THE HISTORY OF VEGETATION OF THE EEMIAN INTERGLACIAL IN THE GREAT POLISH LOWLAND

MAŁGORZATA MALKIEWICZ

Department of Palaeobotany, Institute of Geological Sciences
University of Wrocław
Cybulskiego 30, 50-205 Wrocław, Poland

(Received: May 18, 2001. Accepted: Jannuary 21, 2002)

ABSTRACT

The subject of this paper is the history of vegetation in the Eemian Interglacial in southern Great Poland determined in the course of palaeobotanical research. Pollen analysis was conducted for lacustrine deposits from two localities (Grudzielec near Kalisz and Lechitów near Góra). The obtained pollen diagrams show diagnostic features of the Eemian. The succession of vegetation in both studied localities is characterised by three distinctive phases: protocratic with dominant pine-birch and birch-pine forest and communities of mixed pine-oak and oak forest, mesocratic with predominant hazel and well developed hornbeam-lime forest, and a telocratic one with widespread fir-spruce and pine forest. Moreover, the vegetation succession in top sections of the studied profiles was recognised as typical of the Early Vistulian. The presence of taxa with higher climatic requirements enabled the assessment of palaeoclimatic conditions in the Eemian climatic optimum of southern Great Poland. The development of vegetation in the Eemian Interglacial corresponds with the changes recorded in the nearby localities of Great Polish Lowland and other regions of Poland, as well as those of neighbouring countries. Some minor differences between the studied profiles result from different geographical location of the localities and various genesis of sedimentation basins.

KEY WORDS: pollen analysis, Eemian Interglacial, vegetation history, palaeoclimate, Great Polish Lowland.

INTRODUCTION

As a result of drilling for the Detailed Geological Map of Poland in the scale of 1:50 000 by the State Geological Enterprise Proxima S.A. from Wrocław and Geological Enterprise from Warsaw (works in Łódź), in 1994 new localities of biogenic deposits were discovered near Góra (Lechitów) and Kalisz (Grudzielec).

The palynological expertise, preliminary results of the pollen analysis from Lechitów published by the author, as well as the assessment of the age of Lechitów sediments (Malkiewicz 1998) had not given a complete stratigraphic and floristic picture of the studied sediments. Likewise, the palynological analysis of lacustrine sediments from Grudzielec was fragmentary and comprised only 7 samples (Kuszel and Sadowska 1994). Hence, these preliminary results encouraged the author to start the detailed palynological analysis of the mentioned deposits. This study aimed to help filling the gap in our knowledge on the palaeogeography and palaeoecology of the Eemian Interglacial in the Great Polish Lowland.

Morphology of the Great Polish Lowland

The Great Polish Lowland is one of the most extensive natural geographical regions of Poland. It is situated in the western part of the Polish Lowland, and comprises areas between the Warta–Noteć Valley in the north and the Trzebnica Hills in the south. Its western border is demarcated by the valleys of the Odra and Nysa Łużycka Rivers, the north-eastern border by the Vistula River Valley, and the south-eastern one by the margins of the Łódź Upland (Krygowski 1961) (Fig. 1).

The morphology of the Great Polish Lowland is associated with the processes of the Middle Polish and Vistulian Glaciations. Two separate macroregions are distinquished within the area (Kondracki 1994). The northern part of the Great Polish Lowland, with early glacial sculpture associated with the Vistulian Glaciation, is called Great Polish Lakeland. The southern part, of the Great Polish Lowland, is characterised by an old glacial sculpture resulting from the Middle Polish Glaciation. The boundary between the two regions goes along the line Zielona Góra, Leszno, Poznań.

Despite numerous, long-lasting studies of the Quaternary deposits of Great Polish Lowland (Krygowski 1961; Kozarski 1981; Stankowski and Krzyszkowski 1991 and others), the stratigraphic documentation of this area is still unsatisfactory. Among relatively well studied and palaeobotanically documented sediments there are deposits of the terminal warm section of the Pleistocene – the Eemian Interglacial. A total of 160 sites of the Eemian have been de-

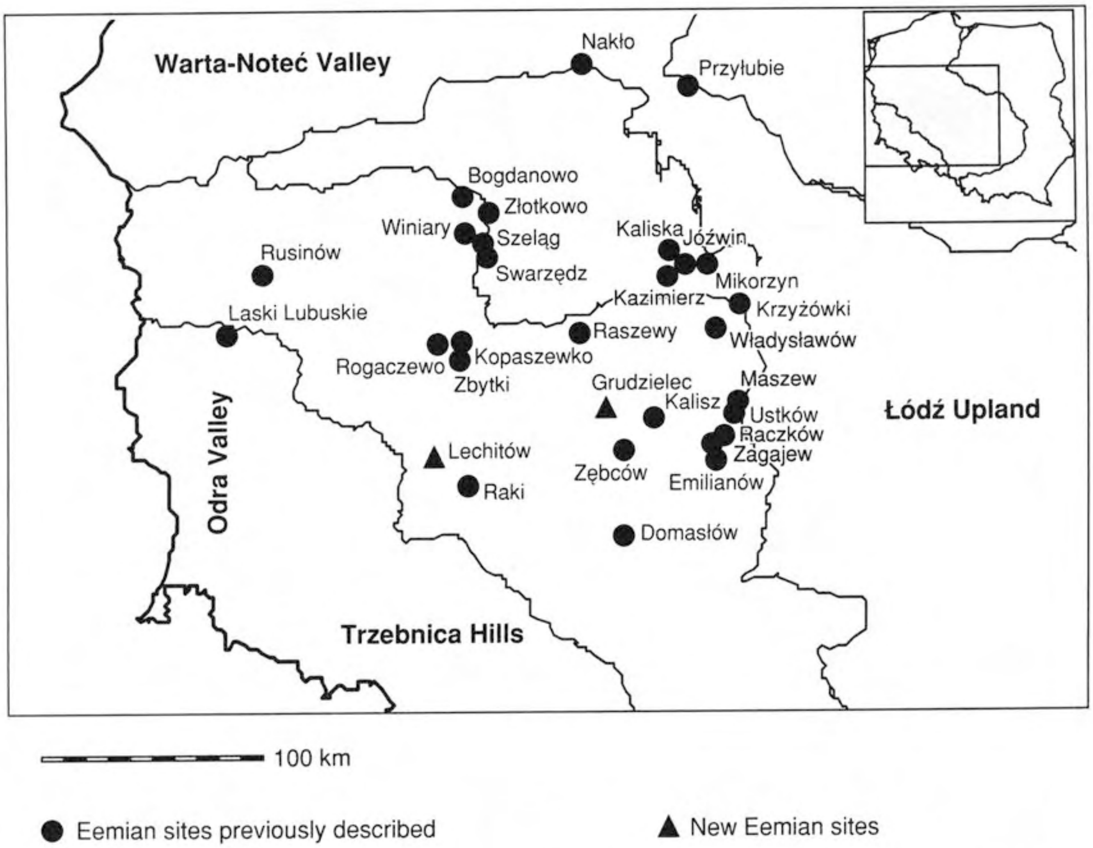


Fig. 1. Location of the Lechitów and Grudzielec in relation to other Eemian Interglacial sites in the Great Polish Lowland.

scribed so far in Poland. The 30 localities of the Eemian floras are situated within the Great Polish Lowland (Fig. 1, Table 1). The floras of middle and northern Great Poland have been relatively well studied (Środoń 1956; Janczyk-Kopikowa 1965, 1972; Noryśkiewicz 1978, 1999; Winter 1994; Kuszell 1997; Tobolski 1991; Stankowski et al. 1999), whereas the data from its southern part are scarce. Only a profile from Kalisz (Tołpa 1952) has a complete palaeobotanical documentation. Two other sites: Zębców (Borówko-Dłużakowa 1978) and the near Domasłów (Rotnicki and Tobolski 1965) have been described in the form of expertises, whilst a profile from Raki near Żmigród (Kuszell 1980) represents only an older part of the interglacial. The sites presented in this paper are situated in the southern Great Polish Lowland. The results extend the current knowledge on the history of vegetation of the Eemian Interglacial in this part of Great Poland.

Position of the studied localities

Lechitów is situated ca. 20 km west of Rawicz, in the Głogów Proglacial Stream Valley (Fig. 1). The geology and geomorphology of this locality has been included in a sheet description by Wąsosz (Chachaj1994). The subject of pollen analysis was a section of sediments between 28.00 and 49.75 m a.s.l. The detailed description of the lithological profile has been presented by Malkiewicz (1998).

Grudzielec is situated ca. 27 km west of Kalisz, on Kalisz Plateau, and ca. 80 km north-east of Lechitów along a straight line (Fig. 1). The studied profile comprises 3.45 m thick peats and loams at the depth of 2.55-6.00 m a.s.l.

The sediments were deposited in a small hollow situated in a deep subglacial channel.

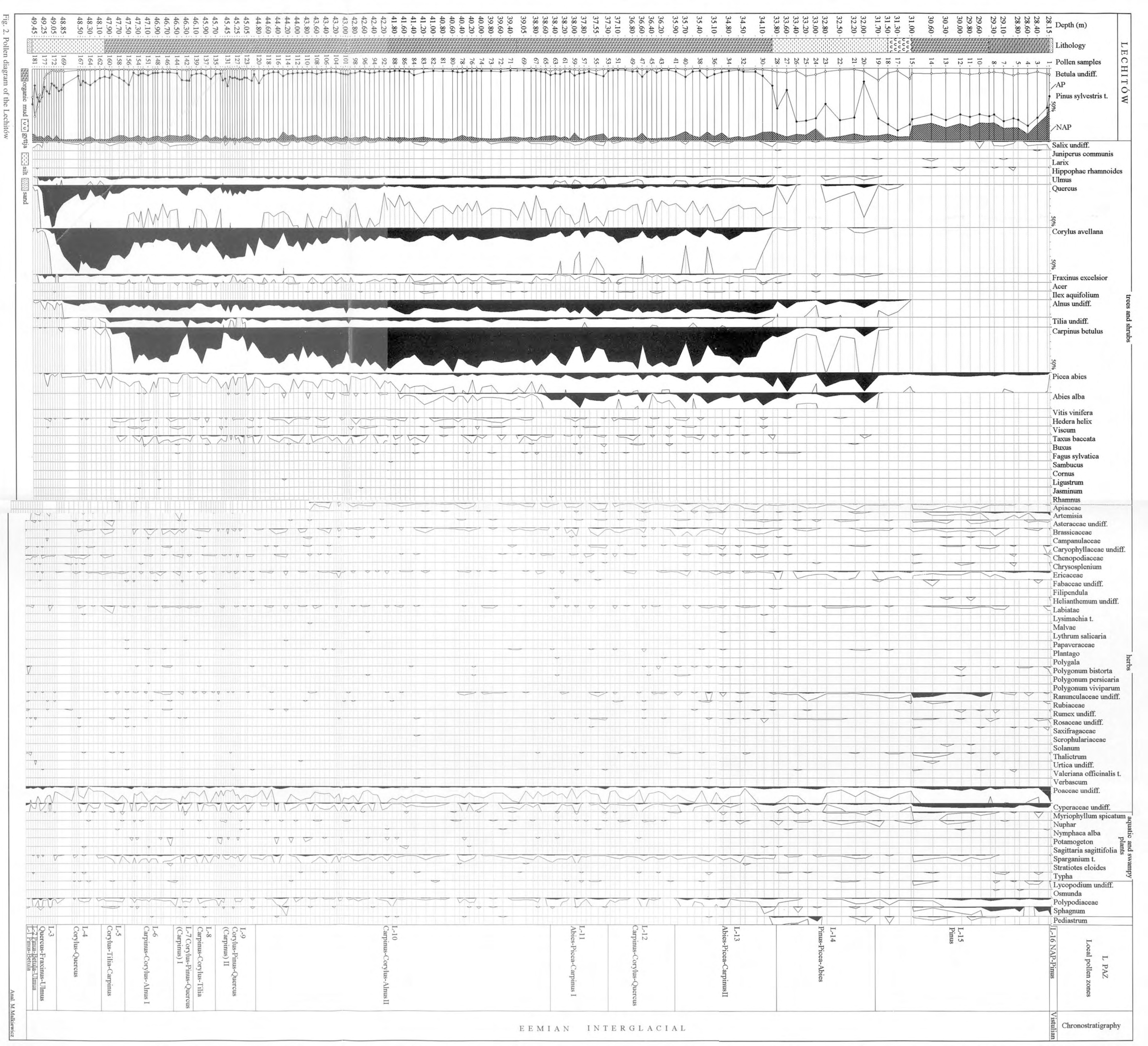
MATERIAL AND METHODS

In the course of this study a total of 249 samples were subjected to palynological examination (186 samples from Lechitów and 63 from Grudzielec). The samples of a volume of ca. 10 cm^3 were collected from borehole cores at every 10 (Lechitów) or 5 cm (Grudzielec).

Methods of preparation of the material for the pollen analysis depended on the type of sediments in the particular samples. Peat deposits were boiled in KOH, while samples with considerable content of mineral material, such as loams and silty deposits, were treated with concentrated hydrofluoric acid for 24 hours. Subsequently the material was macerated using the Erdtman's acetolysis (1952). Sporomorphs were identified and counted using a light microscope. For identification of pollen grains and spores papers by Erdtman et al. (1961), Moore et al. (1991), Reille (1992, 1995) were used, as well as the data from The Palynological Card Index of Polish Plants (Sadowska et al. 1994-2001). Pollen spectra were counted on at least two slides; only in samples with low concentration of sporomorphs 3-4 slides were examined. In all analysed samples sporomorphs were well preserved and did not contain any damaged or unidentifiable grains. Likewise, the samples did not contain Tertiary taxa. On average a total of 600--1000 sporomorphs was found in each sample.

The results of pollen analysis are presented in two percentage pollen diagrams (Figs 2, 3). The calculations for the Lechitów profile are based on the total of 100% (AP + + NAP), which include trees, shrubs and dwarf shrubs (AP), herbaceous plants (NAP) together with aquatic, marshy and spore plants. As in material from Grudzielec Polypo-

Fig. 2. Pollen diagram of the Lechitów



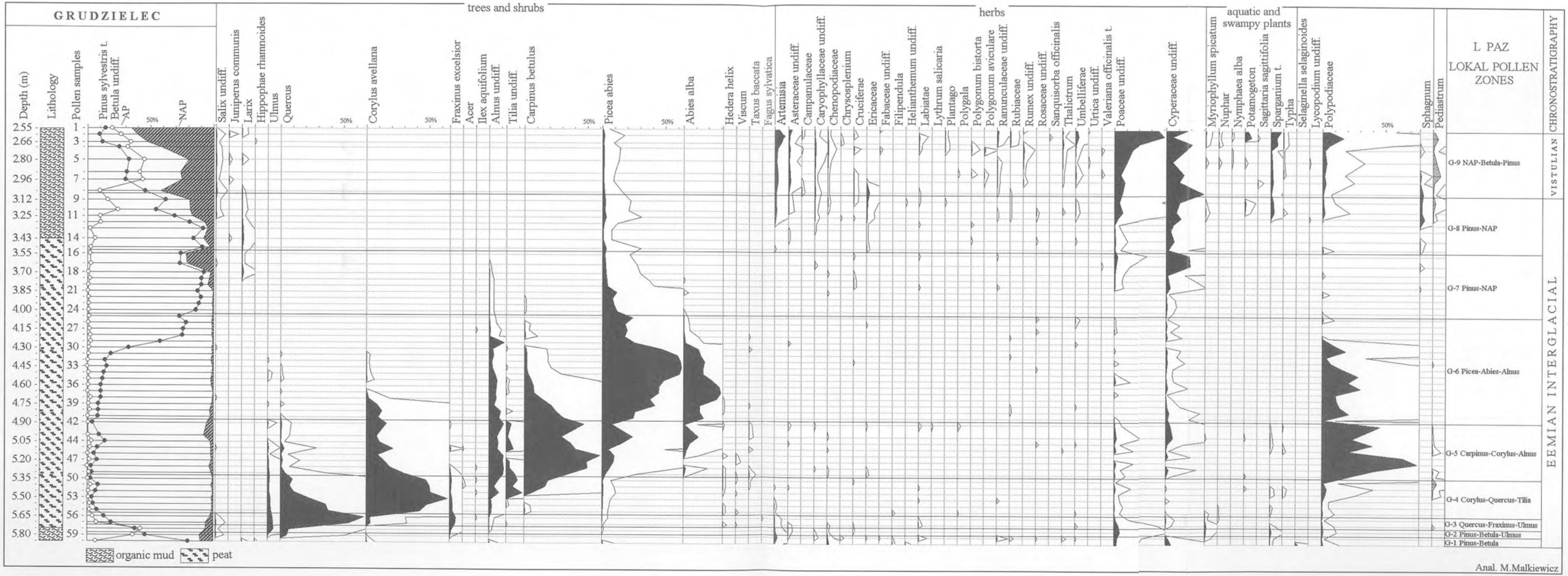


Fig. 3. Pollen diagram of the Grudzielec

TABLE 1. List of sites of the Eemian Interglacial floras in the Great Polish Lowland.

	Locality	Author and year
1	Szeląg	Środoń 1956
2	Rusinów	Stark et al. 1932
3	Winiary	Gołąb and Urbański 1938; pollen analysis Bąkowski
4	Kalisz	Tołpa 1952
5	Kaliska	Janczyk-Kopikowa 1965
6◆	Domasłów	Rotnicki, Tobolski 1965
7	Laski Lubuskie	Janczyk-Kopikowa 1972; Skompski 1975
8	Przyłubie	Klatkowa 1990
9◆	Raszewy near Żerków	Rotnicki 1975; pollen analysis Tobolski
10	Raki near Żmigród	Kuszell 1980
11◆	Swarzędz	Kunkel and Tobolski 1977
12◆	Zębców	Borówko-Dłużakowa 1978
13	Nakło on the River Noteć	Noryśkiewicz 1978
14	Józwin/84/76	Tobolski 1991
15	Kazimierz	Tobolski 1991
16	Władysławów	Tobolski 1986, 1991
17	Raczków	Załoba and Jastrzębska-Mamełka 1990a
18	Zagajew	Załoba and Jastrzębska-Mamełka 1990b
19	Maszew	Klatkowa 1990
20	Ustków	Klatkowa and Załoba 1991
21	Emilianów	Klatkowa and Załoba 1991
22	Zbytki 1, 2	Kuszell 1997
23	Kopaszewko	Kuszell 1997
24	Rogaczewo	Kuszell 1997
25	Złotkowo	Winter 1994
26	Bogdanowo	Winter 1994
27	Krzyżówki	Noryśkiewicz 1999
28	Mikorzyn	Stankowski, Bluszcz and Nita 1999
29	Lechitów	Malkiewicz 1998, this paper
30	Grudzielec	This paper

(◆ palynological expertise)

diaceae were over-represented; water, swamp and spore plants were excluded from the basic sum. The ratio of trees, shrubs and dwarf shrubs to herbaceous plants is shown in pollen diagrams. Subsequently, curves for all the identified taxa are drawn. In each diagram local pollen assemblage zones are distinguished. They are numbered from the bottom towards the top of the profile, and marked with the first letter of the locality name.

Deposits from Grudzielec were additionally subjected to macroscopic examination. The material of the volume 50--100 cm^3 was derived from the same core, from which samples for pollen analysis were collected. Sediments of the particular samples were kept in water for 48 hours, then boiled with 10% KOH. Afterwards, the material was washed using double 0.5 mm and 0.1 mm mesh sieves. Both fractions of the material were searched under binocular microscope for plant macroremains, which were subsequently identified using keys and detailed carpological papers (Nilsson and Hjelmqvist 1967 and others).

RESULTS AND DISCUSSION

History of terrestrial vegetation

Although both localities differ in terms of sediment thickness (small at Grudzielec, and over 21 m at Lechitów), both diagrams represent the complete pollen succession of the Eemian, including protocratic, mesocratic and telocratic phases (Iversen 1958; Dzięciołowski and Tobolski 1982; Birks 1986). It is characterised by the development of forest communities, starting from boreal pine and pine-birch forest, through deciduous forest, where trees and shrubs spread in the following order: *Ulmus*, *Quercus-Fraxinus*, *Corylus*, *Alnus*, *Tilia*, *Taxus* and *Carpinus* (Fig. 4). The characteristic trait of the section of thermophilous deciduous forest are also the very high values of *Corylus*, reaching 65.0% at Grudzielec and 63.0% at Lechitów. The younger part of the interglacial is characterised by coniferous forest with *Picea* and *Abies*, followed by re-spread of *Pinus* in its final part. These features enable the correlation between the studied interglacial sediments and the Eemian deposits from the classic locality at the River Eem near Amersfoort in Holland (Zagwijn 1961) and numerous Polish sites of this age (Niklewski 1968; Noryśkiewicz 1978; Kuszell 1980, 1997; Krupiński 1988; Mamakowa 1988, 1989; Tobolski 1991).

In the obtained diagrams, local pollen assemblage zones are distinguished. The diagram from Lechitów comprises 16 local zones, whereas the Grudzielec diagram – 9 zones. The local zones have been correlated with the regional pollen zones of the Eemian Interglacial distinguished for Poland (Mamakowa 1989) and for the Konin region (Tobolski 1991) (Table 2).

The protocratic phase is represented by pollen spectra from regional pollen zones E1 and E2 (Mamakowa 1989).

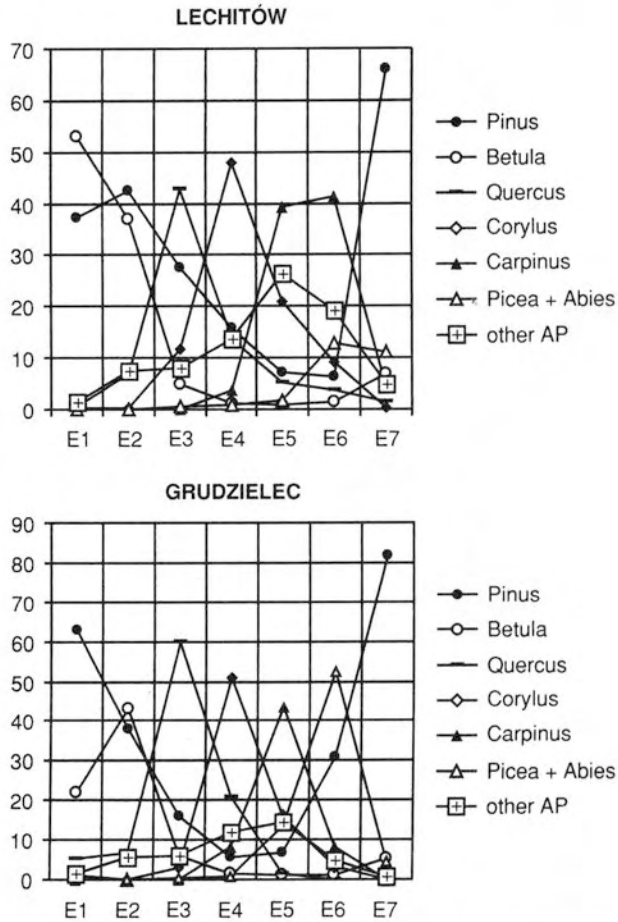


Fig. 4. Average percentages of trees in the pollen zones of Eemian Interglacial in investigated localites.

TABLE 2. Table of correlation of local pollen asemblage zones at investigated localities with biostratigraphy elaborated for Poland and the Konin Region.

R PAZ	Poland Mamakowa 1988, 1989	Konin Region Tobolski 1991	L PAZ		Phases Iversen 1958
			Grudzielec	Lechitów	
V 1	Gramineae–Artemisia–Betula nana	Artemisia–NAP	G-9 NAP–Betula–Pinus	L-16 NAP–Pinus	cryocratic
E 7	Pinus	Pinus	G-8 Pinus–NAP G-7 Pinus–Picea	L-15 Pinus L-14 Pinus–Picea–Abies	telocratic
E 6	Picea–Abies–Alnus	Picea–Abies	G-6 Picea–Abies–Alnus	L-13 Abies–Picea–Carpinus II L-12 Carpinus–Corylus–Quercus L-11 Abies–Picea–Carpinus I	
E 5	Carpinus–Corylus–Alnus	Carpinus	G-5 Carpinus–Corylus–Alnus	L-10 Carpinus–Corylus–Alnus II L-9 Corylus–Pinus–Quercus (Carpinus) II L-8 Carpinus–Corylus–Tilia L-7 Corylus–Pinus–Quercus (Carpinus) I L-6 Carpinus–Corylus–Alnus I	mesocratic
E 4	Corylus–Quercus–Tilia	Corylus	G-4 Corylus–Quercus–Tilia	L-5 Corylus–Tilia–Carpinus L-4 Corylus–Quercus	
E 3	Quercus–Fraxinus–Ulmus	Quercus	G-3 Quercus–Fraxinus–Ulmus	L-3 Quercus–Fraxinus–Ulmus	
E 2	Pinus–Betula–Ulmus	Pinus–Betula	G-2 Pinus–Betula–Ulmus	L-2 Pinus–Betula–Ulmus	protocratic
E 1	Pinus–Betula	Betula	G-1 Pinus–Betula	L-1 Pinus–Betula	

In southern Great Poland its initial part (zone E1) is characterised by the dominance of pine-birch and birch-pine forest (Figs 2, 3). These communities were dispersed in various habitats, from poor sandy and outwash areas to richer habitats in river valleys. The continuous curves of *Salix* and *Alnus* may suggest the development of willow thickets associated with the close vicinity of a river or a stream, similar to the present-day *Salici-Populetum* (R. Tx. 1931) Meijer Drees 1936, or *Salicetum pentandro-cinerae* (Almq. 1929) Pass. 1961. The relatively low percentage of *Alnus* may indicate that the alder probably did not form forest communities, such as alder carrs or riverside carrs. It most likely occurred only as an admixture in willow communities.

Pollen grains of *Salix*, *Hippophaë rhamnoides* and spores of *Selaginella selaginoides*, found in the oldest part of this zone in Grudzielec, confirm the occurrence of shrub communities. The proportion of herbaceous plants, which does not exceed 10.6% in this zone, indicates the small importance of herb communities, which occurred mainly in open and sun-lit areas with low density of forest stands.

In the younger part of the protocratic phase (zone E2) the pine invaded all accessible habitats. On poor sandy soils it formed pine forest with the admixture of birch, which probably resembled the present-day fresh pine forest *Vaccinio myrtilli-Pinetum* Kobendza 1930. On richer soils, pine forest appeared with biger proportion of oak and birch, and the admixture of hazel in the undergrowth. Also communities of humid and fertile habitats and riparian forest were of greater importance. The maximum share of *Ulmus* and the higher curve of *Fraxinus* indicate the development of communities resembling elm-ash riveside carrs, probably in type of the present-day *Fraxino-Ulmetum campestris* association (R. Tx. Ap. Lohm. 1952) Oberd. 1955. The dominant trees of these forest were elm and ash, with some admixture of alder and spruce. The continuous presence of *Salix* pollen, and the occurrence of *Alnus* suggest that in wetter habitats, in the vicinity of a lake or in river valleys, willow and alder thickets were possibly present.

The zone E2 is characterised by the absolute though low-percentage curve of elm (Mamakowa 1989). In the Grudzielec profile the culmination of *Ulmus* (4.7%) occurs at the end of the protocratic phase, whereas at Lechitów maximum values of *Ulmus* (6.3%) appear at the beginning of mesocratic phase, before the highest values of oak. The absolute culmination of *Ulmus* in the Eemian Interglacial could occur much later, even in the middle section of this interglacial (zone E5). This phenomenon was recorded in several profiles of Great Poland, such as Zbytki 2 (Kuszell 1997), Kalisz (Tołpa 1952) and Jóźwin 84 (Tobolski 1991), as well as in other parts of Poland (Krupiński 1992; Klatkowa 1990; Klatkowa and Balwierz 1990; Klatkowa and Winter 1990 and others). A maximum proportion of the elm in forest communities of various sections of the mesocratic phase has been observed also in some profiles from Germany (Seifert 1990; Litt 1994). In both the present profiles the content of elm was the highest, as compared with the values found in other localities of Great Poland, where they range from 1.8 to 4.0% (Tołpa 1952; Mamakowa 1989) (Fig. 5). The proportion of *Ulmus* at Grudzielec is similar to that found at Kalisz (4.0%) (Tołpa 1952) and Imbramowice (Mamakowa 1989). The Lechitów profile is the first Eemian locality in the Great Polish Lowland, where the elm values exceed 6.0%. High percentage values of *Ulmus* at Imbramowice, compared with other sites of Poland, have been explained by the south-western migration of this taxon (Mamakowa 1989). Such a large share of the elm at Lechitów, as well as the substantial proportions of this tree at Jaworzyna Śląska (3.0%) and Wołów (3.2%) (Kuszell 1980) support the probable direction of migration of the elm from the south-west.

At the beginning of the mesocratic phase (zone E3) the pine-birch forest was still quite important in forest commu-

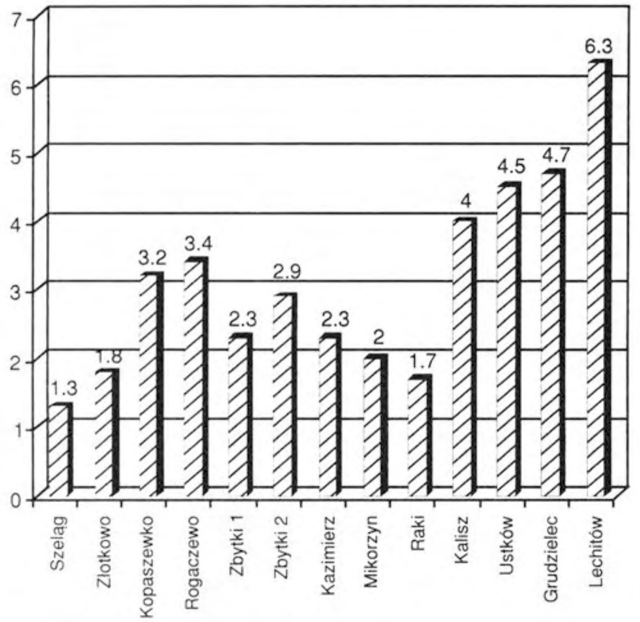


Fig. 5. Maximum pollen values of *Ulmus* in Eemian sites in the Great Polish Lowland.

nities. This is especially clear in the diagram from Lechitów. At Grudzielec we observe a rapid development of mixed and oak forest (Fig. 3). Pine-oak forest of the Eemian resembled most likely the modern forest communities of the alliance *Pino-Quercion*, or communities similar to the present-day *Pino-Quercetum* Kozłowska 1925 em. Matuszkiewicz et Polakowska 1955. Apart from main components of this forest, birch and lime were also relatively frequent. Hazel was the dominant species of the shrub-layer. Forest communities of that time were comparatively light with Ericaceae and Poaceae spreading in their herb layer. Maximum shares of *Quercus* suggest the development of forest similar to the present-day light oak forest *Potentillo-Quercetum* (Libbert 1933) Knapp 1942, that occurred only in south-exposed areas. They most likely covered southern slopes of moraine hills. Such communities were dominated by oak, with some admixture of pine. In this forest, like in mixed coniferous forest, tree crowns were faintly dense, which allowed the development of the undergrowth and herb layer. The dominant of the shrub layer was hazel, sometimes accompanied by birch. The southern exposure of oak forest communities enabled the development of more thermophilous plants, such as *Ilex aquifolium*, *Hedera helix* or *Viscum alba*.

The maximum percentage values of *Fraxinus* and *Ulmus* suggest that communities of riverside forest played still an important role in the vegetation cover of the studied area. An increase in the ash values could be associated not only with the development of communities resembling the present-day elm-ash riverside carrs, but also the association *Carici remotae-Fraxinetum* Koch 1926, whose present localities are reported from the Great Polish Lowland. Besides, *Ulmus* and *Fraxinus*, *Alnus*, *Salix* and *Hedera* could occur in this forest. In moist habitats, near rivers and around the studied sedimentation basins alder thickets with some admixture of the spruce developed.

An absolute culmination of *Corylus* in the middle part of the mesocratic phase (zone E4) indicates that in this time this shrub was most widespread. The period is characterised by an intensive development of thermophilous deciduous forest. Undoubtedly, a part of hazel pollen comes from the undergrowth of oak-pine forest. As oak forest are light, and their leaves develop in late spring, the hazel had favourable conditions for flowering and dispersal in these communities. However, such high contents of hazel pollen in the climatic optimum of the Eemian were probably associated with the development of distinct hazel thickets or even forest. According to Mamakowa (1989) they could resemble the present-day association *Peucedo cervariae-Coryletum* Kozł. 1925 em. Medw.-Korn. 1952, though at present is of a relic character due to excessive damage by man. The contemporary hazel communities could have ideal conditions for their development in dry and warm habitats facing south. The important components of these communities, besides the dominating hazel, were probably oak, elm, hornbeam and pine. They most likely had the form of shrubs (like in modern warm thickets of *Peucedano cervariae-Coryletum*).

Apart from communities that had already existed, the formation of new multispecies deciduous forest and mixed forest developed. Predominating were hornbeam-lime and oak-hornbeam communities characterized by a large share of *Tilia* and the increasing role of *Carpinus*. A new species, *Taxus baccata*, appeared in forest communities. Due to its wide ecological tolerance it occurred probably as a shrub, displacing the hazel from the undergrowth, or a tree. However, *Taxus* did not play an important role in forest communities of southern Great Poland. The shares of *Taxus* in the studied profiles are low and range 0.6-0.1%. Similarly its values were found in other localities of the Great Polish Lowland (Środoń 1956; Borówko-Dłużakowa 1978; Tobolski 1991; Klatkowa and Załoba 1991; Kuszell 1997). *Taxus* was specially abundant at sites of Lower Silesia: Imbramowice – 11.8% (Mamakowa 1989), Jaworzyna Śląska 1.1%, Wołów – 4.6%, and Zofiówka – 7.8% (Kuszell 1980, 1997). High percentage values of the yew in south-western Poland correspond with the content of this species in West-European localities, e.g. in Lower Lusatia (Erd 1973) and north-western Germany (Behre 1962, 1970; Menke 1967; Müller 1974). Yew came most probably to south-western Poland from the west of Europe. Climatic conditions at this new site turned out to be the most favourable for its development (Mamakowa 1989).

The profiles from Grudzielec and Lechitów represent the so-called „late lime" sites, included to variant A by Mamakowa (1989). They are characterised by a maximum share of lime coming after the culmination of *Corylus* and before the highest values of *Carpinus* (Figs 2, 3). Maximum values of lime in both the studied profiles are similar, and amount to 12.5% and 13.5% at Grudzielec and Lechitów, respectively. Even values as high as 5-8% indicate the large importance of the species in communities of deciduous forest (Mamakowa 1989). The examination of the Eemian pollen diagrams from Great Poland (Tołpa 1952; Tobolski 1991; Kuszell 1997) and south-western Poland (Kuszell 1997; Mamakowa 1989) reveals the average values of lime ranging 5-10%. The distribution of profiles, in which features of „early lime" and „late lime" could be distinguished, suggests the geographical variability of this zone (Mamakowa 1989). Characteristics of „late lime" occur most often in diagrams from localities of western and south-western Poland. Similar features are typical of most German profiles (Erd 1973; Seifert 1990; Litt 1994). In the undergrowth of various types of communities of deciduous forest, *Hedera*, *Viscum* and *Ilex* were also common.

An increase in the share of *Alnus* and the permanent ocurrence of *Ulmus* and *Fraxinus* may indicate that besides the existing riverside elm-ash carrs in the type of *Fraxino-Ulmetum campestris* (R. Tx. Ap. Lohm. 1952) Oberd. 1955 and riverside ash carrs similar to *Carici remotae-Fraxinetum* Koch 1926, ash-alder forest appeared. It might resemble the present-day *Circaeo-Alnetum* Oberd. 1953. Most likely these communities invaded the habitats of riverside elm-ash carrs, or shallow and drying out peripheral parts of the lake. On the other hand, peatbog and swampy areas overgrown by alder carr communities, may be similar to the present association *Carici elongatae-Alnetum* (Koch 1926) R. Tx. et Bodeaux 1955. The dominants of these communities were alder, with the admixture of ash, birch and spruce.

The terminal section of the mesocratic phase (zone E5) represents a strong expansion of *Carpinus betulus*, a tree species of a wide edaphic tolerance. This resulted in the reconstruction of the existing forest communities. Mixed oak forest, sometimes with a considerable admixture of *Carpinus*, still occurred, though their distribution was probably strongly limited. Likewise, the hazel communities were still present. However, the most widespread type of community became dry-ground forest. The present-day hornbeam forest belong to climax communities occurring in a wide range of habitats, on different soil types (in terms of fertility), and in various water conditions. They form numerous subcommunities, variants and facies. Also in the Eemian Interglacial dry-ground forest could develop, the physionomy of which depended on habitat conditions. On relatively dry, mesotrophic substrata dry-ground forest occurred, of which the main components, apart from the hornbeam, were probably oak and pine. Lime and maple could appear in smaller quantities. On fresh eutrophic soils communities of typical dry-ground forest were present. In thise forest, hornbeam was accompanied by numerous deciduous trees, such as oak, lime, maple, elm, ash. On moist, fertile soils another type of dry-ground forest developed, similar to riverside carrs, with alder, elm and ash as dominants. The main component of the undergrowth of all the mentioned dry-ground types of forest was hazel, though *Hedera*, *Viscum*, *Ilex*, *Buxus*, *Vitis* and *Taxus* were also present. In phytosociological aspect, dry-ground forest of the Eemian of Great Poland was probably similar to *Galio-Carpinetum* Oberd. 1957, and *Tilio-Carpinetum* Traczyk 1962, the two associations of dry-ground forest occurring nowadays in Poland. Although the distribution of the latter community is at present limited to areas east of the Lower Vistula River and the line Konin–Krotoszyn–Wrocław, it could have been much more widespread in Eemian in the eastern part of Great Poland. The Eemian dry-ground forest near Lechitów were probably similar to *Galio-Carpinetum*, the present-day type of dry-ground forest occurring in western Poland. This hypothesis may be supported by the presence of pollen grains of *Galium* (Rubiaceae). *Galium sylvaticum* is one of the characteristic species of the association *Galio-Carpinetum*.

A new component of dry-ground stands in the studied area was the beech. At Grudzielec only one pollen grain of *Fagus sylvaticus* was found, while at Lechitów as many as 23. In central and northern Europe, *Fagus sylvaticus* is considered a characteristic tree of the Holocene, whereas in the interglacial sediments it is rare, and only single pollen grains of this species are found (Środoń 1984, 1985). In Poland *Fagus* has been reported from 26 sites of the Eemian Interglacial (Kuszell 1997). Considering the whole number of Polish localities of the Eemian (around 160), it seems that this genus did not play an important role in forest communities of that time. Frenzel (1968) suggested that *Fagus* could survive the South and Middle Polish glaciations in mountain refuges of the Near East. The distance between the refuges of this tree and the Central European mountain ranges was to long, and the time of the Masovian and Eemian Interglacials too short for tree to became widespread in the forest of the Eemian Europe.

The communities of wetlands and swampy habitats were still of great importance, especially in the vicinity of Lechitów. Apart from the riverside elm-ash and ash carrs also alder carrs appeared, probably in type of the modern *Carici elongatae-Alnetum* (Koch 1926) R. Tx. et Bodeaux 1955.

The telocratic phase (zones E6 and E7) is characterised by a large share of conifers. Apart from still existing communities of dry-ground forest, communities of coniferous forest became more widespread. At the beginning the dominant species was *Abies alba* accompanied by pine and spruce. In poorer habitats most probably forest with *Picea* was more common. However, the subsequent expansion of the pine led to its dominance in coniferous stands, and to the disappearance of taxa of higher thermal requirements. Maximum values of *Abies alba* at Lechitów amount to 17.5%, and correspond with the numbers found in localities closer to the Sudety Mountains, such as Jaworzyna Śląska, Wołów and Kubryk (Kuszell 1980, 1997). The fir values at Grudzielec reach 30%, like in Kalisz (Tołpa 1952) and Ustków (Klatkowa and Załoba 1991). The present geographical distribution of *Abies alba* is restricted to submontane areas and uplands of southern Poland, with the centre in the Carpathians. Forest with the fir may be encountered also in the South Polish Upland and Roztocze. In the Eemian Interglacial communities with fir forest may have been much more widespread, as compared to their present distribution.

The high values of *Alnus* suggest that swampy alder forest of *Carici elongatae-Alnetum* type, with a relatively large share of the spruce, was still important. The continuous presence of *Ulmus* and *Fraxinus* may be associated with the riverside elm-ash and ash carrs. However, they occurred only in the vicinity of Lechitów, probably in the Barycz Valley.

In the terminal section of the Eemian Interglacial (zone E7), in areas surrounding the studied localities, pine forest with some admixture of birch started to dominate. At Grudzielec it comprised also the larch.

The expansion of pine forest and the recession of other forest communities was accompanied by the occurrence of various communities of open habitats. The presence of *Salix*, *Juniperus* and *Hippophaë* indicates the formation of shrub communities, whereas the Chenopodiaceae, *Artemisia*, *Rumex acetosella*, *Helianthemum* and Caryophyllaceae – the development of steppe-like and grassland communities.

Profiles representing a complete pollen succession of the Eemian Interglacial only rarely include sediments of the

Early Vistulian. Within Great Polish Lowland deposits of the Early Vistulian were recorded only at 9 sites: Kalisz (Tołpa 1952); Kaliska (Janczyk-Kopikowa 1965); Raki (Kuszell 1980); Jóźwin 84 and 76, Kazimierz and Władysławów (Tobolski 1991), Ustków (Klatkowa and Załoba 1991) and Mikorzyn (Stankowski et al. 1999). Profiles from Grudzielec and Lechitów make this list longer.

The Early Vistulian in the Lechitów profile is represented by only one sample, which indicates the decrease in *Pinus* content (below 40%), and the increase in NAP values to over 50%. From among other trees, only *Betula* and *Picea* survived, although their shares are very low. Such a pollen picture suggests that pine forest was very sparse or occurred only in patches, with sporadically occurring birch trees. The presence of *Salix* and *Hippophaë* in this sample could indicate the formation of shrub communities (Fig. 2). A rise in values of Poaceae and *Artemisia*, as well as the presence of Caryophyllaceae, Chenopodiaceae and *Helianthemum* could suggest the increasing role of xeromorphic communities.

In the Grudzielec profile sediments of the Early Vistulian were found at the depth of 3.12-2.55 m. They represent an open birch forest or its patches with admixture of pine and larch. The importance of larch increases in the upper part of the zone. Open areas were covered by the vegetation of shrub tundra with willows and probably shrub birches, juniper, sea buckthorn and grasses (Fig. 3). It seems that xeromorphic communities were also widespread, especially in the younger part of this period, as evidenced by the increasing share of *Artemisia*. Like at Lechitów, *Picea*, that survived the Eemian Interglacial, is present in small quantities. An increasing importance of wet, peaty meadows may be concluded from the high values of Cyperaceae, continuous though low values of *Sphagnum* and the presence of *Ranunculus*, *Rumex acetosella* type, *Polygonum bistorta*, *Sanquisorba officinalis* or *Plantago media* type. The frequent occurence of Apiaceae, Asteraceae, Chenopodiaceae and Brassicaceae probably indicates the important role of nitrophilous communities.

From among the mentioned sites of the Early Vistulian, found in the area of Great Polish Lowland, only Kalisz II (Tołpa 1952; Mamakowa 1989) and Ustków (Klatkowa and Załoba 1991) have the vegetation picture similar to that found at Grudzielec. Other sites, like the neighbouring Władysławów, Kazimierz and Jóźwin, represent the steppe vegetation with conspicuous continental features (Tobolski 1991). In the profile from Mikorzyn (Stankowski et al. 1999) another important component of plant communities was the pine. A different composition of vegetation communities has also the first pollen zone of the Early Vistulian from Zgierz-Rudunki (Jastrzębska-Mamełka 1985). It represents shrub tundra with an important share of juniper, dwarf birch and shrub willows. The vegetation picture of the Early Vistulian found in the Lechitów profile can be compared only with Imbramowice (Mamakowa 1989), where open pine forest, or its patches, with rare tree birches and the larch occurred.

Characteristics of aquatic and marsh vegetation

To obtain a more detailed information on the vegetation and palaeoecological conditions of the studied water bodies, the analysis of plant macroremains was applied (Table 3).

Since the beginning of the interglacial (zone E1) till the middle part of the mesocratic phase (zone E4) quiet and warm lakes of a considerable depth occurred at the studied sites. In their deeper parts several plant taxa, such as *Myriophyllum spicatum*, *Nuphar*, *Potamogeton*, *Ceratophyllum demersum* and *Najas sp.* occurred, whereas in shallower places *Nymphaea alba* was present. The margins of lakes were covered by communities of rushes with *Sparganium*, *Typha latifolia*, Poaceae, *Carex rostrata*, *Carex fusca* and other sedges.

The spore-pollen picture of the upper part of the mesocratic (zone E5) and telocratic phases (zones E6 and E7) indicates that the sedimentation basin became shallow and partly overgrown. At Grudzielec large quantities of Polypodiaceae s.l. (over 70%), numerous fragments of brown mosses of the genus *Drepanocladus* and fruits of *Carex sp.* were found. *Dryopteris thelypteris* could be a representative of ferns. The genus, like *Drepanocladus*, occurs in abundance on marshy and peatbog lake margins, and its thick floating mats impede the development of water vegetation. The scarcity of other aquatic plants in the studied samples indicates that the Grudzielec lake basin was of similar edaphic conditions. Apart from single pollen grains of *Myriophyllum spicatum* and *Potamogeton*, which could survive in small water bodies, no other taxa of aquatic plants have been found. The abundance of ferns made also difficult the development of reed swamps and other lakeside communities. At Lechitów the process of shallowing of the lake was much slower. The presence of aquatic plants, such as *Myriophyllum*, *Nuphar*, *Potamogeton* or *Saggittaria* indicates a considerable depth of the basin, at least in its central part. However, marginal parts of the basin were overgrowing intensely, as suggested by the presence of *Stratiotes eloides*, *Nymphaea alba*, *Sparganium*, *Typha latifolia*, numerous sedges and ferns.

Estimation of palaeoclimatical conditions of the Eemian Interglacial

The presented palaeobotanical material not only provides the information on plant cover, but also enables the estima-

TABLE 3. Plant macroremains in the Grudzielec profile (F – fruit, L – leaf).

Number of samples		1	2	3	4	5	6	7	8
Depth (m)		5,85-5,75	5.60-5,50	5,30-5,15	4,85-4,65	4,60-4,30	4,25-4,00	3,95-3,70	3,65-3,45
Ceratophyllum demersum	F	5	2	–	–	–	–	–	–
Najas sp.	F	2	–	–	–	–	–	–	–
Carex fusca	F	2	–	–	–	–	–	–	–
Carex rostrata	F	2	2	3	–	–	2	–	–
Carex sp.	F	–	–	2	–	–	–	–	–
Betula sp.	F	–	–	–	–	–	–	6	–
Drepanocladus	L	–	–	1	7	6	13	3	8

tion of palaeoclimatic changes. Alterations of climatic conditions have an overwhelming impact on physico-geographical conditions, and hence the direction and rate of changes in the plant cover and animal world.

Numerous earlier palaeobotanical papers on the Eemian indicated that its climate was stable and oscillated from a cool one in its early part, through warm in its climatic optimum, to become again boreal at the decline of the Interglacial (Frenzel 1968; Mamakowa 1989; Mojski 1993; Taylor et al. 1993; Litt et al. 1996; Kuszell 1997 and others). In recent years the climate of the Eemian has been a subject of vigorous debate, which produced numerous palaeoecological and palaeogeographical papers discussing the instability of the climate of this last warm section of Pleistocene (Anklin et al. 1993; Field et al. 1994; Thouveny et al. 1994; Seidenkrantz et al. 1995; Kukla, Mc Manus et al. 1997; Cheddadi et al. 1998).

The obtained palaeobotanical material enables to draw conclusions on the climate of the Eemian Interglacial in the southern part of the Great Polish Lowland.

The early section of the protocratic phase is characterised by a cool and dry climate. The evidence for this comes from the high values of herbaceous plants, and the occurrence of xeromorphic communities with heliophytes. The subsequent improvement of climate was associated with a gradual expansion of deciduous trees. The presence of fruits of *Ceratophyllum demersum* and *Najas sp.* in the Grudzielec profile, and the occurrence of *Fraxinus* in forest communities of both the profiles indicate warm summers and mild winters (Tobolski 1991). The appearance of *Typha latifolia* enables the assessment of an average temperature of July at about 14-15°C for this part of the Eemian, while the presence of *Selaginella selaginoides* indicates that the mean temperature of July did not exceed 17°C (Tobolski 1991; Kuszell 1997).

In the mesocratic phase the climate was markedly warmer. This is suggested by the appearance of taxa with higher thermal requirements, such as: *Viscum*, *Hedera helix*, *Ilex aquifolium*, *Buxus*, *Vitis vinifera* and *Taxus baccata*. The presence of flowering *Hedera* is associated with fairly high summer temperatures and the temperature of the coldest month, not dropping below -1.5°C (Iversen 1944). The appearance of the *Viscum*, whose northern limit of continuous range is associated with the July isotherm of 17°C, suggests also that summer temperatures were high (Iversen 1944; Tobolski 1991). The presence of *Ilex aquifolium* and *Taxus baccata* indicates that winters could be even warmer than suggested by the presence of *Hedera helix* (Iversen 1944). The fruiting *Ilex aquifolium* in Rusinowo and Imbramowice allow to assume the average temperatures of January around 0°C in south-western Poland. Nowadays it does not occur in Polish natural forest communities. Its present distribution is associated with western, central and southern parts of Europe and the north of Africa. *Taxus baccata* develops best in a climate characterised by a high air humidity, mild winters and warm (not hot) summers. It is most abundant in central and western Europe, north Africa, Asia Minor and the Caucasus. In Poland the yew reaches its western distribution limit. *Taxus baccata* grows in single island-like localities, predominantly in the west and north of the country. It may be concluded that the climate of the Eemian in its climatic optimum was warm and oceanic. The average temperature of July could be 20-22°C, and in January exceeded 0°C. Also the rapid it expansion of the hazel indicates that the climate gradually became more oceanic (Zagwijn 1961; Mamakowa 1989; Tobolski 1991; Litt 1994; Kuszell 1997). In the last section of the mesocratic phase the climate was still warm and humid, similar to that in the interglacial optimum. The recorded *Hedera* and *Viscum* suggest high temperatures of the warmest and the coldest month (Iversen 1944). The appearance of *Ligustrum* and *Jasminum* in forest communities provides evidence for mild winters, as both genera are frost-sensitive. The continuous occurrence of *Taxus baccata* signals good habitat conditions and more pronounced oceanic influence. At Lechitów additionally the pollen of *Buxus* was found. *Buxus sempevirens* is classified as an atlantic-mediterranean species. At present the best conditions for the species development are in western and southern Europe, north-western Africa and Asia Minor. The species has limited habitat requirements, though it is sensitive to frost and extremely drought-resistant. *Buxus* pollen is rarely found in the Eemian sediments; in Poland it has been reported from 15 localities of the Eemian (Noryśkiewicz 1978; Krupiński 1978, 1986, 1988; Kuszell 1980, 1997; Dąbrowski et al. 1987; Janczyk-Kopikowa 1991; Granoszewski 1993; Krupiński and Morawski 1993; Malkiewicz 1998). The occurrence of *Buxus* and *Ilex aguifolium t.* in the Eemian Interglacial suggests that the climate of this period was warm, winters mild, and air humidity high.

The telocratic phase represents the Eemian section, when climate became cooler and moister. The spread of the fir and spruce in this time suggests the increased air humidity. According to Mamakowa (1989) the expansion of the spruce and fir reflects climatic conditions similar to those found at present in the lower sub-alpine forest zone. Only the survival of *Hedera helix* till the end of this period proves that mean temperatures of January did not fall below -4,0 – -5,0°C (Mamakowa 1989). The terminal part of the interglacial is characterised by a complete disappearance of trees and bushes with higher thermal requirements, the lack of indicator plants of a warm climate and widespread pine forest. All this allows to estimate the climate of this period of the Eemian as boreal.

ACKNOWLEDGEMENTS

The study was financed by the grant No. 2022/W/ ING/ 01-20 from the Institute of Geological Sciences, the University of Wrocław.

I would like to express my sincere gratitude to the supervisor of my doctoral thesis, Prof. Anna Sadowska for introducing me into palynology – a fascinating field of botany, as well as for her constant care and help during my work on the thesis.

Sincere thanks go also to Prof. Teresa Kuszell for all the information on the palynostratigraphy of Pleistocene. Her help and advice were essential in my learning of identification of sporomorphs.

I extend my thanks to Prof. Dariusz Krzyszkowski, who helped me to gather the latest data on the palaeoclimate of the Eemian Interglacial. In addition, my appreciation and thanks go to M.Sc. Jan Jeziorski for the access to the scientific data on geology and geomorphology of Kalisz neighberhood, and to Dr Klara Tomaszewska for her help and valuable remarks during identification of plant macroremnants from Grudzielec.

LITERATURE CITED

ANKLIN M., BARNOLA J.M., BEER J. et al. 1993. Climate instability during the last interglacial period recorded in the GRIP ice core. Nature. 364: 203-207.

BEHRE K. 1962. Pollen- und diatomeenanalytische untersuchungen an letztinterglazialen Kieselgurlagern der Lüneburger Heide (Schwindebeck und Grevenhof im oberen Luhetal). Flora. 152: 325-370.

BEHRE K. 1970. Die Flora des Helgolander Süsswasser- "Töcks", eines Eem-Interglazials unter der Nordsee. Flora. 159: 133--146.

BIRKS H.J.B. 1986. Late-Quaternary biotic changes in terrestial and lacustrine environments, with particular reference to North-West Europe. In: Handbook of Holocene palaeohydrology. Berguland B. (ed.). Chichester.

BORÓWKO-DŁUŻAKOWA Z. 1978. Ekspertyza palinologiczna 3 próbek z sondy 345 – profilu Zębców, ark. Krotoszyn (1:100 000) oraz 1 próbki z sondy 1066 – profilu Rososzyce, ark. Opatówek (1:100 000). Mat. Arch. Państw. Inst. Geol. Warszawa (in Polish).

CHACHAJ J. 1994. Objaśnienia do Szczegółowej Mapy Geologicznej Polski w skali 1:50 000, arkusz Wąsosz. Państw. Inst. Geol. Warszawa (in Polish).

CHEDDADI R., MAMAKOWA K., GUIOT J., DE BEAULIEU J.-L., REILLE M., ANDRIEU V., GRANOSZEWSKI W., PEYRON O. 1998. Was the climate of the Eemian stable? A quantitative climate reconstruction from seven European pollen records. Palaeography, Palaeoclimatology, Palaeoecology. 143: 73-85.

DĄBROWSKI S., DZIERŻEK J., KRUPIŃSKI K.M., LINDNER L., MARCINIAK B. 1987. On the occurrence of two series of interglacial sediments in the Piła section (Northern Poland). Bull. Pol. Acad. Earth Sc. 35 (4): 379-390.

DZIĘCIOŁOWSKI W., TOBOLSKI K. 1982. Czwartorzędowe cykle klimatyczno-ekologiczne a ewolucja gleb. (Quaternary climatic-ecologic cycles and the evolution of soils). Rocz. Gleb. 33: 201-211 (in Polish with English summary).

ERD K. 1973. Pollenanalytische Gliederung des Pleistozäns der Deutschen Demokratischen Republik. Geol. Wiss. 15 (3): 1087-1103.

ERDTMAN G. 1952. Pollen Morfology and Plant Taxonomy. Angiosperms (An Introduction Palynology. I). Uppsala, pp. 6--10.

ERDTMAN G., BERGLUND B., PRAGLOWSKI J. 1961. An introduction to a Scandinavian pollen flora. Grana Palynologica. An International Journal of Palynology, vol. II, nr. 3, Stockholm, pp. 1-94.

FIELD M. H., HUNTLEY B., MÜLLER H. 1994. Eemian climate fluctuations observed in a European pollen record. Nature 371: 779-783.

FRENZEL B. 1968. The Pleistocene vegetation of Northern Eurasia. Science 161: 637-649.

GOŁĄB J., URBAŃSKI J. 1938. Nowa odkrywka interglacjału na Winiarach koło Poznania. (Neuer Aufschluss des Interglazials in Winiary bei Poznań). Rocz. Tow. Geol. 12: 104-143 (in Polish with German summary).

GRANOSZEWSKI W. 1993. Results of palaeobotanical studies of interglacial sediments from Golasowice (Rybnik plateau, S. Poland). Acta Palaeobot. 33 (2): 295-303.

IVERSEN J. 1944. *Viscum*, *Hedera* and *Ilex* as climate indicators. Geol. Fören. Förhlandl. 66 (3): 463-483.

IVERSEN J. 1958. The bearing of glacial and interglacial epochs on the formation and extinction of plant taxa. Uppsala Universitets Arsskrift. 6: 210-215.

JANCZYK-KOPIKOWA Z. 1965. Flora interglacjału eemskiego w Kaliskiej koło Chodcza na Kujawach. (Eemian Interglacial flora at Kaliska near Chodecz in Kujawy). Biul. Inst. Geol. 187: 107-117 (in Polish with English summary).

JANCZYK-KOPIKOWA Z. 1972. Orzeczenie dotyczące próbki z miejscowości Laski, ark. Słubice. Centr. Arch. Państw. Inst. Geol. Warszawa.

JASTRZĘBSKA-MAMEŁKA M. 1985. Interglacjał eemski i wczesny vistulian w Zgierzu-Rudunkach na Wyżynie Łódzkiej. (The Eemian Interglacial and Early Vistulian at Zgierz-Rudunki in the Łódź Plateau). Acta Geogr. Lodz. 53: 1-75 (in Polish with English summary).

KLATKOWA H. 1990. Występowanie eemskich osadów organicznych i uwagi o paleomorfologii środkowej Polski u schyłku Warty i podczas Eemu. (The occurrence of the Eemian organic deposits and remarks on the paleomorphology of Central Poland at the Warthian decline and during the Eemian peroid). Acta Geogr. Lodz. 61: 1-7 (in Polish with English summary).

KLATKOWA H., BALWIERZ Z. 1990. Bezodpływowy zbiornik z florą eemską w Modlnej koło Łodzi. (A closed depression with the Eemian flora at Modlna near Łódź). Acta Geogr. Lodz. 61: 39-49 (in Polish with English summary).

KLATKOWA H., WINTER H. 1990. Interglacjał eemski w Ostrowie koło Grabicy. (The Eemian interglacial at Ostrów near Grabica). Acta Geogr. Lodz. 61: 59-68 (in Polish with English summary).

KLATKOWA H., ZAŁOBA M. 1991. Kształtowanie budowy geologicznej i rzeźby południowego obrzeżenia Basenu Uniejowskiego. (The formation of the geological stucture and relief of the southern margin of the Uniejów Basin) In: Przemiany środowiska geograficznego obszaru Konin-Turek. Stankowski W. (ed.). UAM, Poznań, pp. 33-44 (in Polish with English summary).

KONDRACKI J. 1994. Geografia Polski. Mezoregiony fizyczno-geograficzne, PWN, Warszawa, pp. 105-125 (in Polish).

KOZARSKI S. 1981. Stratygrafia i chronologia vistulianu Niziny Wielkopolskiej. (Stratigraphy and chronology of the Great Polish Lowland). PAN, Oddz. Pozn. ser. Geografia 6: 7-44 (in Polish with English summary).

KRUPIŃSKI K.M. 1978. Historia, dynamika rozwoju i zaniku zbiornika interglacjalnego w Żyrardowie. (History and dynamics of the development and disappearance of an interglacial basin in Żyrardów). Biul. Inst. Geol. 300: 153-178 (in Polish with English summary).

KRUPIŃSKI K.M. 1986. Sediments of the Eemian Interglacial at Komorów near Pruszków (Mazovian Lowland). Bull. Pol. Acad. Earth Sc. 34 (4): 387-394.

KRUPIŃSKI K.M. 1988. Stanowisko flory interglacjału eemskiego w Warszawie przy ul. Kasprzaka. (Site of Eemian Interglacial flora in Warsaw, Kasprzaka street). Kwart. Geol. 32 (3-4): 663-669 (in Polish with English summary).

KRUPIŃSKI K.M., MORAWSKI W. 1993. Geological position and pollen analysis of Eemian Interglacial sediments of Warszawa–Wawrzyszew. Acta Palaeobot. 33 (1): 5-42.

KRYGOWSKI B. 1961. Geografia fizyczna Niziny Wielkopolskiej. Geomorfologia. (Physical geography of the Great Poland Lowland. Geomorphology). Pozn. Tow. Przyj. Nauk: 1-203 (in Polish with English summary).

KUKLA G., MCMANUS J.F., ROUSSEAU D.-D., CHUINE I. 1997. How long and how stable was the a last interglacial? Quaternary Science Reviews 16: 605-612.

KUNKEL A., TOBOLSKI K. 1977. Interglacjał eemski w Swarzędzu koło Poznania. (Eemian Interglacial from Swarzędz near Poznań). Przegl. Geol. 5: 249-250 (in Polish with English summary).

KUSZELL T. 1980. Trzy stanowiska flory z interglacjału eemskiego na Dolnym Śląsku. (Three new localities of Eemian flora in Lower Silesia). Geol. Sudetica 15 (1): 143-167 (in Polish with English summary).

KUSZELL T. 1997. Palinostratygrafia osadów interglacjału eemskiego i wczesnego vistulianu w południowej Wielkopolsce i na Dolnym Śląsku. (Palynostratigraphy of Eemian Interglacial and Early Vistulian in the South Great Polish Lowland (Wielkopolska) and Lower Silesia). Prace Geol.-Min. LX: 1--69 (in Polish with English summary).

KUSZELL T., SADOWSKA A. 1994. Badania palinologiczne osadów organicznych ze stanowisk Gutów i Grudzielec Nowy do „Szczegółowej Mapy Geologicznej Polski" w skali 1: 50 000 dla arkusza Skalmierzyce. Mat. Arch. Inst. Nauk Geol. UWr (in Polish).

LITT T. 1994. Paläoökologie, Paläobotanik und Stratigraphie des Jungquartäras im nordmitteleuropäischen Tiefland (Unter besonderer Berücksichtigung des elbe-Saale-Gebietes). Dissertationes Botanicae 227: 1-185.

LITT T., JUNGE F.W., BÖTTGER T. 1996. Climate during the Eemian in north-central Europe a critical review of the palaeobotanical and stable isotope data from central Germany. Vegetation History and Archaeobotany 5: 247-256.

MALKIEWICZ M. 1998. Historia roślinności interglacjału eemskiego z Lechitowa (Dolina Baryczy), Polska południowo-zachodnia. (Eemian floral succession at Lechitów in Barycz River Valley, Southwestern Poland). Biul. Państw. Inst. Geol. 385: 143-152 (in Polish with English summary).

MAMAKOWA K. 1988. Pollen stratigraphy of the Eemian Interglacial and the adjoining glacial deposits based on continuous sequences in Poland. Bull. Pol. Acad. Sc. 36 (3-4): 299-307.

MAMAKOWA K. 1989. Late Middle Polish glaciation, Eemian and Early Vistulian vegetation at Imbramowice near Wrocław and the pollen stratigraphy of this part of the Pleistocene in Poland. Acta Palaeobot. 29 (1): 11-176.

MENKE B. 1967. Ein Beitrag zur eemzeitlichen Vegetations- und Klimageschichte nach dem Profil von Ostrohe/Schleswig-Holstein. Fundamenta R. B. 2: 126-135.

MOJSKI J. 1993. Europa w plejstocenie. Ewolucja środowiska przyrodniczego. PAE, Warszawa, pp. 164-202 (in Polish).

MOORE P.D., WEBB J.A., COLLINSON M.E. 1991. Pollen analysis. Second edition. Blackwell Scientific Publications, Oxford, pp. 1-205.

MÜLLER H. 1974. Pollenanalytysche Untersuchungen und Jahresschichtenzählungen an der eem-zeitlichen Kieselgur von Bispingen/Luhe. Geol. Jb. 21: 149-169.

NIKLEWSKI J. 1968. Interglacjał eemski w Główczynie koło Wyszogrodu. (The Eemian Interglacial at Główczyn near Wyszogród (Central Poland)). Monogr. Bot. 27: 125-192 (in Polish with English summary).

NILLSON O., HJELMQVIST H. 1967. Studies on the Nutlet structure of south Scandinavian species of Carex. Botaniska Notiser. 120: 460-485.

NORYŚKIEWICZ B. 1978. Interglacjał eemski w Nakle nad Notecią. (The Eemian Interglacial at Nakło on the River Noteć (N Poland)). Acta Palaeobot. 19 (1): 67-112 (in Polish with English summary).

NORYŚKIEWICZ B. 1999. Palynology of biogenic sediments of the Eemian Interglacial at Krzyżówki near Koło, central Poland. Geological Quarterly 43 (1): 107-112.

REILLE M. 1992. Pollen et spores d'Europe et d'Afrique du Nord. Laboratoire de Botanique Historique et Palynologie, France, pp. 1-520.

REILLE M. 1995. Pollen et spores d'Europe et d'Afrique du Nord. Supplement 1. Laboratoire de Botanique Historique et Palynologie, France, pp. 1-327.

ROTNICKI K. 1975. Stratigraphic evidences of the survival of Riss glacitectonic structures and forms in the marginal zone of the maximum extent of the last glaciation. Questiones Geographicae. 2: 113-137.

ROTNICKI K., TOBOLSKI K. 1965. Pseudomorfozy wieloboków z lodem szczelinowym i stanowisko tundry w peryglacjalnym basenie sedymentacyjnym ostatniego zlodowacenia w Kępnie. (Pseudomorphoses on the fissure ice polygons and the locality of tundra in the periglacial sedimentary basin of the period of last glaciation at Kępno (South Great Poland)). Bad. Fizjogr. nad Polską Zach.15: 93-146 (in Polish with English summary).

SADOWSKA A., KUSZELL T., MALKIEWICZ M. 1994-2001. Kartoteka Palinologiczna Roślin Polski. (The Palynological Card Index of Polish Plants). Zeszyty Przyr. Opol. Tow. Przyj. Nauki: 30-35 (in Polish with English summary).

SEIDENKRANTZ M., KRISTENSEN P., KNUDSEN K.L. 1995. Marine evidence for climatic instability during the last interglacial in shelf records from northwest Europe. Journal of Quaternary science 10: 77-82.

SEIFERT M. 1990. Ein interglazial von Neumark-Nord (Geiseltal) im Vergleich mit anderen Interglazialvorkommen in der DDR, [In:] Mania D., Thomae M., Litt T., Weber T.: Neumark-Gröbern, Beiträge zur Jagd des mittelpaläolithischen Menschen., Deutscher Verlag der Wissenschaften, Berlin, s. 149-158.

SKOMPSKI S. 1975. Die Ergebnisse der Untersuchungen űber die Stratigraphie des Pleistozäns im Westteil der Hochfläche von Lubusz. Wiss. Ztschr. Univ. Greifswald, Math.-naturwiss. 24: 143-146.

STANKOWSKI W., KRZYSZKOWSKI D. 1991. Stratygrafia czwartorzędu okolic Konina. (The Quaternary stratigraphy of the Konin area). In: Przemiany środowiska geograficznego obszaru Konin-Turek. Stankowski W. (ed.). UAM, Paznań, pp. 11-31 (in Polish with English summary).

STANKOWSKI W., BLUSZCZ A., NITA M. 1999. Stanowiska osadów górnoczwartorzędowych Mikorzyn i Sławoszewek w świetle badań geologicznych, datowania radiowęglowego i luminescencyjnego oraz analiz palinologicznych. In: Geochronologia Górnego Czwartorzędu Polski. Pazdur A. i inni (ed.). pp. 87-112 (in Polish).

STARK P., FIRBAS F., OVERBECK F. 1932. Die Vegetationsentwiklung des Interglazials von Rinnersdorf in der östlichen Mark Brandenburg. Abh. Naturwiss. Ver. Bremen 28: 105-130.

ŚRODOŃ A. 1956. W sprawie interglacjału w Szelągu pod Poznaniem. (Interglacial in Szeląg near Poznań). Biul. Inst. Geol. 100: 45-60 (in Polish with English summary).

ŚRODOŃ A. 1984. Uwagi o florze w Hamerni nad Lubaczówką. (Some remarks on the interglacial flora from Hamernia (SE Poland)). Acta Palaeobot. 24 (1-2): 53-66 (in Polish with English summary).

ŚRODOŃ A. 1985. Fagus in the forest history of Poland. Acta Palaeobot. 25 (1-2): 115-133.

TAYLOR K.C., HAMMER C.U., ALLEY R.B., CLAUSEN H.B., DAHL-JENSEN D., GOW A.J., GUNDESTRUP N.S., KIPFSTUHL J., MOORE J.C., WADDINGTON E.D. 1993. Electrical conductivity measurements from the GISP2 and GRIP Greenland ice cores. Nature 366: 549-552.

THOUVENY N., DE BEAULIEU J.L., BONIFAY E., CREER K.M., GUIOT J., ICOLE M., JOHNSEN S., JOUZEL J., REILLE M., WILLIAMS T., WILLIAMSON D. 1994. Climate variations in Europe over the past 140 kyr deduced from rock magnetism. Nature 371: 503-506.

TOBOLSKI K. 1986. Palaeobotanical studies of the Eemian Interglacial and Early Vistulian, Władysławów in the vicinity of Turek (preliminary report). Quaternaria Stud. in Poland 7: 91-101.

TOBOLSKI K. 1991. Biostratygrafia i paleoekologia interglacjału eemskiego i zlodowacenia Wisły rejonu konińskiego, (Biostratigraphy and palaeoecology of the Eemian interglacial and the Vistulian glaciation of the Konin region). In: Przemiany środowiska geograficznego obszaru Konin-Turek. Stankowski W. (ed.). UAM, Poznań, pp. 45-87 (in Polish with English summary).

TOŁPA S. 1952. Flora interglacjalna w Kaliszu. (Interglacial flora at Kalisz). Biul. Inst. Geol. 68: 73-120 (in Polish with English summary).

WINTER H. 1994. The floral characteristic of Upper Pleistocene organic sediments at Bogdanowo and Złotkowo near Poznań, western Poland. Folia Quaternaria 65: 303-309.
ZAGWIJN W.H. 1961. Vegetation, climate and radiocarbon datings in the Late Pleistocene of the Netherlands. I. Eemian and Early Weichselian. Meded. Geol. Sticht. N.S. 14: 15-45.
ZAŁOBA M., JASTRZĘBSKA-MAMEŁKA M. 1990a. Stanowisko interglacjału eemskiego w Raczkowie koło Warty. (A fossil basin of the Eemian age at Raczków near Warta). Acta Geogr. Lodz. 61: 69-74 (in Polish with English summary).
ZAŁOBA M., JASTRZĘBSKA-MAMEŁKA M. 1990b. Stanowisko interglacjału eemskiego w Zagajewie koło Warty. (A site of the Eemian interglacial at Zagajew near Warta). Acta Geogr. Lodz. 61: 75-82 (in Polish with English summary).

HISTORIA ROŚLINNOŚCI INTERGLACJAŁU EEMSKIEGO NA OBSZARZE NIZINY WIELKOPOLSKIEJ

STRESZCZENIE

Tematem pracy jest historia roślinności w interglacjale eemskim w południowej Wielkopolsce przedstawiona na podstawie badań paleobotanicznych. Analizie pyłkowej poddano osady jeziorne z dwóch stanowisk: Grudzielec koło Kalisza i Lechitów koło Góry.

Uzyskane diagramy pyłkowe wykazują cechy diagnostyczne dla interglacjału eemskiego. Sukcesja roślinności w badanych stanowiskach charakteryzuje się wyraźnie wykształconymi fazami: protokratyczną, w której panują lasy sosnowo-brzozowe i brzozowo-sosnowe oraz zbiorowiska lasów mieszanych sosnowo-dębowych i dębowych, mezokratyczną z dominującą leszczyną i dobrze wykształconymi lasami grabowo-lipowymi oraz telokratyczną, w której panują lasy jodłowo-świerkowe i sosnowe. Ponadto w stropowych odcinkach badanych profili stwierdzono sukcesję roślinności typową dla początku wczesnego vistulianu. Występowanie taksonów o wyższych wymaganiach klimatycznych pozwoliło ocenić warunki paleoklimatyczne południowej Wielkopolski. Rozwój roślinności w interglacjale eemskim wykazuje podobieństwo do zmian roślinności, jakie obserwowano w sąsiednich stanowiskach z obszaru Niziny Wielkopolskiej, a także z innych rejonów Polski i krajów sąsiednich. W opracowanych profilach zaobserwowano nieznaczne różnice, które wynikają z odmiennego położenia geograficznego stanowisk i różnej genezy zbiorników sedymentacyjnych.

SŁOWA KLUCZOWE: analiza pyłkowa, interglacjał eemski, historia roślinności, paleoklimat, Nizina Wielkopolska.