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EARLY VISTULIAN DEPOSITS AT ŚWINNA PORĘBA, WESTERN OUTER CARPATHIANS (SOUTHERN POLAND)

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Abstract

Alluvial and oxbow deposits preserved 18 m above the Skawa River valley floor are related to the Early Vistulian. Pollen analysis of the two mainly terrestrial profiles revealed a boreal forest succession. The age of the deposits is discussed.

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Key words: Carpathians, Early Vistulian, pollen, alluvia, oxbow deposits

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INTRODUCTION

In the Western Outer Carpathians, similarly to many other mountainous regions, the Pleistocene cover is markedly discontinuous. Complete sequences are scarce, and the regional stratigraphy is based mainly on detritic alluvial deposits formed during cold stages not influenced by tectonic activity (Starkel 1988, Zuchiewicz 1995). The deposits occurring higher than 6 m above the present valley floors have been typically associated with glacial stages older than the Vistulian (Klimaszewski 1967). However, some of them, including more or less complete organic sequences, have been related to the Eemian Interglacial or the Early Vistulian (Starkel 1988, 1995). The palaeobotanical bases of such age determination are controversial (Velichkevich, Mamakowa 1999).

This paper brings the results of investigations carried out on detritic and organic deposits recognized at Świnna Poręba, 6 km from Wadowice (Fig. 1), which comprises similar deposits hitherto regarded as Early Vistulian in age on the basis of palynological and geological data (Starkel 1988, 1995). According to Velichkevich and Mamakowa (1999) these deposits are presumably older.

GEOLOGIC CHARACTERISTICS

Small fragments of two Late Quaternary alluvial covers (Grzybowski, Śniadek 1997), overlying sandstones, mudstones and shales of the Lower Istebna beds (Upper Cretaceous, Fig. 2, layer 1), are preserved in the Skawa River valley at Świnna Poręba, roughly 2 km south of the Silesian thrust (Fig. 1). The younger of these covers is separated from the Lower Istebna beds by an erosional surface; it comprises pebbles, gravels and sandy, locally peaty silts and thin silty intercalations (Fig. 2, layer 2). Higher up, on the contrary, there are mainly silts and peaty silts, considered as oxbow deposits (Fig. 2, layer 3). These are overlain by solifluctional and deluvial loams and loess-like silts (Fig. 2, layer 4, cf. Grzybowski 2001). The layers 2–4 are cut by a small denudational valley filled by deluvial sands and gravels (Fig. 2, layer 5). The alluvial and oxbow deposits correspond to the Early Vistulian, the solifluctional, deluvial and loess-like deposits are related to the Plenivistulian. As a root found at the bottom of the deluvia gave radiocarbon date 1080 ± 50 BP (Lod 840), the existence of the denudational valley must be related to the Late Holocene.

The grain-size and mineralogic analyses interpreted in this paper were carried out for the Early Vistulian deposits collected from the sections A and B, situated in an outcrop excavated during the dam construction (Fig. 2). In section A the bottom surface of the Early Vistulian alluvia is located at 290.3 m a.s.l., *i.e.* 18.3 m above the present flood plain of the Skawa River valley. These alluvia contain mainly pebbles (with some boulders up to 0.5 m) and substantial amounts of fine gravel and sand. The pebbles are arranged horizontally or dip southwards; most of them come from flysch rocks occurring in the upstream sections of the Skawa River valley, mainly of the Godula and Krosno beds. The sand strata developed in the upper part of the described alluvia contain a noticeable proportion of garnets (roughly 20% of heavy minerals in the 0.06–0.1 mm fraction), which are generally absent in the weathered Lower Istebna beds. These features, as well as presence of an ancient erosional surface roughly parallel to the present-day valley slope, and surrounding the discussed deposits from the west, allow us to suggest that the alluvia have been laid down by the waters running northwards, *i.e.* in the same direction as today.

Higher up, in the oxbow deposits, the content of detritic material is evidently reduced. In the lower and upper parts of

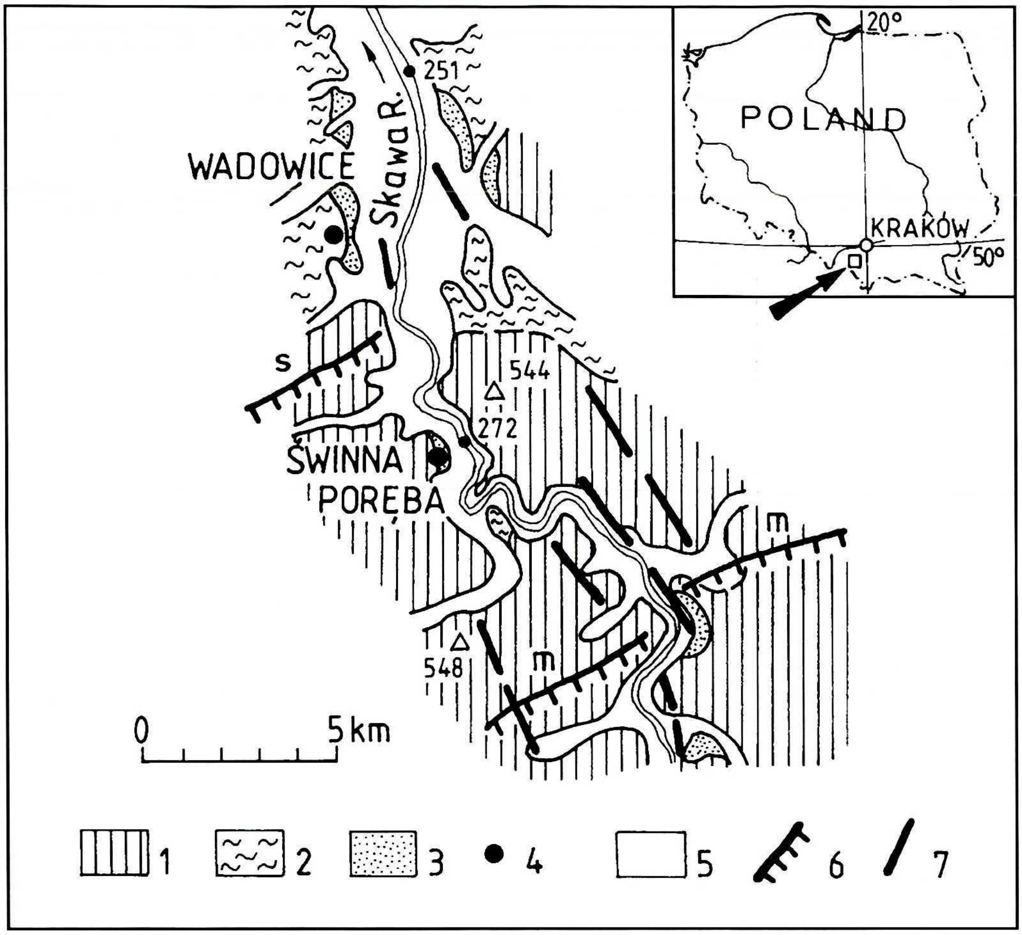


Fig. 1. Geological setting of the Early Vistulian deposits at Świnna Poręba. *1* – flysch rocks, *2* – flysch rocks under thick slope cover, *3* – Quaternary alluvia older than the Late Vistulian, *4* – Brörup Interstadial sites, *5* – Upper Vistulian and Holocene alluvia, *6* – thrusts (s – Silesian thrust, m – Magura thrust), *7* – main faults.

these deposits, the clayey silts with a variable content of organic matter prevail over the sandy silts; in the middle part they contain peaty silts and peats. The sandy silts differ from the alluvial sands in mineralogic composition, especially by a small amount of garnets (less than 2% of heavy minerals); these features indicate a washout of the weathered Lower Istebna beds from the valley slope. Occurrence of peat lumps above the peat strata suggests the washout activity on the floor of the basin (which became a peat-bog).

Section B is located 7.5 m southward from section A; it contains similar Early Vistulian alluvia and oxbow deposits, however without their uppermost part. The deposits of this section differ from those of the section A in some details, *e.g.* in a slightly higher (0.1 m) position of the alluvia bottom surface and in a smaller thickness of gravels, probably connected with the location of section B in the upstream outlier of a gravel bar; the suggested form of the paleochannel could explain some minor differences observed in the later depos-

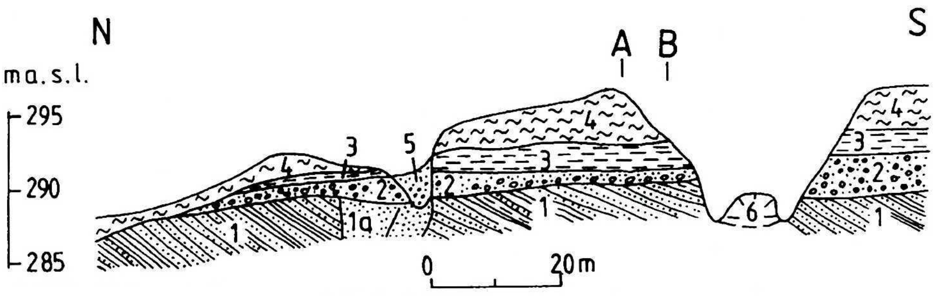


Fig. 2. Geological cross-section of the eastern side of the Świnna Poręba outcrop. 1 – sandstones, mudstones and shales (Lower Istebna beds, Upper Cretaceous), 1a – sandstones of the Lower Istebna beds, weathered in a fault zone, 2 – alluvial pebbles, gravels, sands and silts (Early Vistulian), 3 – silts, peaty silts and peat (Brörup Interstadial), 4 – solifluctional, deluvial and loess-like loams and silts (Plenivistulian), 5 – deluvial sands and gravels (Holocene), 6 – embankment. A, B – sections investigated in detail.

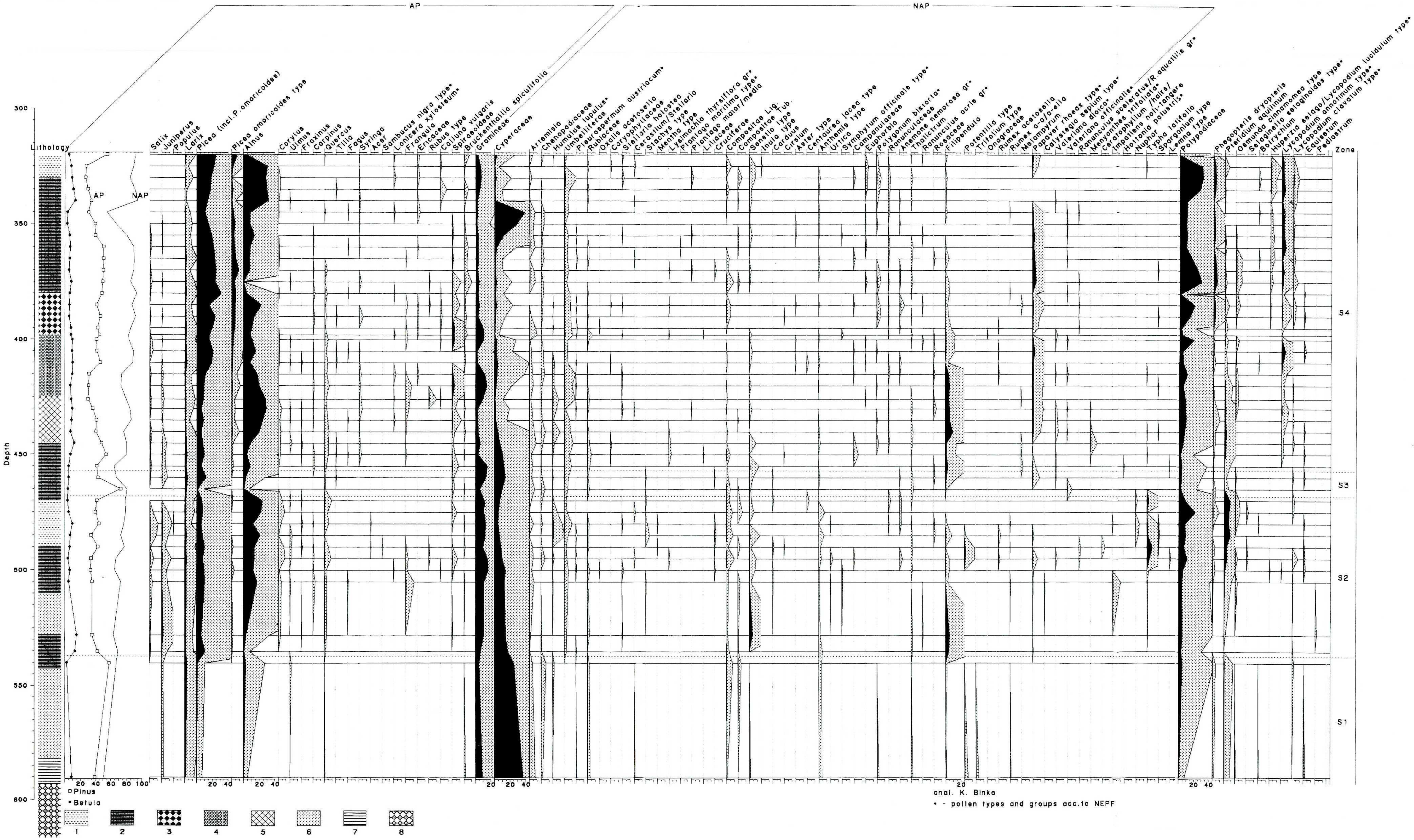


Fig. 3. Percentage pollen diagram from the Świnna Poręba section A. Lithology key: *1* – sandy silt, *2* – silt with diverse (locally significant) amount of organic matter, *3* – silt with organic matter and peat lumps, *4* – peat, *5* – peaty silt, *6* – sands – generally fine and very fine, *7* – clayey silt occasionally containing small amount of organic matter, *8* – gravels.

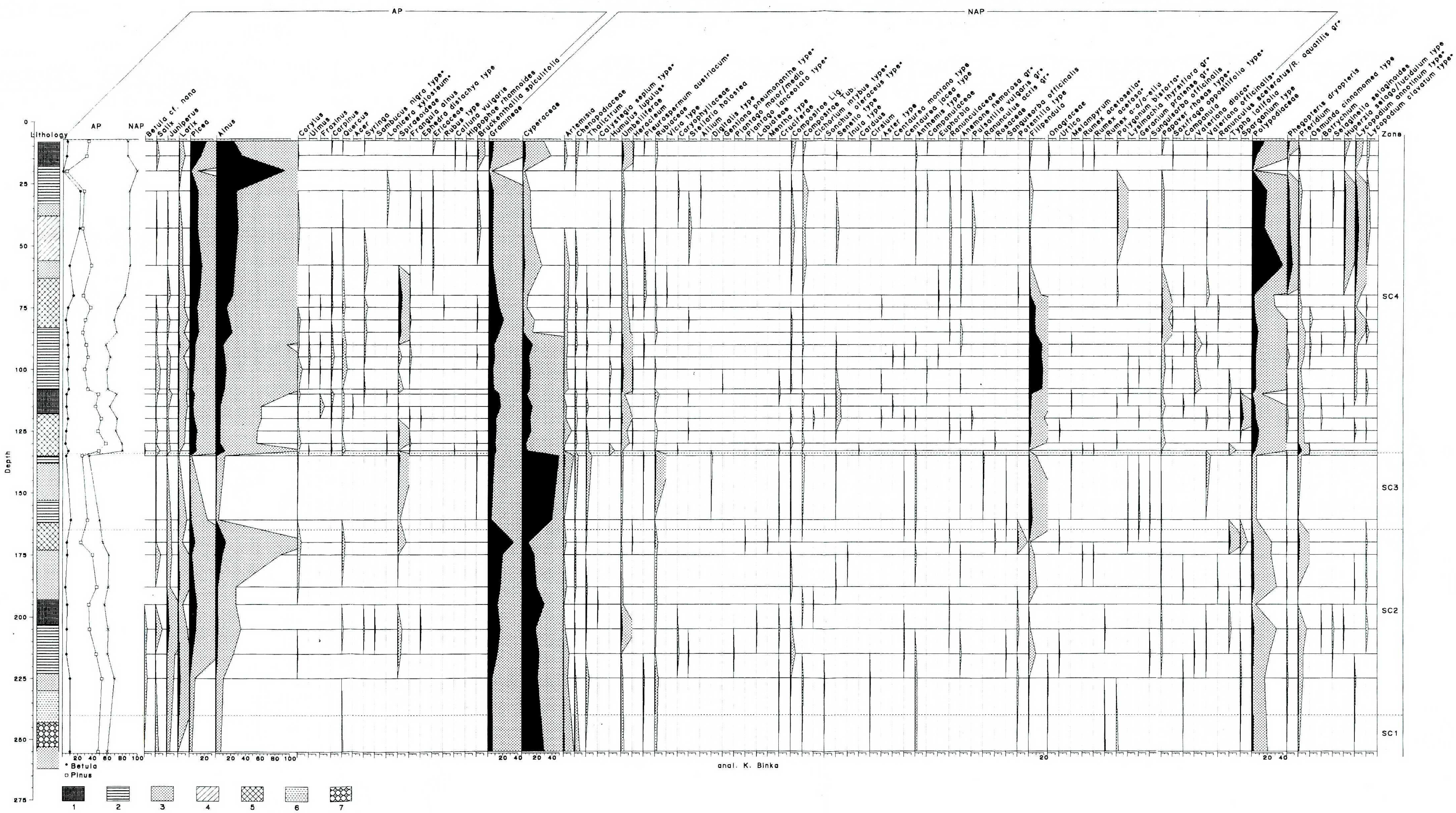


Fig. 4. Percentage pollen diagram from the Świnna Poręba section B. Lithology key: *1* – silt with diverse (locally important) amount of organic matter, *2* – clayey silt occasionally containing small amounts of organic matter, *3* – sands – generally fine and very fine, *4* – disturbed sand and sandy silt, *5* – peaty silt, *6* – sandy silt, *7* – gravels and pebbles.

its. The absence of peat (replaced by peaty silts) may be related to the washout activity just at the base of the valley slope. The peaty silt from the lowermost strata gave radiocarbon date > 48000 BP (Gd-11276).

POLLEN ANALYSIS

Two sections, ranging over 2.5 m in length, were selected for pollen analysis. Samples from both sections were collected from an exposed face, at irregular intervals and stored in plastic bags. In the laboratory each sample (about 1 cm^3 in volume) was treated with KOH, HCl, HF and then prepared using Erdtman's acetolysis. For each pollen slide about 500 sporomorphs were counted at 400x magnification.

In both sections (Figs. 3 and 4) four Local Pollen Assemblage Zones (LPAZ) were distinguished (*i.e.* S1–S4 and SC1–SC4 in section A and in section B, respectively). A few macro-remains were collected from the organic deposits in section B.

Pollen stratigraphy

The lowest zone (**S1** and **SC1**) is recorded in two samples from both sections. The AP curve is formed by pine (including *Pinus cembra*), birch and larch. A high NAP is dominated by grasses and sedges, partly local in origin, with a wide variety of herbaceous types – *Pleurospermum* (Fig. 5/17), *Rubiaceae*, *Cerastium* t., *Compositae* undiff., *Senecio* t., *Cirsium*, *Anthemis* t., *Polygonum bistorta* t., *Potentilla*, *Trifolium* t., *Onagraceae*, *Cruciferae*, *Thalictrum* and *Apiaceae* undiff..

The **S2** and **SC2** zones mark a decrease in pine up to 40% and an increase in *Alnus*, *Picea abies* as well as in other AP elements – *Salix*, *Juniperus*, *Frangula*, *Spiraeoideae* and *Rubus*, which were found frequently, however with low percentage values. The non-arboreal pollen (NAP) with characteristic *Filipendula* and *Pteridium aquilinum* are more abundant than in the previous zone. Higher pollen percentages of aquatics and plants from lake shores – *Nuphar*, *Lemna*, *Ceratophyllum*, *Typha latifolia* and *Sparganium*, are noted in the whole section only in this level.

S3 and **SC3** zones. During this short interval the reestablishment of semi-open plant communities, similar in part to those from the oldest level took place. It is marked in pollen diagrams by the reduction in the *Alnus* and *Picea* curves and a small culmination of the NAP curve, built probably by pollen local plants, which may cause some confusion in the interpretation. Generally, the *Pinus* curve dominates in S3.

The **S4** and **SC4** pollen zone is characterized by a return of warmer climatic conditions, which started generally in the S2 level. The dominant tree curves in the zone – pine, alder and spruce – fluctuate and are different in both sections because of the terrestrial origin of the deposits. This might involve partial destruction of the sporomorphs and, as a consequence, oscillation of pollen curves. Overrepresentation of some local plants from the immediate vicinity can be also invoked as a cause of variability of pollen curves in both profiles. For these reasons, the preserved spectrum in the pollen diagram is probably somewhat distorted, and it might show local rather than regional features.

The new floral element is the extinct species – *Picea omoricoides* Weber. Its curve starts from the very beginning of the zone and gradually rises, with a maximum simultaneous with the *Picea abies* culmination. However, its curve does not exceed 20% of the total *Picea* pollen. Pollen grains of *Syringa* are also limited to this level. The zone S4, generally developed similarly as zone S2, is marked by increasing pollen content of climatically more demanding species – *Syringa*, *Hottonia*, *Calystegia*, *Humulus*, *Valeriana dioica* (Fig. 5/3), as well as development of shrub understory with *Lonicera xylosteum* (Fig. 5/9), *Spiraea* and *Frangula* within the forest.

The deciduous tree pollen from long distances are noted more often but at low frequecies. *Carex* sp., *Filipendula* sp. and a variety of marshland herbs – *Valeriana dioica* (Fig. 5/3), *Calla palustris*, *Menyanthes trifoliata*, *Stellaria palustris*, *Comarum palustre*, *Carex rostrata*, *Glyceria maxima* as well as *Typha latifolia* and *Sparganium* grew in damper sites and around the short-lived margins of depositional basins.

In general, pollen profiles are characterized by:

1. Large oscillations of pollen curves in both sections, that is characteristic for deposits accumulated under terrestrial conditions. Thus the overrepresentation of some pollen types and variation of curves may have taken place according to the local spatial plant composition.

2. A small proportion of pollen grains indicative of a regular lake basin, which confirms mostly terrestrial origin of the deposits. A small pool with a low water level existed only in level S2.

3. Large variations of lithology resulting from its position on the slope are reflected by the presence of plant species characteristic for places rich in calcium carbonate with temporary erosional activity (*Pleurospermum*).

DISCUSSION

Climates and vegetation illustrated by the Świnna Poręba sequences

The character of the flora from both sections (macrofossils and pollen grains) generally bears boreal features. Most of the recorded species have a northern limit of their present distribution within the boreal zone. Only a few plants found in the profiles such as: *Hottonia palustris* (p – pollen), *Valeriana dioica* (p) (Fig. 5/3), *Humulus lupulus* (p), *Sambucus racemosa* (m – macrofossils) and *Calystegia sepium* (p) have a modern range not exceeding the boreal zone. They are, however, not abundant. Distribution of *Bruckenthalia spiculifolia* cannot be taken fully into consideration because of the gradual contraction of its range during the Pleistocene. This is also the case in *Syringa*, which occurred abundantly in the Pleistocene deposits not only in the climatic interglacial optima but also in the boreal spectra. In the other Carpathian pollen record at Polańczyk (Gerlach *et al.* 1997), pollen grains identified as *Ligustrum* type (*Syringa*?) were found as late as the final Eemian.

The species found in Świnna indicate diverse features of the climate. The oceanic influences are shown by the presence of such plants as *Oxalis acetosella* (m,p), *Stellaria holostea* (p), *Calystegia sepium* (p), *Humulus lupulus* (p), *Valeriana dioica* (p), suboceanic – by *Frangula alnus* (m), *Sambucus racemosa* (m), *Lonicera xylosteum* (p), *Impatiens noli tangere* (p), *Hottonia palustris* (p).

Continental floral elements are represented by: *Trientalis europea* (p) (Fig. 5/4–7), *Lysimachia thyrsiflora* (m, p), *Bruckenthalia spiculifolia* (p), *Stellaria palustris* (m), *Calla palustris* (m), *Larix*, *Picea abies*.

Stratigraphic position

Stratigraphical composition of the main AP components at Świnna Poręba is very similar to those in the neighbouring site at Wadowice (Sobolewska *et al.* 1964). Despite diverse shape of the pollen curves in individual sites, which might be an effect of preservation state of the pollen grains in terrestrial conditions, the sequences seem to represent the same age. The first appearance of the extinct species – *Picea omoricoides*, which was excellently studied using statistical methods by M. Sobolewska, represents a very characteristic horizon crucial for correlation of both sections. The Brörup age of the Wadowice sequence was generally accepted (Sobolewska *et al.* 1964). Recently, further studies in this site (Velichkevich, Mamakowa 1999), especially analysis of some *Potamogeton* fruits, demonstrate that the described sequence is characterised by "thermophilous" and "old" features and that the flora might represent a part of interglacial or a "warm" interstadial succession older than the Eemian interglacial. However, in the light of evidence from Świnna Poręba the interglacial age seems excluded. At Wadowice, the *Pinus* phase marks the end of the pollen record. The Świnna record begins with open communities with pine. If we accept the interglacial age of the deposits, it seems very strange that there is no representation of a deciduous temperate forest in all the examined sections. The reconstructed pattern of vegetation seems to be much diversified and more thermophilous in comparison with the Brörup records from the Polish Lowlands, where the pine – birch forests were more often. However, the thermophilous elements from deciduous forest zone mentioned above and those found at Wadowice (Velichkevich, Mamakowa 1999) are not abundant. This is also the case in exotic taxa within the pollen flora and macrofossils noted in Świnna and Wadowice.

Analysis of *Heracleum sphondylium* ssp. *sibiricum* pollen (Fig. 5/10–11) provides interesting age arguments. This type differs from the second species occurring in Poland – *H. sphondylium* ssp. *sphondylium* in its smaller colummellae, the lack of area without columellae at the end of ectoaperture and the smaller size. In the fossil material analysed (Holocene, Eemian and Holsteinian records) only the first type was observed.

Size measurements of the interglacial (Holsteinian and Eemian) *Heracleum* pollen show a mean length of grains of about 36 µm (like modern *Pastinaca* pollen). The Holocene specimens are characterized by the mean length of about 41 µm – similarly as the specimens of *H. sphondylium ssp. sibiricum* in the reference material. Measurements of *Heracleum* pollen from the Świnna Poręba site gave values of about 40 µm. These estimates indicate close resemblance to the modern material rather than to the interglacial material.

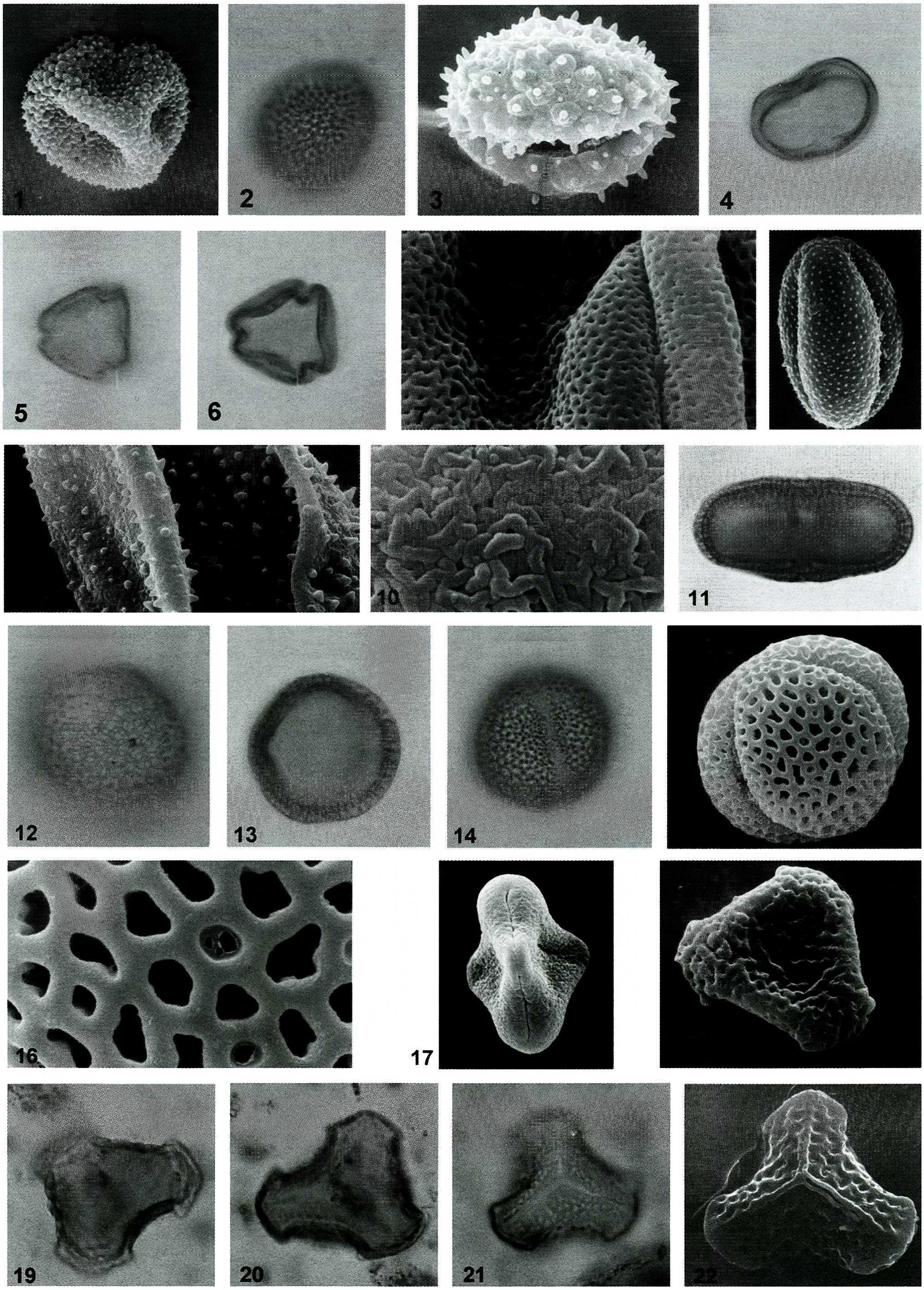
The similarities, which to some extent allow us to estimate the age of the Świnna deposits, result from the characteristic bipartite warm succession with the intervening cold event. To a certain degree this resembles the Amersfoort-Brörup interstadials interrupted by a short period of abrupt cooling as shown by Vistulian pollen diagrams (Menke, Tynni 1984, Behre 1989). For these reasons, the interstadial age (Amersfoort-Brörup) of the deposits at Świnna Poręba is postulated.

CONCLUSIONS

Pollen succession, lithostratigraphy and geomorphologic setting of the described Early Vistulian deposits are similar to those occurring at Wadowice, 6 km NNW from Świnna Poręba (Fig. 1), related to the Brörup Interstadial (Sobolewska *et al.* 1964; Starkel 1995) or older stratigraphic units (Velichkevich, Mamakowa 1999). In our opinion there are pros and con for correlation of the Świnna Poręba and Wadowice deposits. There is no doubt that the pollen successions at both sites represent the same pattern. Both sites also contain alluvia and oxbow deposits, overlain by slope deposits, so the Early Vistulian terrace has not been preserved in the present-day topography. One striking difference of the correlated deposits is that at Wadowice the erosional bottom surface of the Early Vistulian alluvia is buried 2.5 m below the present-day channel of the Skawa River, while the top surface of the oxbow deposits reaches only 9.7 m above the present-day flood plain. These discrepancies may be related to the location of the two sites in the different morphotectonic units: Świnna Poręba is located in the Beskid Mały Mts, south from the Silesian unit thrust, whereas Wadowice lie at the Silesian foothills, north of that thrust (Fig. 1). According to earlier suggestions (Grzybowski 1999), the Flysch rocks and some Quaternary deposits south of the Silesian trust were uplifted during the Vistulian, involving also intense erosion in the mountainous section of the Skawa River valley, thus the position of the Early Vistulian deposits is higher here than in the neighbouring Carpathian sites.

Correlation of the deposits described at Świnna Poręba with those of the mountainous (upstream) sections of the Skawa River valley is difficult to realise. Klimaszewski (1967) has found there some remnants of the high terrace (18–30 m) alluvia related to the Cracovian glacial stage (Mindel?) and of the middle terrace (7–12 m) alluvia attrib-

Fig. 5. Pollen grains from the Świnna Poręba site (SEM and LM). **1–2.** *Thymelaeaceae* (SEM ×10000 and LM ×500), **3.** *Valeriana dioica* (SEM ×2500), **4–7.** *Trientalis europea* (LM ×500 and SEM ×10000), **8.** *Papaver rhoeas* type (SEM ×2500), **9.** *Lonicera xylosteum* (SEM ×2500), **10–11.** *Heracleum sphondylium ssp. sibiricum* (SEM ×10000 and LM ×500), **12–16.** *Syringa* sp. (SEM ×2500, ×10000 LM ×500), **17.** *Pleurospermum austriacum* (SEM ×2500), **18–21.** *Lycopodium lucidulum* type (SEM ×2500 and LM ×500), **22.** *Lycopodium lucidulum* type (SEM ×2500) from the Eemian (Dziewule site, Podlasie region).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uted to the Middle Polish glacial stage (Riss?). However, in the sites described by that author, palaeobotanic sequences are missing. Moreover, in most of these sites, according to the referred data, the detritic deposits form the alluvial cones and not the terrace levels, thus their morphometric correlation is vague. Closely upstream of Świnna Poręba, in the deposits reaching up to 7 m, one of abundant branches preserved at 3–4 m above the valley floor gave radiocarbon date 850 ± 50 BP (Lod 948). Few kilometers further upstream the second author of this paper has found some detritic alluvia remnants at elevation intervals 63–65 m (Mindel?), and 30–36 m (Riss?); those preserved at 18–20 m could represent the Early Vistulian (Würm). Taking into consideration possible effects of recent tectonic movements, we do not assign absolute importance to morphometric criteria; nevertheless in some sections the Klimaszewski's opinion could be more valid. The pertinent solution is expected from further palaeobotanic investigations.

We maintain the opinion about the Brorup age of the analyzed deposits at Świnna Poręba. However, some doubts raised with the assumption that the strata represent older age (Velichkevich, Mamakowa 1999) need further investigation.

Appendix: Notes on pollen identifications

Syringa. In both sections, especially in the lowermost level, the pollen grains of the *Syringa/Ligustrum* complex are relatively frequent. SEM photographs did not reveal the characteristic sculpture elements (granules) in the lumina of the reticulum, allowing identyfying *Ligustrum vulgare* (Punt *et al.* 1991). Thus, the pollen grains noted in the sections are represented by *Syringa* (Fig. 5/12–16), a genus abundant in the Eemian and the Holsteinian of Poland. However, the nature of the reticulum with its small lumina does not allow relating these grains to *Syringa vulgaris*. Currently *Syringa* has two European representatives: *Syringa vulgaris* and *S. josikaea* both distributed in the south-eastern Carpathians (Meusel *et al.* 1978).

Huperzia selago/Lycopodium lucidulum type. Spores characterized by an overall shape (Fig. 5/18–21) similar to *Lycopodium lucidulum* and to some others members of the genus *Lycopodium* – *L. squarrosum* Ham., *L. chinense* Christ, *L. serratum* Thunb., and at the same time to a certain degree similar to those of *Huperzia selago* were often identified in the uppermost zone of both sections. They also occur at other sites in Poland in the Holsteinian (Bińka *et al.* 1995) and in the Eemian deposits (Fig. 5/22). It is very characteristic that these spores appear usually in temperate climate intervals and are not found in the cold treeless periods, where spores of *Huperzia selago* are often noted. Menke (1976) includes these species in one broad morphological type.

The main difference between *Huperzia selago* and the spores from Swinna is that the proximal face of the fossil spores is more angular and the sides opposite the laesura arms are more convex – hence an impression that the arms are more elongated than those of *Huperzia*.

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