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Cyclicity in the Eemian climate? A case study of the Eemian site at Czaple, Eastern Poland

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ABSTRACT

The newly discovered lacustrine deposits from Czaple, Eastern Poland, examined by means of pollen analysis, revealed an undisturbed, continuous sequence of vegetational development of the Eemian/Early Vistulian age. We tried to trace the secondary climatic trends, cyclic in part on the basis of plant taxa — representing the second league in the spectra, as to frequency, but forming an important group of the index plants. Their appearance becomes more pronounced and reliable when extraordinarily high numbers of pollen are analyzed. The oscillations of curves of these taxa are more clearly expressed than by traditional counts, revealing the hidden picture in the palynological background. It is interesting that some taxa – e.g. *Hedera* – form a distinctive intermittent pattern reflecting cyclicity of climatic condition or additional factors which are responsible for it. Pollen curves of other index plants do not show such regular variation. This cyclicity can be traced in many European Eemian diagrams. Especially interesting is the sudden decline of ivy as well as of other indicator plants in the subzone E4b such as the *Corylus* which marks some increase in a continentality of climate. We can also trace this trend in other sequences. In addition, extra counts allow us to estimate the exact timing of the migration of rarely noted exotic taxa and their range of distribution in the sequence. *Buxus*, *Osmunda cinnamomea* and *Lycopodium lucidulum* types are the best examples illustrating this.

1. Introduction

In the Earth's history, cyclicity in climatic evolution is a feature commonly observed. In the Pleistocene it is exemplified by stadial/interstadial and glacial/interglacial successions as a result of persistent variations of climatic parameters. Moreover, this cyclicity is clearly visible not only as large-scale events. Regular, surely climatically induced, secondary oscillations can be seen in the isotope composition of ice cores or deep ocean records. However these small variations, surely resulting from changes in climatic conditions are not practically reflected in the frequency of main components of AP during traditional pollen analysis. One way of overcoming this problem is by the use of bioindicators — plants with rather narrow climatic requirements responding to environmental changes. Unfortunately, they usually occur sparsely — hence subtle oscillations are hard to identify and they only form curves in the diagram when the total sum of pollen is very high. Counting of this type was undertaken by Müller et al. (2005), following the works of other palynologists who postulated about such smaller cyclical variations earlier (e.g. Zagwijn, 1961). Using extra counts, they identified the existence of 6 "cold" intervals (average recurring time 1450 years) in the temperate Eemian with a total lack of *Hedera* pollen and "warm" stages showing a culmination of ivy.

As has been shown by Blaauw et al. (2010) cyclicity as well as other abrupt quasi periodic climate signals may be reproduced by random walk simulations of fossil data. Therefore, the confirmation of postulated cyclicity inferred from the Eemian pollen data by Müller et al. (2005), seems to be necessary. We would like to test this method by making additional counts of rare taxa, including a bioindicator. The source material is the sequence from Czaple (Eastern Poland) which records changes in vegetation in the Eemian and the Early Vistulian periods. Deep-water sedimentation yields in a good pollen preservation state and undisturbed palynological succession.

2. Material and methods

The palaeolake at Czaple was found within an E–W-oriented, small depression located on the Siedlce Plateau in Eastern Poland, 9 km to the west of Drohiczyn. This depression, incised about 2–3 m into the postglacial Wartanian plateau, corresponds to the nearby Bug River valley. During cartographic studies for the Detailed Geological Map of Poland (Fig. 1) 1:50 000, Drohiczyn chart (Nitychoruk et al., 2009), in 2005, a drilling was undertaken that revealed interglacial deposits. The next two cores (taken with a hydraulic corer — WH 5) were raised in 2008 from a marginal part of the interglacial lake with numerous sandy intercalations and from the deeper, and probably, central part

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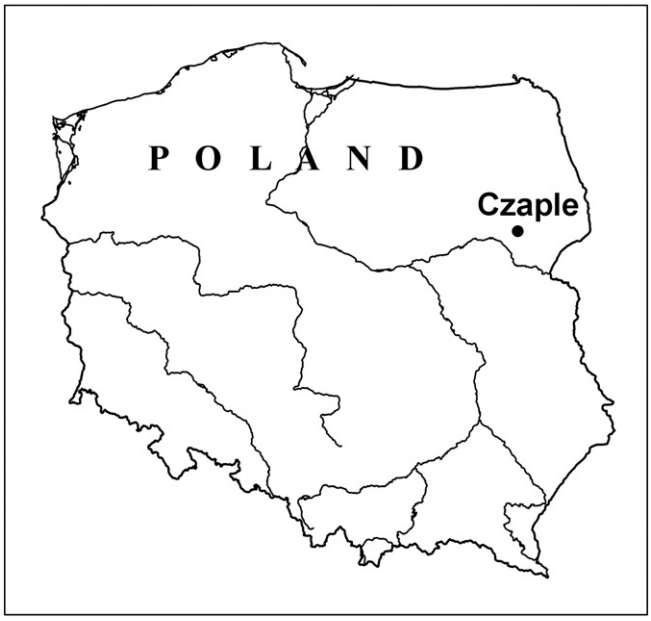

Fig. 1. Map showing the locality of investigated site at Czaple.

of the palaeolake where below the 2.5 m sandy deposits an 11 m long core of deep-water sediments was collected. The lake deposits were underlain by glacial till from the Wartanian Glaciation.

The core, was cut into slices roughly 7.5 cm thick and stored in plastic sachets. In the laboratory, samples of a volume of approximately 1 cm^3 were washed with hot 15% HCl, boiled in 10% KOH, treated with cold HF and finally treated with traditional Erdtman's acetolysis. About 1000 pollen grains were counted at a 400× magnification in each of the 144 samples (except at the post-interglacial part, where the pollen frequency was lower). For these samples a percentage pollen diagram was prepared. Additionally, slides from temperate phases of the same profile (65 samples) containing about 5000 pollen were counted in case they contained rare, underrepresented and usually insect-pollinated bioindicators. They were the base for the construction of a histogram.

3. Results

Monotonous deposits of interglacial gyttia and post-interglacial silt are the main components of the lacustrine sequence. The only exception is a thin layer of peat in the Vistulian interval (subzone 9B).

Pollen zones (Figs. 2 and 3):

Betula L PAZ 1 (samples 142–144)

The samples represent initial, boreal stages of interglacial succession that were probably contaminated by oak pollen during boring.

Quercus L PAZ 2 (121–141)

Pollen of *Quercus* and, at the end of the zone *Corylus* – expanding into the oak forest – form the main components of the AP curve. Damper places in the valley were, in turn, occupied by *Fraxinus* and *Ulmus* communities — the pollen of which was more numerous at this level. Favorable summer and winter temperatures allowed the existence of such warmth demanding plants, exotic in part – as *Hedera*, *Viburnum lantana*, and *Viscum* – and appearing in the second half of the zone, *Syringa*, *Cotinus coggygria*, and *Vitis* as well as *Cornus mas.*

Littoral and shallow water plants – *Sparganium*, *Ceratophyllum*, and *Typha* as well as *Myriophyllum alterniflorum* – predominated in the lake. Sporadically pollen of *Nymphaea*, *Myriophyllum spicatum* and *Alisma* were found in this zone.

As suggested by the histogram, the carbonate-poor lake was rather small because most plants mentioned above (including marginal ones) are noted more abundantly in this zone than in other intervals.

The occurrence of mistletoe, ivy, wayfaring tree and alternate water milfoil is a reliable proof that in this area the climate must have been more maritime than today.

Corylus L PAZ 3 (113–120)

This zone is marked by an almost absolute dominance of *Corylus*. Tree pollen occurred in small quantities. *Ulmus* reaches an inconspicuous culmination and the same goes for *Taxus* in the second part of this interval. Curves of *Tilia* and *Alnus* rise slowly. The range of distribution of both thermophilous as well as exotic taxa, more abundant in the previous zone is restricted.

The decrease in local pollen, especially of plants from the marginal zone (*Typha* and *Sparganium*), can mean that the basin deepened.

Corylus–Tilia L PAZ 4 (104–112)

Sharp rises in *Alnus*, *Tilia*, and *Fraxinus* and some decrease in *Corylus* pollen mark the lower boundary of the zone. Also the percentages of *Carpinus* slowly increase. So the nature of contemporary forest communities was complex and transitional.

The proportion of thermophilous elements – *Viscum*, *Hedera* and *Syringa* – again reached significant values.

There are no vital changes in the lake at that time. Like in the hazel zone the basin was occupied by *Sparganium*, *Ceratophyllum, Nuphar*, *Myriophyllum alterniflorum*, *Typha latifolia* and *Isoetes*. The frequency of these plants in pollen spectra, is however, very low. The high proportion of *Alnus* pollen is a proof that alder grew along the shores or neighboring sedimentary basins were gradually infilled with deposits and this created suitable habitat for communities dominated by alder.

Carpinus L PAZ 5 (80–103)

This interval is marked by a pronounced rise of *Carpinus*. Two subzones can be distinguished — one with gradually declining values of *Tilia* and *Ulmus* and the other with maximum percentages of hornbeam and the beginning *Picea* curve.

Pollen percentages of *Hedera* and *Viscum* do not show substantial changes against the previous zone. New exotic elements are *Buxus* and *Osmunda cinnamomea*, curves of which start at the same time, as well as *Ilex* and *Lycopodium lucidulum* t.

We cannot trace any significant changes in the lake, when compared to the previous level. Pollen of *Sparganium*, *Typha*, *Nuphar*, *Nymphaea, Myriophyllum alterniflorum*, *Myriophyllum spicatum* and *Ceratophyllum* hairs occur rather rarely. A certain sign of decrease in water level may be the appearance of *Trapa* and *Salvinia* – plants characteristic of the mature stages of interglacial lakes – shallow, usually eutrophic basins infilled with deposits.

Picea–Abies L PAZ 6 (77–79)

A short-lived zone with small maxima of *Abies* and *Picea* and quick rise in *Pinus* and somewhat higher percentages of *Betula* against the decrease in *Alnus*, *Corylus* and *Carpinus*. So, the communities of that time seem to be transitional and a tendency of the expansion of more light-demanding plants (e.g. Gramineae and Cyperaceae) is observed. A small increase in *Pteridium* spores may prove the possibility of fires.

A single pollen of *Typha*, *Polygonum amphibium* and a spore of *Isoetes* were found.

Pinus L PAZ 7 (65–76)

An almost total predominance of *Pinus* in the spectra with only a low amount of *Picea* and *Juniperus*. Pollen of *Betula* (curve less than 25%) was probably wind transported from the south. Good light conditions in the pine boreal forest gave rise to expansion of herbaceous plants, mainly *Artemisia*, Gramineae, Cyperaceae and Chenopodiaceae.