particularly in determining the genesis of peatland ecosystems, since it provides information about local ecosystems and succession taking place within biogenic accumulation reservoirs [Konieczna and Kowalewski 2009].

The aim of the present study was to investigate succession processes reflecting changes that took place in the „Uroczysko Jęzor" peatbog in the past and reconstruction of plant communities that contributed to terrestrialisation of the water reservoir. Identification of ecosystems present within the reservoir and description of sediments deposited therein are vital for conservation of the natural values of the site.

STUDY OBJECT

The study object, i.e. Uroczysko Jęzor (coordinates of the centre: N 50°29'46,5"; E 23°01'52,3") is located in Roztocze, which is a belt of land elevation running from the north-west to the south-east. It is separated by the Wieprz and Bug river systems in the north-east and the San and Dniestr river systems in the south-east. Roztocze separates the Sandomierz Basin from the Nadbuże Basin and connects the Lublin Upland with Podole. Due to its varied geological structure, vegetation cover, and terrain features, Roztocze has been divided into three parts: Western, Central, and Southern Roztocze [Chałubińska and Wilgat 1954] or into Goraj, Tomaszów, and Rawskie Roztocze [Maruszczak 1972]. The main elements of the terrain relief are built of Upper Cretaceous deposits: opokas and marls, formation of which was influenced by a number of factors varying in time and space. The major role in the development of the Roztocze terrain relief was played by faults, tectonic movements (dislocations), resistance of the bedrock (primarily Upper Cretaceous rocks), and climate changes [Buraczyński 1997]. Probably, Roztocze was twice covered by an ice sheet [Harasimiuk 1980, 1994].

Uroczysko Jęzor, with a surface area of ca. 12,5 ha, is located north-east of Józefów. It is situated in a large deflation basin surrounded in the south-west and west by a belt of dunes with a maximum height of 262,7 m a.s.l. In the south-western fragment of the basin, a transitional mire, i.e. the so-called floating bog, has evolved (area of ca. 4,5 ha),which is inhabited by communities from the class *Scheuchzerio-Caricetea nigrae* (patches of the *Sphagno-Caricetum rostratae*, *Caricetum limosae*, and *Rhynchosporetum albae* associations as well as *Calla palustris* and *Comarum palustre* communities). Aquatic communities from the class *Potametea*, e.g. *Nupharo-Nymphaetum* and *Hottonietum palustris*, and sedge communities from the association *Magnocaricion* have developed in the water reservoir (surface area ca. 2 ha). In the northern part of Uroczysko, there are rush communities from the class *Phragmitetea*, with the common reed *Phragmitetum australis* association covering the largest area. The edges of the peatbog are covered by clumps of the purple moor grass *Molinia caerulea* and the soft rush *Juncus effusus*. Rare and legally protected species that can be found here include the round-leaved sundew *Drosera rotundifolia*, podgrass *Scheuchzeria palustris*, mud sedge *Carex limosa*, bogbean *Menyathes trifoliata*, and white water lily *Nymphaea alba*.

MATERIAL AND METHODS

Using methods that are widely applied in peat science research [Tobolski 2000], 4 bore-holes UJI, UJII, UJIII, and UJIV were drilled (coordinates of the transect centre N 50°29'43,9"; E 23°01'51,3") in the analysed transitional mire with an Instorf bore. Full cores with an undisturbed structure of sediments were collected for laboratory analysis from the profiles (between the ground surface and the mineral substrate). The cores were divided into fragments in the laboratory according to their diversity identified in the field analysis. Material designed for determination of macrofossil plant remains (sample volume of 50 cm^3) was sampled from the peats and gyttja at 10-cm intervals. Separation of plant remains was performed according to the methodology developed by Tobolski [2000]. The plant macroremains were identified using available keys and atlases [Dombrowskaja *et al.* 1969, Grosse-Brauckmann 1972, 1974, Grosse-Brauckmann and Streitz 1992, Tobolski 2000] as well as contemporary reference vegetation preparations. The nomenclature for vascular plants and for mosses follows that proposed by Mirek *et al.* [2002] and Ochyra *et al.* [2003], respectively. The gyttja and peat samples were also assayed for the reaction (pH in H_2O and KCl), and the ash content was determined by burning the samples in a muffle furnace at a temperature of 550°C [Sapek and Sapek 1997].

Diagrams showing the results of the analysis of the plant macroremains were constructed with the use of programme POLPAL 2004 ver. 2012.05.

RESULTS

The analysis of the macrofossil plant remains from the investigated deposits revealed 5 stages of development of plant communities. The diagrams of the maecroremains are presented in Fig. 1–4.

Lacustrine stage I

The bottom of the deposit is formed by grey-coloured clayey gyttja (UJ I and UJ III) with a small admixture of sand (UJ IV), which becomes detritus gyttja. In core UJ II, gyttja was deposited directly on sand with a grain size of 0.2–0.6 mm. The thickness of the gyttja layer varies between the cores from 20 cm (UJ I, II, III) to 50 cm (UJ IV). The gyttja layer contains scarce plant remains, primarily sedge roots with dominance of the beaked sedge *Carex rostrate.* The common reed *Phragmites australis*, bulrush *Typha sp.*, swamp horsetail *Equisetum fluviatile*, bogbean *Menyanthes trifoliata*, and marsh fern *Thelipteris palustris* are complementary elements of the mosaic of the rush-peatbog species responsible for the initiation of the peat-formation process. Gyttja layering was identified at a depth of 120–125 cm in core UJ II. The layer was characterised by strongly acidic reaction (pH in KCl 3.84–4.26) and a high ash content (58.5–96.0%).

Fen stage II

The presence of a layer of sedge-moss fen peat (UJ III), sedge peat (UJ I), and sedge gyttja peat (UJ II, IV) was found at the contact with the mineral substrate. The botanical composition of this layer comprised species from the class *Scheuchzerio-Caricetea nigrae* such as the cotton grass *Eriophorum angustifolium*, bogbean *Menyanthes trifoliata*, feathery bog-moss S*phagnum cuspidatum*, and *Carex* sp. sedges including the slender sedge *Carex lasiocarpa*. There were also species from the class *Phragmitetea*: the beaked sedge *Carex rostrata* and the common rush *Phragmites australis*. Additionally, *Bryopsida* were found in the admixture in core UJ IV. Layering was observed in core UJ I at the depths of 136–148 cm and 152–156 cm. The pH of this layer was acidic with pH in KCl in the range of 3.88–4.23 and the ash content increased with depth from 5% in the roof of the deposit to 15% in its bottom.

Transitional mire stage III

Another layer was formed by transitional sphagnum peat. The preserved plant macroremains revealed massive occurrence of fragments of *Sphagnum cuspidatum* stems and leaves and sphagnum species from the section *Cymbifolia*. A considerably lower proportion in the botanical composition was found for transitional mire species from the class *Scheuchzerio-Caricetea nigrae* such as the podgrass *Scheuchzeria palustris*, cotton grass *Eriophorum angustifolium*, or bogbean *Menyanthes trifoliata*. Noteworthy, core UJ III contained a 5-cm thick layer at the depth of 110–105 cm, which demonstrated a large proportion of roots of the podgrass *Scheuchzeria palustris* among the preserved plant remains. The peat in this layer was characterised by a low degree of decomposition (7%), low ash content (4.7–7.9%), and acidic reaction (pH 2.95–3.55).

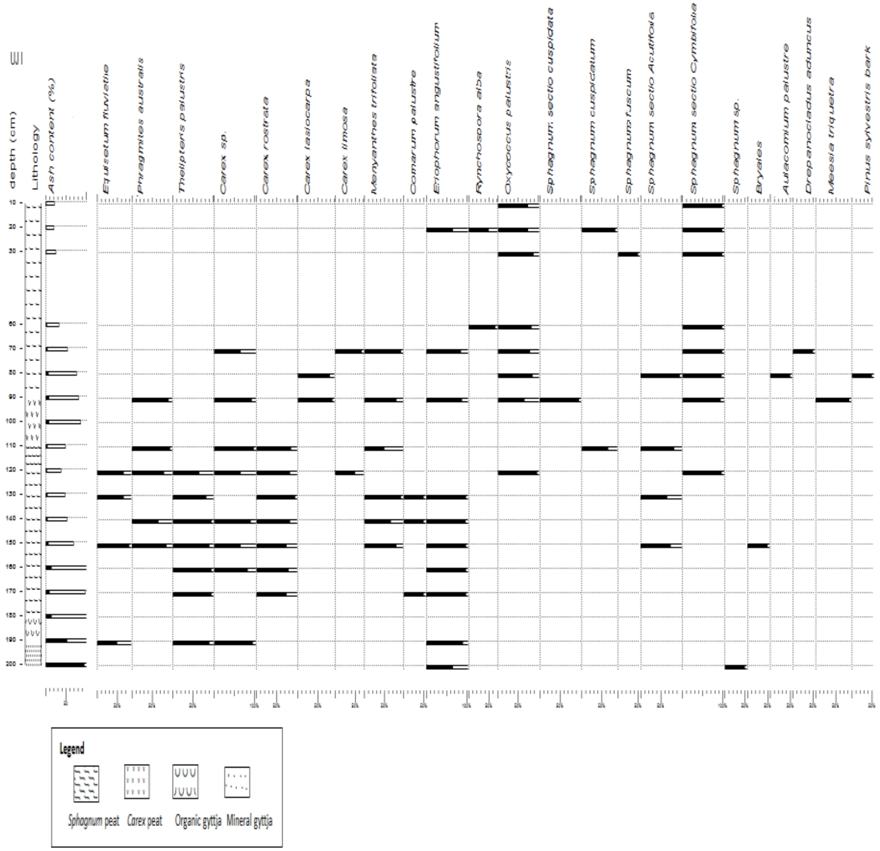

Fig. 1. Diagram of macroscopic plant remains – profile UJ I

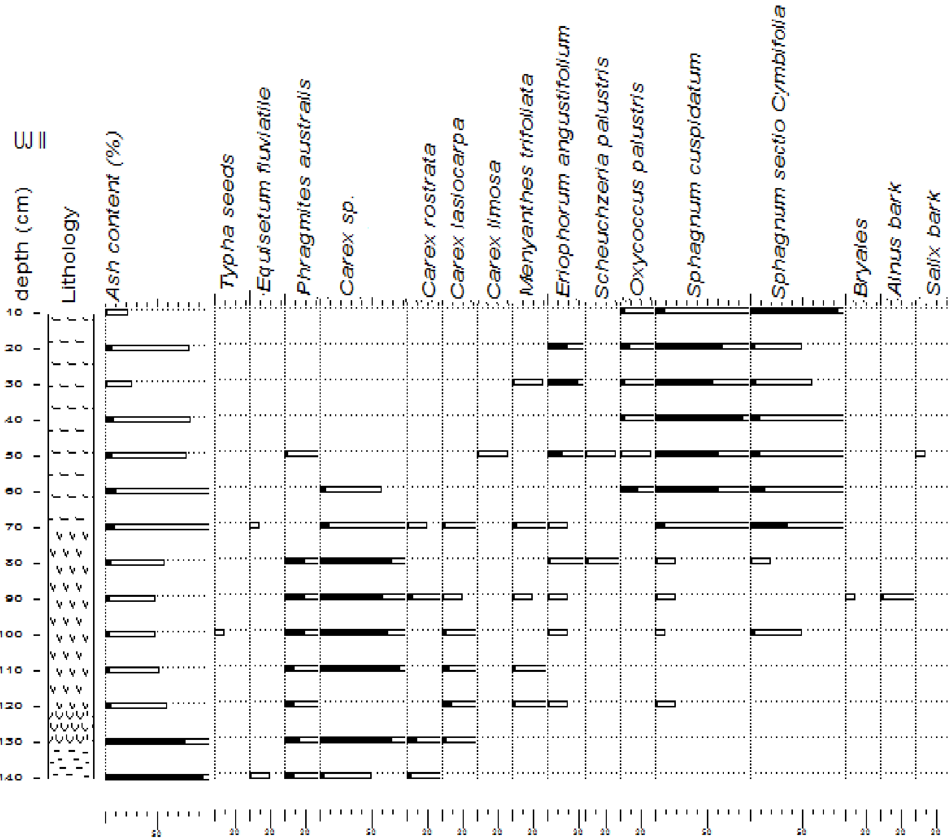

Fig. 2. Diagram of macroscopic plant remains – profile UJ II

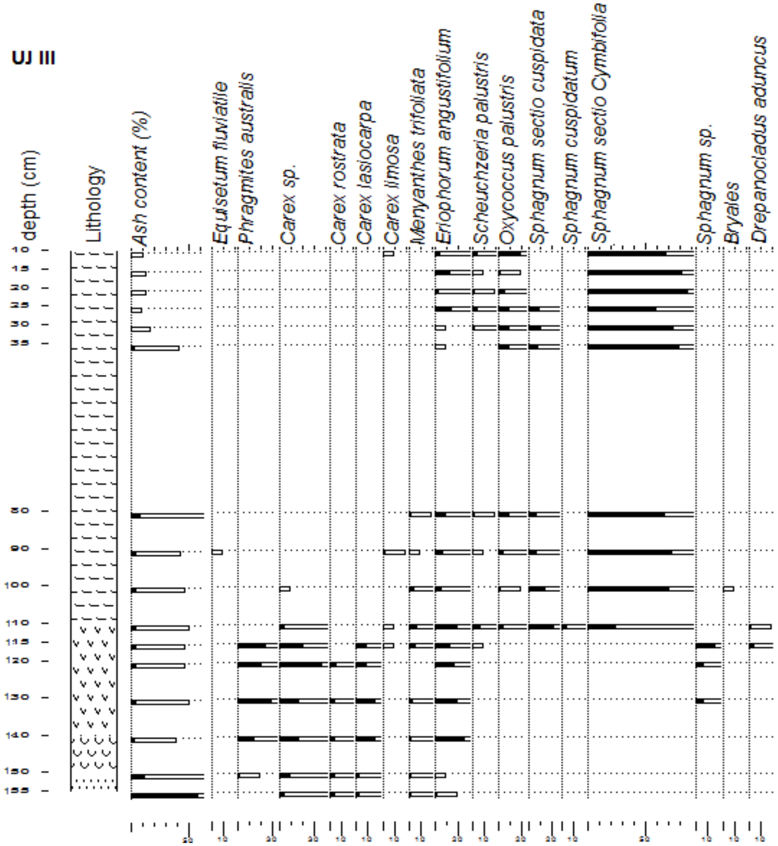

Fig. 3. Diagram of macroscopic plant remains – profile UJ III

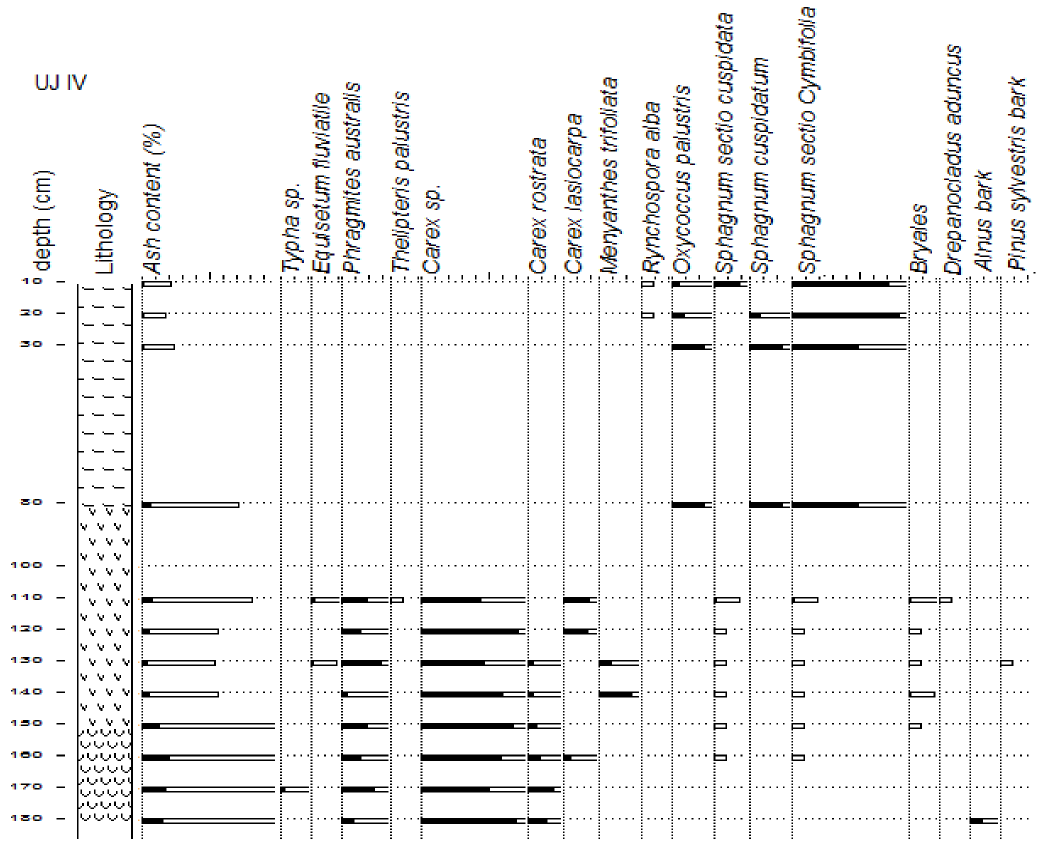

Fig. 4. Diagram of macroscopic plant remains – profile UJ IV

Gyttja stage IV – remnants of an overgrown water reservoir

In cores UJ III and UJ IV, located at the shortest distance from the present lake, a layer of strongly hydrated gyttja containing small amounts of plant and animal remains was observed. Sediment sampling from this part was extremely difficult due to the low cohesion of the material. This layer is a remnant of a water reservoir, which was gradually overgrown by a floating carpet of transitional mire vegetation (the so-called floating bog). The botanical composition of the preserved plant remains was dominated by sphagnum species, primarily those from the section *Cymbifolia*. We noted a low share of vascular plants from the class *Scheuchzerio-Caricetea nigrae* such as the podgrass *Scheuchzeria palustris*, cotton grass *Eriophorum angustifolium*, mud sedge *Carex limosa*, and swamp cranberry *Oxycoccus palustris* from the class *Oxycocco-Sphagnetea*. The pH of this layer was strongly acidic (pH in KCl 3.30–3.45), and the ash content was estimated at 9%. A 10-cm thick layer of sedge fen peat was found on transitional sphagnum peat in core UJ I. It was formed by sedges, primarily the beaked sedge *Carex rostrata*, accompanied by inconsiderable amounts of *Sphagnum.*

Transitional peatland stage V

The roof of the analysed cores was formed by an almost undecomposed transitional sphagnum peat. Its botanical composition was dominated by *Sphagnum* sp., mainly from the section *Cymbifolia*, the swamp cranberry *Oxycoccus palustris*, mud sedge *Carex limosa*, podgrass *Scheuchzeria palustris*, and cotton grass *Eriophorum angustifolium*. In core UJ I, a 5% share of *Meesia triqetra* was noted, i.e. a meso-acidophillic species, which finds optimum development conditions in acidic habitats with pH 4.6–6.5. The layer was characterised by acidic reaction with pH in the range of 3.9–5.0 and a low ash content value of 8.3–1.5%.

DISCUSSION

The peatlands of Roztocze have been poorly investigated and described in literature. One of the few papers describing the peatlands of the Lublin Region, including Roztocze, was published by Borowiec [1990]. The area of Central Roztocze covers mainly forested (60%), largely marshy land. It comprises numerous usually small peatbogs and marshes as well as wetlands with a natural vegetation cover (marshy coniferous forests, sphagnum bog communities, scrub) excluded from plant production and having great importance for conservation of the biological and landscape diversity of Roztocze. Due to their midforest location and small area, many of the peatland objects have no geological documentation.

The analysis of the microscopic plant remains in the cores sampled from Uroczysko Jęzor helped to distinguish two major succession phases: lacustrine and peat bog stages. Since there are no palinological or radiocarbon dating analyses, conclusions about the age of the sediments can only be drawn indirectly based on the macroscopic remains. The onset of accumulation of sediments deposited in the lake and analysed in core UJ 1 is unknown, but it must have taken place relatively late, as *Alnus* alder wood debris was found in core UJ IV at a depth of 180 cm. The research conducted by Bałaga [1998] from Central Roztocze indicates that sediment accumulation was initiated in the Alleröd period. Unpublished [Tokarz – unpublished] results of radiocarbon analysis in the Margólka peatbog (Aleksandrów) show that the process of organic matter deposition may date back to approx. 7185 ±75 BP. Analysis of pollen spectra of accumulation reservoirs in Krasnobród and Tarnawatka has confirmed the presence a pine-birch forest with an admixture of spruce, larch, alder, and poplar in their vicinity [Bałaga 1998]. According to Marek [1965], alder communities in Poland developed in the Holocene Climatic Optimum (the Atlantic).

The lacustrine stage is characterised by presence of a clayey gyttja layer becoming mineral-organic gyttja layered by sand in the littoral zone and by peat in the pelagic zone. The thickness of the deposit in the analysed profiles from Uroczysko Jęzor is low and ranges from 0.20 to 0.5 m, likewise in the other objects in Central Roztocze, where the thickness of the layer is between 0.7 and 1.0 m [Bałaga 1998]. Studies on the genesis of the post-lacustrine peatlands of the Łęczna-Włodawa Lakeland show that the thickness of gyttja deposits in some objects is substantially higher and reaches as much as 12–14 m [Gawlik and Urban 2003, Bałaga and Chodorowski 2006, Urban 2009a, b]. The investigations carried out by Bałaga [1998] indicate that the lacustrine sedimentation process in Central Roztocze started approx. 10 750–11 780 ±150 BP and the duration of the open lake stage varied. Depending on the object, the sedentation process was initiated ca. 7300–9450 ±150 BP. As demonstrated by studies, the process of overgrowing of the Łęczna-Włodawa lakes started in the Subboreal period, e.g. peat formation in the Moszne reservoir was initiated ca. 4300 ±120 BP [Bałaga *et al.* 1995]. The profiles from Uroczysko Jęzor comprise few bioindicators of the limnitic accumulation environment. There are no remains of aquatic plants and the botanical composition of peat does not indicate development of littoral rush communities in the genesis of the peatland.

The peatland stage in the Uroczysko Jęzor object is poorly visible at a depth of 150 cm, where peat-forming sedge-moss communities overgrow the lake shallowed by limnic sediments. The presence of many *Sphagnum* leaves demonstrated by the analysis of macroscopic plant remains indicates the occurrence of a floating bog. Similarly, the peat-forming process in the lakes of the Włodawa-Łęczna Lakeland was initiated by encroachment of a floating vegetation carpet on the open water surface [Okruszko *et al.* 1971, Urban 2009a, b]. It is not known when the encroachment of the floating carpet on the open water surface took place in Uroczysko Jęzor, but its rate must have varied, as indicated by the differences in the thickness of the peat layer between the individual cores. The peat thickness is 180 cm in core UJ I but 140 cm in core UJ IV at an 8-m distance between them. The difference in the peat thickness is approx. 20%. Assuming a maximum sedentation rate of 1 mm/year [Żurek 1986], the differences in the deposition period can be estimated at 4 000 years at least. Occurrence of such species as the slender sedge *Carex lasiocarpa*, beaked sedge *Carex rostrata,* bogbean *Menyanthes trifoliata*, cotton grass *Eriophorum angustifolium*, or common reed *Phragmites australis* indicate high humidity still prevailing in the habitat. The peat decomposition degree varied within a broad range of 11–20%, suggesting variable hydrological conditions and occurrence of drier periods, which promote more efficient decomposition of autochthonous matter. At the depth of 110 cm, accumulation of transitional moss peat was evident. In core UJ III, it was possible to distinguish a 5-cm layer dominated by the podgrass *Scheuchzeria palustris*. The species composition of the entire layer indicates a high degree of habitat hydration. The sediment sedentation process occurring in the conditions of low oxygenation and at a slow rate of biological transformations is reflected by the low degree of decomposition (7%) of deposited organic matter [Ilnicki 2002, Żurek 1986]. The roof of the sediments in the Uroczysko Jęzor object is formed by almost undecomposed transitional sphagnum peat and the current vegetation cover is constituted by transitional mire communities from the class *Scheuchzerio-Caricetea nigrae* (patches of the associations *Sphagno-Caricetum rostratae*, *Caricetum limosae*, and *Rhynchosporetum albae*).

CONCLUSIONS

The accumulation reservoir Uroczysko Jęzor is classified as a largely sediment--filled acidic lacustrine-peatland ecosystem. The succession sequence of Uroczysko Jęzor comprises a process of water reservoir shallowing and decreasing the water table by gyttja deposition. Encroachment of rush and peatland vegetation communities was initiated after the appropriate depth was achieved. This stage was characterised by fluctuations in the water level. Together with stabilisation of the hydrological conditions, rush and sedge communities gave way to transitional peatland communities, which entered the open water surface in the form of floating vegetation carpets. The quaking bog is a type of a floating peatbog according to the hydrodynamic typology developed by Timmermann [1999]. The degree of the loss of the open lake basin is substantial, as the open water surface accounts for approx. 16% of the entire surface of the accumulation reservoir.

1. The analysed peat deposit lies on a gyttja layer, which is up to 20 cm thick in the littoral zone, and on an up to 0.5-m thick floating bog, which evidences its lacustrine genesis.

2. Out investigations have shown that the Uroczysko Jęzor peatland is still undergoing the accumulation phase of development.

3. The following stages can be distinguished in the vegetation transformations in the analysed peatland: stage I – lacustrine, stage II – fen, stage III – transitional mire, stage IV hydrated gyttja, and stage V – transitional mire with the onset of the raised bog phase.

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ROZWÓJ ZBIOROWISK ROŚLINNYCH UROCZYSKA JĘZOR W ŚWIETLE ANALIZY MAKROSKOPOWYCH SZCZĄTKÓW ROŚLINNYCH

Streszczenie. Z torfowiska „Uroczysko Jęzor”, położonego na pn.-zach. od Józefowa, do badań paleobotanicznych pobrano świdrem typu Instorf rdzenie torfowe o miąższości od 150 do 200 cm. Do analizy makroszczątków roślinnych pobierano próbki co 10 cm, wykonano również analizę pH (w 1M KCl i H_2O) oraz określono popielność.

Na podstawie analizy szczątków makroskopowych roślin stwierdzono, że spąg buduje gytia ilasta z obecnymi nielicznymi szczątkami roślinnymi, głównie korzonkami turzyc dzióbkowatej i nitkowatej. Powyżej stwierdzono obecność warstwy torfu niskiego turzycowo-mszystego. Kolejną warstwę buduje torf przejściowy sfagnowy. Na głębokości 85–35 cm (UJ III) i 80–100 cm (UJ IV) odnotowano obecność silnie rozwodnionej gytii, zaś strop badanego złoża jest zbudowany przez prawie nierozłożony torf przejściowy sfagnowy.

Obecnie ogromna misa „Uroczyska Jęzor” wypełniona osadami organicznymi z otwartym lustrem wody otoczona jest łukiem potężnych wydm. Na podstawie analizy współczesnej pokrywy roślinnej stwierdzono, że oczko wodne tworzą zbiorowiska *Nupharo-Nymphaetum* oraz *Hottonietum palustre* z klasy *Potametea.* W części północnej torfowiska wykształciły się zbiorowiska szuwarowe z klasy *Phragmitetea*, zaś pozostałą część obniżenia zajmuje spleja, na której występują zbiorowiska torfowisk przejściowych z klasy *Scheuchzerio-Caricetea nigrae* (zespoły: *Sphagno-Caricetum rostratae, Caricetum limose, Rhynchosporetum albae*).

Słowa kluczowe: analiza makroskopowych szczątków roślinnych, Roztocze, rekonstrukcja zbiorowisk roślinnych