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The local Holocene history near Tomisław (Lower Silesian Forests, Poland) in the light of pollen analysis

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ABSTRACT. A sedimentary core obtained from a mire ca. 2 km north-west of the village of Tomisław, about 10 km west of the town Bolesławiec (Silesian Forests) in western Poland, was investigated by pollen analysis. The core is 1.90 m long and preserves Holocene sediments that range from the older part of the Boreal period to the older part of the Subboreal period. Absence of the younger part of the Subboreal and the entire Subatlantic periods seems to suggest the gradual disappearance of mires in this region, corresponding with the previous findings of peat researchers. Peat disappearance probably resulted from drainage of the area and its subsequent use for agriculture or forestry.

KEYWORDS: pollen analysis, Holocene, Lower Silesian Forests

INTRODUCTION

Within the area of Lower Silesian Forests, peatlands are the most frequently reported from valley depressions in the basin of the Bóbr, Kwisa and Nysa Łużycka rivers (Pender et al. 1992–1994). Areas of peat development are most numerous near the village of Tomisław (51°17′N 15°26′E), in river basins of the Czerna Wielka, Łącznica Dolna and Górna and numerous small tributaries of the Kwisa. Previous research in this region revealed the presence of 18 peat deposits with a total area of 142 ha (Pałczyński 1970). Numerous peat objects were also identified among Świętoszów a Ławszowa (Berdowski et al. 2003). The present flora and plant communities of these peatlands, as well as the peat types and thickness of deposits, have been thoroughly studied (Pałczyński 1970, Berdowski 1992, Berdowski et al. 2003).

Until now, the area of Lower Silesian Forests has not been subjected to palynological investigations. The nearest sites where palynological research was carried out are situated in the Lubuskie Region (Nowaczyk & Okuniewska-Nowaczyk 1992, 1999, Burdukiewicz et. al. 2006, Masojć et. al. 2006) and Great Polish Lowland (Tobolski 1966). The notable lack of data on the Holocene plant history of this area encouraged us to undertake a study of International Geological Correlation Project (IGCP) for Poland (Ralska-Jasiewiczowa & Latałowa 1996) and to summarize the distribution of pollen percentages in Poland, so-called isopollen maps (Ralska-Jasiewiczowa et al., 2004). Our investigation aimed to reconstruct the past history of vegetation and plant succession during peat deposition as well as to assess the estimated age of peat deposition (acc. to Mangerud et al. 1974).

In this paper we will present the preliminary results of pollen analysis of one of a few peat profiles – Tomisław I (TI), whose fragmentary results were published by Popowski and Maj (2006). This is the first stage of our project that will in the future present data from other profiles in this region.

POSITION, GEOLOGY AND GEOMORPHOLOGY OF THE STUDIED LOCALITY

The studied area is located ca. 2 km northeast of the village of Tomisław, about 10 km west of the town Bolesławiec (Fig. 1). The studied organic deposit is situated in the area of forest division no. 556 and is located between two small watercourses that are tributaries of the Kwisa river. At present the mire is overgrown with ca. 90 year old spruce forest planted around 1920 (A. Hyjek pers. comm.).

According to the physiographic division of Poland (Kondracki 2000) the investigated area lyies on the south-western Polish lowlands. It belongs to the mesoregion of the Lower Silesian Forests, which is a part of Silesio-Lausatian Lowland macroregion. The region is characterized by poorly diversified relief. Relative height differences do not exceed a few meters in this part of Lower Silesian Forests.

Geologically the studied area is located in the northern part of North Sudetic Basin that was created as a result of regional spreading processes at the end of the Variscan orogeny (Solecki 1994). The thickness of basin deposits reaches 2500 m and comprises sediments from the highest Carboniferous to Upper Cretaceous Period (Stupnicka 1997). The development of basin deposits differs between its western and eastern part, and so far no uniform lithostratigraphic division of this unit has been created (Śliwiński et al. 2003).

Pleistocene-Holocene sediments of the region vary considerably in thickness and distribution. Glacial and fluvioglacial, as well as fluvial deposits from the Pleistocene, associated with the stages of Middle Polish glaciation are present in the area. Sediments of the glacial maximum stage are represented mainly by severly eroded and unevenly distributed glacial tills, sands and fluvioglacial gravels deposited during the retreat of continental ice sheet. During the Warta stage sands and gravels of ice marginal valley of the Bóbr river formed in the area. At the time of the North Poland glaciations, up to 28 m of river terrace sands and gravels were formed along the Kwisa river. Likewise, mudstones, sands and gravels appeared in reservoirs created in temporary closed depressions. The Holocene was characterized by sedimentation of deposits typical of riverine settings – sands and gravels in river terraces, mudstones in ice marginal valleys, peat silts and peats. Peat deposits are most abundant in the region of Osiecznica, in the valleys of the Łącznica Górna and Dolna, where they exceed 2 m thickness (Milewicz 1976).

At present in the Lower Silesian Forest the most common plant communities are mainly pine forests, associated with podsolic soils. Within these forests, depending on soil richness and water regime, a few types of phytocoenoses can be distinguished: *Vaccinio uliginosi-Pinetum*, *Molinio-Pinetum*, *Leucobryo-Pinetum*, *Cladonio-Pinetum*, and mixed

Fig. 1. Locality of the studied area (**O**). Site with palynological data (**Δ**): **1** – Nowaczyk & Okuniewska-Nowaczyk (1992), **2** – Nowaczyk & Okuniewska-Nowaczyk (1999), **3** – Burdukiewicz et. al. (2006), **4** – Malkiewicz (2002), **5**, **6** – Tobolski (1966).

forest *Querco roboris-Pinetum*. Deciduous forests are represented by small patches of *Luzulo pilosae-Fagetum*, *Galio sylvatici-Carpinetum*, *Circaeo-Alnetum*, *Carici elongatae-Alnetum*, *Aceri-Tilietum*, and *Salicetum triandro-viminalis* (Macicka & Wilczyńska 1992, Berdowski et al. 2003).

MATERIAL AND METHOD

In this investigation a core for pollen analysis, measuring 1.90 m, was obtained from peat sediments. Detailed description of the peat series (acc. to Troels-Smith 1955, simplified and Tobolski 2000) is showed in Table 1. The degree of decomposition of peat components was not estimated.

A total of 20 samples were subjected to palynological examination. Samples (1 cm^3) were taken every 10 cm. At the beginning the samples were treated with 15% hydrogen peroxide (H_2O_2). Subsequently the material was macerated using Erdtman's acetolysis (Erdtman 1952). Pollen spectra were counted on two or three slides. Each sample contained about 1000 sporomorphs. Percentage calculations are based on the total of 100% (AP + NAP) comprising trees, shrubs and dwarf shrubs (AP) and herbaceous plants (NAP). Pollen grains and spores of local plants (aquatic and marshy) were excluded from the total sum. POLPAL palynological software was used to make the percentage pollen diagram (Walanus & Nalepka 1999, Nalepka & Walanus 2003).

RESULTS

DESCRIPTION OF LOCAL POLLEN ASSEMBLAGE ZONES (L PAZ)

Within the pollen diagram from the Tomisław profile (Fig. 2) five local pollen assemblage zones were distinguished (L PAZ), numbered from the bottom to the top of the profile (Birks 1986, Janczyk-Kopikowa 1987), and labeled TI (Tomisław I). Detailed description of the local assemblage zones are showed in Table 2. The absolute age of Tomisław sediments has not been determined. Chronostratigraphic division is based on correlation of local pollen assemblage zones (L PAZ) with climatic zones of the Holocene (Mangerud et al. 1974).

DEVELOPMENT OF VEGETATION

Pollen spectra of zone TI/1 LPAZ show that in the close vicinity to the mire, along watercourses, communities of riverside carrs with alder (*Alnus*), willow (*Salix*), poplar (*Populus*), elm (*Ulmus*), and spruce (*Picea abies*) must have been abundant at the time. Such communities are typical of river and stream valleys, where surface waters are the most important factor shaping the entire habitat (Matuszkiewicz 2002). In drier places located further from the mire, mixed birch-pine forests, accompanied by oak and spruce, were present. In the bush layer of these forests hazel (*Corylus avellana*) was present, while *Calluna* and other Ericaceae were components of the forest floor vegetation. High frequency of herbaceous plants in the pollen spectra of zone TI/1 suggest that the mire started to form in a rather open and sparely forested area. Plant communities reconstructed according to palynological reasearch of peat sediments of zone TI/1 suggest that the mire near Tomisław appeared in the Boreal period (Tobolski 1966, Ralska-Jasiewiczowa et al. 2004). At that time, the mire could be classified as a fen or transitional bog. This conclusion is supported by high values of Cyperaceae and *Sphagnum*, the occurrence of Poaceae, *Menyanthes trifoliata*, *Thalictrum*,

Table 1. Lithology of the Tomisław profile

Depth (m)	Description of the peat series according to Troels-Smith 1955 (simplified) and Tobolski 2000	Sediment description
0.00–0.20	$Tb_{(Sphag.)}$ 2, $Th_{(cari.)}$ 1, Sh 1, Dh+, nig.3, strf. 0, elas. 0, sicc. 3	peat, highly decomposed, dark brown
0.20–0.50	$Tb_{(Sphag.)}$ 3, Sh 1, $Th_{(cari.)}$ +, Dh+, nig. 2–3, strf. 0, elas. 1, sicc. 3, lim. sup. 3	peat, slightly decomposed, brown
0.50–0.70	Tl 2, Dl 1, $Tb_{(Sphag.)}$ 1 $Th_{(cari.)}$ +, Dh+, anth +, nig. 3, strf. 0, elas. 2, sicc. 3, lim. sup. 2–3	peat with the admixture of charred remains, slightly decomposed, dark brown
0.70–0,90	Tl 2, Dl 1, $Tb_{(Sphag.)}$ 1, cort., nig. 3, strf. 0, elas. 2, sicc. 3, lim. sup. 2–3	peat, very slightly decomposed, brown
0.90–1.70	$Tb_{(Sphag.)}$ 2, $Th_{(cari.)}$ 1, Sh 1, Dh+, nig. 3, strf. 0, elas. 2, sicc. 3, lim. sup. 2	peat, very slightly decomposed, brown
1.70–1.90	$Tb_{(Sphag.)}$ 2, $Th_{(cari.)}$1, Sh 1, Ga/Gs+, nig. 3, strf. 0, elas. 1, sicc. 3, lim. sup. 3	peat, highly decomposed, brown- grey and a little of sand

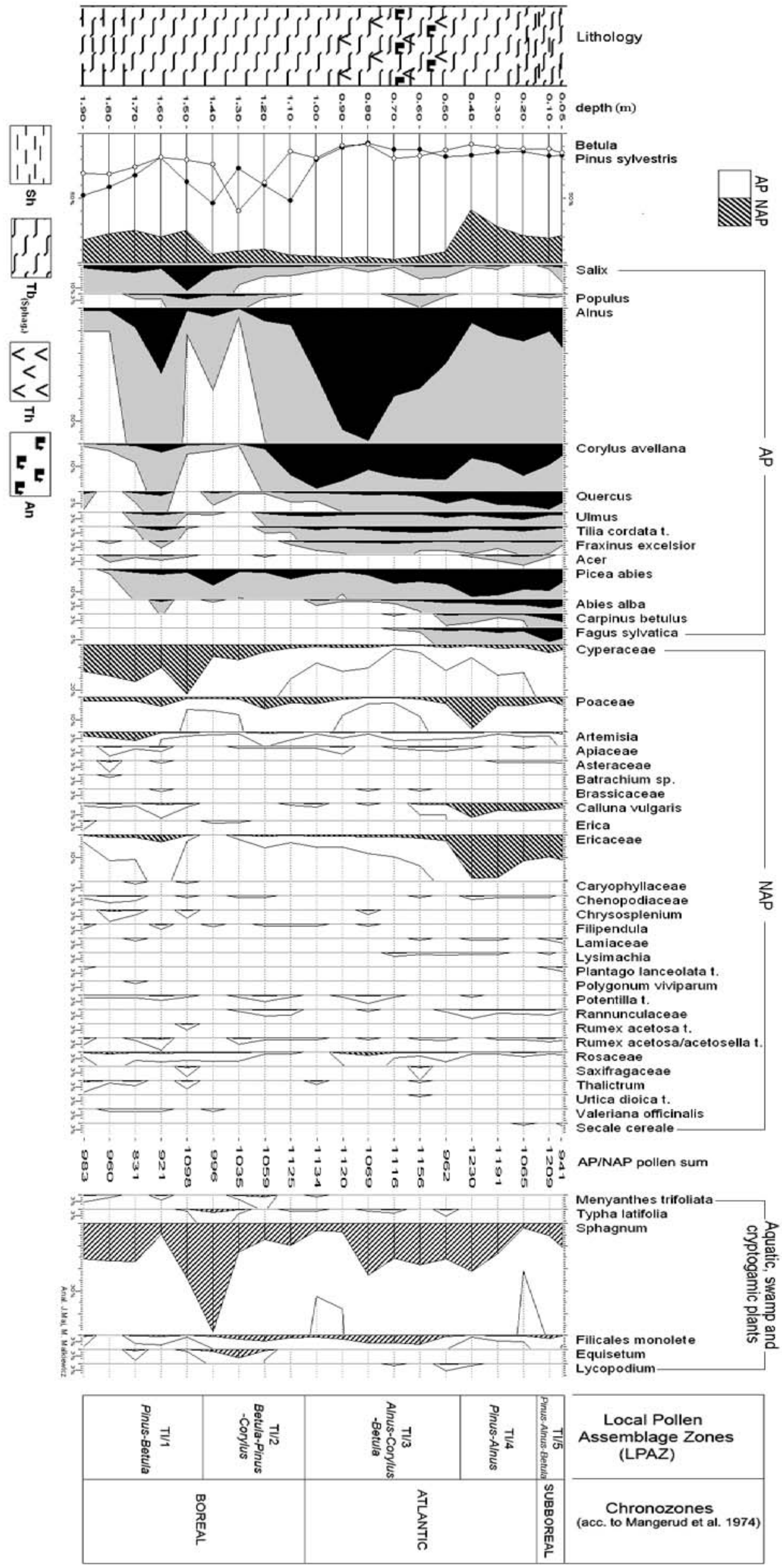

Fig. 2. Pollen diagram from Tomisław

Table 2. Description of local pollen assemblage zones (L PAZ)

Local pollen assemblage zones (L PAZ)	Depth [m]	Description
TI/1 *Pinus-Betula*	1.50–1.90	The high frequency of *Pinus sylvestris* (18.5–47.9%) and *Betula* (18.5–31.5%); relatively high values of *Alnus* (1.0–28.8%) and *Salix* (1.2–11.2%). The presence of *Corylus avellana, Quercus, Ulmus, Tilia, Populus, Fraxinus*, and *Picea abies*. Rather high proportion of NAP – Cyperaceae (10.0–21.5%), Poaceae (0.5–4.0%) and *Artemisia* (0.1–3.7%). The upper limit: increases of *Betula* nad *Pinus sylvestris*; decreases of NAP
TI/2 *Betula-Pinus-Corylus*	1.10–1.40	Increases of *Pinus sylvestris* (27.2–54.2%), *Betula* (14.2 – 60.1%), and *Picea abies* (1.2–7.0%); decrease of *Alnus* (0.3–7.2%); very low frequency of *Salix, Corylus avellana, Quercus, Ulmus*, and *Tilia;* increase of *Sphagnum* spores (to 42.7%). The upper limit: rise of *Corylus avellana* and decreases of *Pinus sylvestris* and *Betula*
TI/3 *Alnus-Corylus-Betula*	0.50–1.00	Maximum of *Alnus* (24.2–58.4%); relatively high values of *Corylus avellana* (11.4–19.6%); decreases of *Pinus sylvestris* and *Betula*; still presence of *Quercus, Tilia, Ulmus*, and *Fraxinus*; increase value of *Picea abies* (1.0– 6.5%); first pollen grains of *Carpinus betulus* and *Fagus sylvatica*; rather low proportion of NAP (ca. 6%) The upper limit: decreases of *Alnus* and *Corylus avellana*; increases of *Picea abies* and NAP
TI/4 *Pinus-Alnus*	0.20–0.40	The high frequency of NAP (20.6–41%); increases of *Picea abies* (8.8–12%), *Abies alba* (1.4–2.2%), and *Quercus* (2.9–5.9%); *Pinus sylvestris* and *Betula* on similar level; continuous and relatively high curves of *Alnus*, *Corylus avellana, Ulmus*, and *Tilia*; presence of *Carpinus betulus* and *Fagus sylvatica;* relatively high values of Poaceae, Ericaceae, and *Calluna vulgaris.* The upper limit: increase of *Carpinus betulus, Fagus sylvatica*, and *Abies alba*
TI/5 *Pinus-Alnus-Betula*	0.05–0.1	*Pinus sylvestris* and *Betula* on similar level; decreases of *Corylus avellana, Ulmus, Tilia*, and *Fraxinus*; increases of *Carpinus betulus*, *Fagus sylvatica*, and *Abies alba*; still presence of Ericaceae, Poaceae, and *Calluna vulgaris*; first pollen grains of *Secale cereale* and *Plantago lanceolata*

Valeriana, and other flowering plants growing on moist soils. Zone TI/2 LPAZ shows that next the area became probably drier, as suggested by the retreat of trees typical of riverside carrs. This resulted in the spread of coniferous communities. Pine and pine-birch forests, with the admixture of oak, spruce and hazel became more abundant. This zone is correlated with the younger part of the Boreal period (Tobolski 1966, Nowaczyk & Okuniewska-Nowaczyk 1999).

Zone TI/3 LPAZ started with the significant reconstruction of forest communities in the area. Coniferous communities disappeared, while mixed deciduous forests and riverside and alder carrs started to re-develop. High values of *Alnus*, reaching 60.0% may suggest the presence of two types of azonal communities in the warmest section of Holocene. Various types of riverside carrs with alder, willow, poplar, elm, and ash (*Fraxinus*), were probably present along the streams. Within the area of the mire, swampy alder forests must have developed. The present-day alder carrs are generally situated in ground depressions with impeded water runoff, and hence shaped by ground waters. Sediments of fen peat or transitional peat are present in their substratum (Matuszkiewicz 2002). Local habitat conditions and the distinct rise in numbers of alder in pollen spectra of zone TI/3 are associated with the occupancy of the mire by alder. This process coincides with the presence of *Typha* pollen representing rushes, and higher values of Filicales monolete spores, with some identified as *Thelypteris palustris*. Today this taxon represents a characteristic species of the alliance *Alnion glutinosae*, occurring frequently in all types of alder carrs (Matuszkiewicz 2002). The presence of forest peat in the studied lithological profile provides additional evidence for the occurrence of alder *in situ* (Tobolski 1966). Drier places were occupied by mixed forests with lime (*Tilia*), oak (*Quercus*), hornbeam (*Carpinus betulus*), and hazel (*Corylus avellana*) in the undergrowth. Beech (*Fagus sylvatica*) was also present. Zone TI/3 is correlated with the older part of the Atlantic period.

In zone TI/4 LPAZ the proportion of trees rapidly declined, whereas values of herbaceous plants increased significantly. Most likely, in this part of Holocene a fire broke out within the mire area. Its traces (charred pieces of wood) were detected in the sediments at the depth of 0.50–0.70 m. The fire resulted in destruction of forest communities, and the development of herbaceous plants, primarily Ericaceae, *Calluna*, and Poaceae. The emerged sunlit areas were occupied also by photophilous hazel, whose share increased in the upper section of zone TI/4 L PAZ. This zone represents the upper part of the Atlantic period.

In the next LPAZ (zone TI/5), the gradual restoration of destroyed forest communities took place. In forest communities the increased significance of oak (*Quercus*), beech (*Fagus sylvatica*), hornbeam (*Carpinus betulus*), and fir (*Abies alba*) is recorded, whereas elm (*Ulmus*) and lime (*Tilia*) decreased in value. The slightly increasing amount of alder in the last sample of the zone indicates the improving local habitat conditions and progressive development of riverside carrs. Sediments of the zone TI/5 L PAZ most likely represent the older part of the Subboreal period.

DISCUSSION

The pollen analysis results obtained are preliminary. The main research aim is to assess the relative age of peat sediments and to distinguish plant succession stages of the investigated area. Due to the large intervals between analysed samples, pollen data is difficult to interpret and the presented relative ages may not be definite. Obtained results are used for making suggestions about general changes in plant communities of the region in the past. This, together with the lack of radiocarbon ages, gives only a general idea of the age of the Tomisław peat deposits.

The idea of distinguishing Younger Dryas deposits (depth 1.50–1.90 m) was taken into consideration. However, this could be only possible when it is assumed that pollen of *Alnus*, *Corylus*, *Quercus*, *Ulmus*, *Tilia*, *Fraxinus*, *Acer*, and *Picea* come from contamination. Assuming that there is no stratigraphical gap, it would be hard to distinguish part of the profile which could be correlated to the Preboreal and Boreal periods. It seems more likely that peat sediments from the depth 1.10–1.90 m are of Boreal age. The curves disturbances of the trees and shrubs mentioned above may show changes in plant communities caused by changes to drainage of the area.

In general, the obtained pollen spectra do not differ too much from the pollen succession in other parts of Poland (Tobolski 1966, Mamakowa 1962, Noryśkiewicz 1978, Nowaczyk & Okuniewska-Nowaczyk 1992, 1999, Nalepka 2005, Milecka 2006, Ralska-Jasiewiczowa et al. 2004, Burdukiewicz et. al. 2006, Masojć et al. 2006). In the Boreal period, the disputed part of Lower Silesian Forests was characterized by the presence of mixed forests with a significant percentage of birch. At the time, in the Lubuskie Region (Nowaczyk & Okuniewska-Nowaczyk 1992, 1999, Burdukiewicz et. al. 2006, Masojć et al. 2006), there were pine forests with low admixture of birch present. Composition of similar type forests in the protocratic part of the Holocene were recorded by Tobolski (1966) in some sites from the valley of Prosna river, who suggested, that in the uplands and areas with no dunes in the closest neighbourhood, the forest development was accompanied by high frequency of birch, while dunes were covered with pine forests. The site described in the paper is located in the valley with streams and beyond close neighbourhood of dune areas, which could therefore explain the significant role of birch in forest communities in the vicinity of Tomisław in the Boreal period.

The obtained pollen spectra also show quite early appearance of spruce in plant communities of the Tomisław environs. In that part of the Lower Silesian Forests spruce was present in forest communities starting from the beginning of the Boreal period and it comes into prominence in the time of climate optimum. The similar forest composition was recorded in Holocene aged sites from the teritory of the Polish foreland (Marek & Casparie 1988) and mountain areas (Marek 1998, Baranowska-Kącka 2003, Madeyska 1989). In the sites located more to the north, from the Lubuskie Region (Nowaczyk & Okuniewska-Nowaczyk 1992, 1999, Masojć et al. 2006) and Prosna valley (Tobolski 1966), spruce does not appear before the Atlantic period and it is decidedly less important in forest communities.

Younger Holocene sediments were not recorded in the profile from Tomisław. The lack of peat desposits representing the younger part of the Subboreal period and the entire Subatlantic period seems to suggest the gradual disappearance of the mires, which corresponds with the findings of peat researchers. The mire disappearance resulted probably from the drainage of the area, and its subsequent forest use (Okruszko 1981, Ilnicki 1972, 2002). The drainage of a mire leads to shrinking of peat and decrease in its volume. This in turn initiates the process of moors-forming and mineralization of organic matter. The annual loss of organic mass in fen amounts to about 1 cm, and results in lowering of the surface of peat deposits (Okruszko et al. 1993). The studied mire has been drained for decades, as suggested by the presence of deep drainage ditches. Around 1920 a spruce forest was planted within the mire area. Both activities must have enhanced the process of peat mineralization, which caused the decline in peat deposit thickness due to the disappearance of its upper section. Assuming the average loss of peat mass given by Okruszko et al. (1993), even the 90 cm peat section could have been mineralized so far.

CONCLUSIONS

Tomisław is the first palynologically investigated site in the area of Lower Silesian Forests. Its sediments show the local record of Holocene plant community history from the Boreal period to the older part of the Subboreal period. The lack of previous palynological research on Lower Silesian Forests explains why no sites form this part of Poland are represented in synthetic treatments of plant community history in Poland (Ralska-Jasiewiczowa & Latałowa 1996), or included in summarized studies of fossil pollen distribution in Poland (Ralska-Jasiewiczowa et al. 2004). Pollen data from the investigated area could be a valuable source to broaden knowledge about the postglacial history of the plant communities that developed in the Lower Silesian Forests as well as elucidating migration pathways of tree species in response to climate change.

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