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[1]Institute of Geological Sciences, National Academy of Sciences of Belarus
[2]Institute of Earth Sciences, Maria Curie-Skłodowska University

GALINA K. KHURSEVICH[1], IRENA AGNIESZKA PIDEK[2],
SVETLANA A. FEDENYA[1]

Environment changes in a fossil lake at Brus (Lublin Polesie – SE Poland) based on palaeoalgological data

Zmiany środowiska w kopalnym jeziorze w Brusie (Polesie Lubelskie – Polska SE) na podstawie danych paleoalgologicznych

INTRODUCTION

Fossil lacustrine deposits at Brus in the Lublin Polesie were found by Buraczyński and Wojtanowicz (1982) in a drill core, during the geological survey for the Detailed Geological Map of Poland 1 : 50 000 (Kołacze sheet), at the beginning of the 80s. In the next years the deposits have been examined by the researchers dealing with stratigraphy of the area (Wojtanowicz 1995, 1996; Lindner, Wojtanowicz 1997; Lindner et al. 1998). On the basis of pollen analysis of 11 samples, the lacustrine part of the sediments from Brus was palynologically dated by Janczyk-Kopikowa (1980) at the Mazovian interglacial age. The thermoluminescence datings were made by Butrym in the TL Laboratory of the Department of Physical Geography and Palaeogeography, Maria Curie-Skłodowska University in Lublin (Wojtanowicz 1995, 1996).

Detailed pollen analysis of 106 samples of the lacustrine deposits from Brus was made by I. A. Pidek. On the basis of the results, the vegetation history was described, since the Late Sanian 2 Glacial, through the whole Mazovian Interglacial s.s., to the Early Liviecian Glacial (Pidek 2000, 2003). The examined deposits are very rich in various fossil algae that have an essential significance when interpreting development and environment changes in fossil lakes (Geel van 1986). Thus the author of the palynological study made also the detailed identification of *Chlorophyta* and undertook cooperation with experts in diatom analysis – Khursevich and Fedenya from the Institute of Geological Sciences, National Academy of Sciences of Belarus.

In this paper we report the results of diatom analyses correlated with palynological ones, on the basis of which the palaeoecological conditions in the fossil lake at Brus have been reconstructed and described against the succession of terrestrial plants.

METHODS

Material for pollen analysis was obtained using the flotation method, after carbonate removal with 10% HCl and boiling with 10% KOH. Organic fraction was subjected to Erdtman's acetolysis. The sporomorphs were stained with acid fuchsin and sluiced with pure glycerine.

Pollen spectra were counted on at least two slides. The calculations of pollen percentages were based on the sum of pollen grains of trees and shrubs (AP) and of terrestrial herbs and dwarf shrubs (NAP). The percentages of aquatic and reedswamp plants pollen were calculated in relation to the sum including AP+NAP+given taxon.

The results of pollen analysis are presented in the form of a simplified percentage diagram (Fig. 1), which was constructed basing on the POLPAL software (Walanus, Nalepka 1994, 1998).

Diatoms were examined in 37 samples which were taken from the profile section of 24.5–12.5 m. Samples were treated with hydrochloric acid and hydrogen peroxide. The cleaned diatoms were mounted in Elyashevs aniline-formaldehyde and observed using a Zeiss-Jena Amplival microscope. In each slide 500 diatom valves were identified. Material for scanning electron microscopy (SEM) was coated with gold and observed using a JEOL-35C in the Institute of Geological Sciences, National Academy of Sciences of Belarus, Mińsk. The results of diatom analysis are presented in the form of a percentage diagram divided into local diatom assemblage zones (L DAZ), which are marked with the symbol BR and numbered from 1 to 10.

Chlorophyta of the *Pediastrum* and *Botryococcus* genera were identified in all the samples on the basis of the descriptions published by Jankovská & Komárek (1997, 2000), Komárek & Fott (1983), Komárek & Marvan (1992), Nielsen & Sörensen (1992), Starmach (1989).

The colonies of different species and varieties of *Chlorophyta* were valuated in relation to 100 pollen grains of AP+NAP, and the results were extrapolated. Percentages of each particular taxon were calculated in relation to the sum including AP+NAP+sum of all taxa. The full results of the *Chlorophyta* analysis are presented in the publication by Pidek (2003). In the present paper several main *Pediastrum* and *Botryococcus* taxa are included in the pollen diagram to make a correlation with diatom assemblage zones (L DAZ) and to supplement the characteristics of the environmental changes in the fossil lake.

DEVELOPMENT OF DIATOM COMMUNITIES AGAINST THE SUCCESSION OF TERRESTRIAL PLANTS AND THE AQUATIC AND LAKE-SHORE VEGETATION

The lake development at Brus since the Sanian 2 Late Glacial, through the Mazovian Interglacial, to the Liviecian Early Glacial is presented with reference to local pollen assemblage zones (L PAZ) as well as *Chlorophyta* communities (Fig. 1). The correlation of local pollen assemblage zones (L PAZ) and local diatom assemblage zones (L DAZ) is given in the diatom diagram (Fig. 2). The pollen diagram is divided into 12 pollen assemblage zones (L PAZ). It should be stressed that the boundaries of the L PAZ and the L DAZ are mostly in line, except the Br-2 L PAZ which covers the BR-1 and 2 L DAZs, and except the Br-5 L PAZ, the lower boundary of which has been put below that of the BR-5 L DAZ (Khursevich et al. 2000).

SANIAN 2 LATE GLACIAL

The **Br-1 NAP–*Juniperus–Betula* L PAZ (25,9–24,6 m)** represents the Sanian 2 Late Glacial, when vegetation of open landscape was widespread. Steppe-tundra communities predominated, and extensive areas were occupied by various communities of a shrub tundra type.

The occurrence of pollen of reedswamp vegetation (*Sparganium* t., *Phragmites*, *Typha latifolia* and *Alisma plantago-aquatica*) probably indicates the existence of a reedswamp belt surrounding the lake and colonies of *Pediastrum kawraiskyi* may indicate that the lake was cold and oligotrophic at that time. Diatoms are not present in this zone but in its younger part the abundance of *Pediastrum boryanum* var. *boryanum* suggests that water in the lake became warmer.

MAZOVIAN INTERGLACIAL

Br-2 *Betula* L PAZ (24.6–23.1 m)

The fall in the NAP values and the simultaneous rapid rise in the *Betula alba* t. pollen values indicate that open areas were quickly colonized by pioneer birch forest with small admixture of *Larix*, *Pinus sylvestris*, and probably stone-pine (*Pinus cembra* t.).

In the older part of the zone diatoms appear. Initially their assemblage is not very differentiated (72 taxa), and dominated by cold-water epiphytic species *Fragilaria lapponica* (40.5%), *F. pinnata* (12.9%) and *F. leptostauron* (3.5%), which are pioneer species in lake colonization (BR1 L DAZ). These features still indicate the initial stage of a shallow lake.

The planktonic but still relatively cold-water species of diatoms which prevail in the younger part of the zone, i.e. *Cyclotella krammeri* (up to 38.3%), and then *C. schumannii* (up to 37.7% the maximum value in the profile), indicate a rise of the water-level (BR2 L DAZ). The lake was probably of a medium depth and still quite oligotrophic. The progressive warming of water resulted in a considerable enrichment of the diatom flora, which consisted of 187 species and varieties belonging to various ecological groups. The number of taxa on the upper boundary of the BR2 L DAZ is over 2.5 times higher than in the preceding zone BR1 L DAZ. The epiphytic diatoms were dominated by the representatives of species more eurythermic than in the older part of the zone, e.g. *Fragilaria construens*. The abundance of *Pediastrum boryanum* var. *boryanum* in the whole zone is also worth mentioning thus confirming the statement of a warm not very deep lake.

Br-3 *Betula–Pinus–Larix* L PAZ (23.1–20.7 m)

The proportion of pine in the forest communities increased gradually during this zone as is evidenced by the rising values of *Pinus sylvestris* t. pollen (up to 43%). These boreal birch-pine forests had probably an important and rather high admixture of larch as *Larix* pollen reaches its maximum values (up to 3%).

Diatoms distinctly predominated in the lake, *Chlorophyta* are not numerous especially in the younger part of the zone. The initial rise in the values of epiphytic diatoms (*Fragilaria construens* 28.8%, *F. brevistriata* 14.4%), and frequent pollen of *Phragmites* indicate a tendency to lowering of the water-level in the lake. *Cyclotella ocellata* (max. 13.8%) predominated among planktonic species but the percentages of *C. schumannii* (20.6%) and *C. comta* var. *lichvinensis* (up to 8.2%) were also rather high. The rapid fall in the diatom amount during the subzone BR3b gives evidence of the unfavourable conditions for their development in the lake.

Br-4 *Pinus–Alnus–Picea–/Fraxinus/* L PAZ (20.7–19.0 m)

The further rise in the values of *Pinus sylvestris* t. pollen indicates that forest communities still had been gradually dominated by pine. The still rather high percentages of *Larix* pollen (up to 1.4%) reflect a significant admixture of larch, and the increasing pollen values of *Picea* indicate that the role of spruce became greater. Alder forests started their expansion just then, as indicated by the high values of *Alnus* pollen, which occur twice in this zone.

Diatom assemblage is represented by various species and varieties of the following genera: *Cyclotella* (*C. schumanni, C. krammeri, C. cyclopuncta, C. comta* var. *lichvinensis*), *Fragilaria* (*F. brevistriata*, *F. construens* et var. var., *F. lapponica*) and *Amphora* (mainly *A. ovalis* the maximum value in the profile).

The composition of diatoms and *Chlorophyta* indicates meso-eutrophic water but the varying amount of diatoms suggests unstable water conditions. The maximum contents of diatoms, which were found in the samples from the depths of 20.5 m and 19.9–19.5 m, correspond to the two maxima of *Alnus* pollen. They probably indicate rapid changes of habitat humidity, which may have resulted from climate humidity fluctuations. The rapid decrease in the diatom amount and very poor representation of *Pediastrum* in this zone confirm conditions rather unfavourable for their development.

Traces of aquatic plants (*Nuphar* pollen and idioblasts of *Nymphaeaceae*) indicate that different communities resembling the modern *Nupharo-Nymphaeetum albae* (Podbielkowski, Tomaszewicz 1996) existed in the water. It provides evidence of warm rather eutrophic water.

Br-5 *Alnus–Picea–Pinus* L PAZ (19.0–16.5 m)

During this zone a successive change in the forest communities occurred from boreal pine-birch forests to mixed forests with dominant spruce. The expansion of *Carpinus* started at the same time. Wet alder forests, and riverine ash-elm and alder-ash forests occupied larger and larger areas. These conclusions were drawn on the basis of the very high pollen values of *Alnus* (over 30%), high percentages of *Fraxinus* (max. 3.5%), and still rather high values of *Ulmus*. The gradual spread of *Taxus* took place in the younger part of the zone.

Similar conditions are recorded in the composition of the diatoms containing thermophilous species, i.e. *Aulacoseira granulata*, *A. ambigua* and *Stephanodiscus niagarae* var. *insuetus*, which occur in warm and eutrophic lakes. The presence of *Salvinia natans* – a water-fern having high thermic demands – is also worth noting.

However, the diatom composition was very much diversified. The maximum values of several planktonic species *Cyclotella krammeri* (38.6%), *C. cy-*

clopuncta (19.2%) and *C. comta* var. *lichvinensis* (up to 15%) indicate a rise of the water-level. *C. comta* var. *lichvinensis* is an indicator taxon of the Mazovian Interglacial because it became extinct towards the end of the middle Pleistocene. This species is rather abundant also in the Mazovian Interglacial deposits in the stratotype profiles at Biała Podlaska, Krępiec and Adamówka (Marciniak 1998). The diatom communities found in the deposits of the Mazovian Interglacial at Brus resemble those of the Alexandrian (=Mazovian) Interglacial in Belarus (Khursevich 1999).

The eutrophic conditions and rather high water level in the lake is also evidenced by the *Chlorophyta* composition in which planktonic *Pediastrum boryanum* var. *cornutum* and *P. duplex* var. *rugulosum* occurred sporadically.

Br-6 *Taxus–Alnus–Picea* L PAZ (16.5–15.5 m)

The maximum values (22.5%) of *Taxus* pollen in this zone indicate that yew played a dominant role in the forest communities at that time. Coniferous and mixed forest underwent a reconstruction. The expansion of *Carpinus*, *Quercus* and *Corylus* resulted in the formation of dry-ground forests. In these forests *Picea* may have been replaced by *Abies*. Wet alder and riverine forests did probably not undergo greater changes.

Communities of hydrophytes and reedswamps probably resembled those from the preceding zone. *Cyclotella*, *Aulacoseira ambigua* (up to 6.7%), *A. granulata* (up to 7.4%) and *Stephanodiscus niagarae* var. *insuetus* (up to 3.5%), i.e. the diatoms of different planktonic groups, which are typical of eutrophic lakes, were dominant in the lake. This abundance of rather thermophilous diatoms coincided with the beginning of the interglacial climatic optimum. At that time the higher values of two *Pediastrum* species *P. boryanum* var. *boryanum* and *P. boryanum* var. *pseudoglabrum* – were probably associated with eutrophication and higher temperature of water.

Br-7 *Pinus–Carpinus–Abies–/Picea/* L PAZ (15.5–14.4 m)

A substantial recession of yew woodlands and wet forests of different types was probably caused by a considerable change of climate, which became more continental and perhaps colder. The considerable rise in the pollen values of *Pinus sylvestris* t. (up to 42%) indicates probably a repeated encroachment of pine. The pine-oak mixed forests may have formed. The dynamic spread of fir started in the younger part of the zone; *Abies* pollen reaches 20%.

The aquatic communities, which occurred in the lake were rich at that time. Hydrophytes with floating leaves covered the lake surface. This provides evidence of the eutrophic nature of the lake.

The diatom composition is characterized by the decrease of the planktonic species (to 35%), and by the considerable rise in the percentages of epiphytes (up to 40–51%), which are represented by various taxa of *Fragilaria*, *Cymbella ehrenbergii* and *Martyana martyi*. This composition indicates a tendency to the lowering of the lake water-level, probably as a result of a drier climate. The community of *Chlorophyta* with high percentages of *Pediastrum simplex* var. *simplex*, also indicates eutrophic nature of the lake water.

Br-8 *Abies–Carpinus–Alnus* L PAZ (14.4–13.8 m)

The increasing role of fir and hornbeam in the mixed forests is reflected by the further rise in the pollen values of *Abies* (up to 26%), and then of *Carpinus* (up to 28%). The dry-ground oak-hornbeam communities, with *Tilia cordata* and frequent *Carpinus*, were probably spread here and there. There was also a repeated expansion of alder and yew which may be indicated by the rise in *Alnus*, and the slight rise in *Taxus* values. This was probably associated with again a wetter climate.

The communities of nenuphars expanded in the lake. The insufficiency of light, and high temperatures strongly influenced the diatom communities, which became impoverished very much. In the younger part of the zone there disappeared most of the species present earlier. However, the species of *Pediastrum* strongly associated with eutrophic water (mainly *P. simplex* var. *simplex*) were very abundant.

Br-9 *Abies–Corylus–Quercus–/Carpinus/* L PAZ (13.8–13.0 m)

The further expansion of *Abies* took place in the forest communities, and fir forests probably covered wide areas. This is indicated by the high value of *Abies* pollen (up to 30%). The role of *Corylus* and *Quercus* also increased in comparison with the preceding zone, and that of *Carpinus* decreased. The riverine elm-ash forests played again a more important role in the landscape as it is evidenced by the increasing pollen values of *Fraxinus*, *Ulmus* and *Taxus*. The rising *Alnus* frequencies indicate that alder forests were also widespread.

The intensive development of the nenuphar communities was still continued. Initially the lake water-level considerably rose in comparison with the last part of the preceding zone. This is indicated by a distinct dominance of planktonic diatoms, i.e. *Aulacoseira ambigua* (up to 32%) and *A. granulata* (up to 20%). They are also indicators of warm water, just as the representantives of the benthonic diatoms (*Navicula oblonga* up to 15%, *Amphora libyca* 7.9–9.3%, and *Anomoeoneis sphaerophora* 8.1–8.4%) and the epiphytic diatoms (*Cymbella ehrenbergii* 8–10% and *Epithemia zebra* 7–8%), which were abundant in this zone. These high values of epiphytic diatoms, recorded in the younger part of the zone, probably indicate that the macrophyte zone widened, and the lake had a tendency to shallowing. The *Pediastrum* composition gives evidence of a large, warm, eutrophic lake.

Br-10 *Abies–Alnus–Carpinus*–/Filicales/ L PAZ (13.0–10,2 m)

The maximum spread of fir forests, probably with a small admixture of other trees, took place during this period as is evidenced by the very high pollen values of *Abies* (up to 43%). The alder communities were the second dominant type of the forests. The values of *Alnus* pollen reach up to 44% in this zone. Multispecies dry-ground forests persisted, in which *Quercus* still dominated. The role of *Carpinus* slightly increases and the occurrence of *Pterocarya* may have been associated with the patches of riverine elm-ash forests, which survived in the landscape.

The variety of aquatic and reedswamp taxa in the whole zone is very great. Thermophilous water-ferns *Salvinia* and *Azolla* dominated providing evidence of water eutrophication as well as intensification of overgrowing processes. Especially the presence of *Azolla*, which occurs frequently in the interglacial deposits of the Middle Pleistocene (Sobolewska 1956), is worth mentioning.

Diatoms are abundant only in the oldest part of this zone. *Aulacoseira ambigua* is the only one planktonic species, which occurs in the considerable percentages (up to 27%). Two epiphytic species *Cymbella ehrenbergii* (11%) and *Epithema zebra* with varieties (up to 8%) reach their maximum values in the whole profile. The frequent representantives of benthonic and periphyton diatoms belong to the following genera: *Fragilaria*, *Anemoeoneis*, *Navicula*, *Neidum*, *Amphora*, *Rhopalodia* and *Nitzschia*. All these data indicate overgrowing and shallowing of the lake. In the higher section of the profile, i.e. above the sample from the depth of 12.5 m, diatoms are found sporadically.

The composition of *Chlorophyta* community indicates also the eutrophic, warm lake. The number of *Pediastrum* colonies decreased simultaneously with the decline of diatoms. The disappearance of diatoms and green algae was evidently associated with shallowing of the lake.

Br-11 *Pinus–Larix* L PAZ (10.2–9.0 m)

The radical changes, which occurred in the forest communities towards the end of the interglacial consisted in the expansion of pine. Pine forests with an admixture of larch and birch probably encroached on the habitats of all other forest communities. However, the initially rather high pollen values of *Alnus*, *Abies*, *Carpinus*, *Quercus* and *Corylus* may indicate that the alder forests, fir communities, and also the patches of mixed forests survived for some length of time. A considerable rise in the NAP values (up to 31%; mainly *Cyperaceae* undiff., *Poaceae* uniff. and *Artemisia*) in the younger part of the zone may indicate that the role of open landscape communities became important.

Diatoms are no more present in the samples but on the basis of *Chlorophyta* and higher aquatic plants it may be concluded that the temperature fell down because the occurrence of idioblasts and pollen of the *Nymphaeaceae* family as well as of *Salvinia* microsporangia is terminated in the older part of this zone. The amount of *Chlorophyta* slightly increased again, probably because of a rise of the water-level in the lake. The diversity of *Pediastrum* is also greater in this zone. Especially coenobia of *P. boryanum* var. *boryanum* are more frequent in the younger part of the zone.

Br-12 NAP – *Betula nana–Salix–/Juniperus/* L PAZ (9.0–3.3 m)

The further rise in the NAP values (to over 50%) is conditioned mainly by the maximum percentages of *Artemisia*, *Poaceae* and *Cyperaceae*. The frequencies of *Juniperus*, *Salix glauca* t. and *Betula nana* t. simultaneously increase, and the pollen values of all trees fall. This indicates the total recession of the forests, which were replaced by open communities of various nature. The deforestation may be also evidenced by the occurrence of redeposited Tertiary sporomorphs. Different tundra communities developed in wet habitats.

The large reedswamp zone surrounded the lake but the occurrence of pollen of aquatic and reedswamp plants, except *Phragmites*, is almost entirely finished in the older part of this zone. The composition of *Chlorophyta*, which is characterized by the continuous curve of *Pediastrum kawraiskyi* together with rather high values of *Botryococcus pila* during the whole Br-12 L PAZ, may indicate that these cold-water species found favourable development conditions in the early glacial lake which got cool. In the opinion of Jankovská and Komárek (2000) such a community of *Chlorophyta* is typical of a cold, oligotrophic lake.

CONCLUSIONS

The pollen succession from Brus records the development of forest communities from the pine-birch forests, through the spruce and alder ones, and subsequently the yew forests, to the hornbeam-fir forests of climatic optimum. This provides unquestionable evidence of the Mazovian (Holsteinian, Alexandrian, Likhvian) age of the lacustrine deposits from Brus (Pidek 2000, 2003). *Carpinus* is the only mesophytic tree, which reaches high values in the Brus profile, simultaneously with the high percentages of *Abies*. Other thermophilous trees were not frequent in any zone. Janczyk-Kopikowa (1991) considered that these features are typical of the Mazovian Interglacial stratotype successions. Thus the new palynological results confirm the earlier statement by Janczyk-Kopikowa (1980) of the Mazovian age of the organogenic deposits from Brus. This fact definitely closes the discussion of a possible Zbójnian, not Mazovian, age of these series (Lindner, Wojtanowicz 1997).

The same conclusions were drawn from the composition of the diatoms. The authors of the diatom analysis distinguished the following features, which undoubtedly indicate the Mazovian (Holsteinian, Alexandrian, Likhvian) age of the examined lacustrine deposits from Brus:

1. The occurrence of the Pliocene-Pleistocene extinct species *Cyclotella comta* var. *pliocaenica* Krasske (up to 2%), *C. comta* var. *lichvinensis* (Jouse) Log. (up to 15%), and *Stephanodiscus niagarae* var. *insuetus* Khurs & Log. (up to 3.5%).

2. The absence of the indicator species of the Ferdynandowian (Byelovezhian, Muchkapian) interglacial, i.e. *Cyclotella reczickiae* Khurs & Log., *Stephanodiscus determinatus* Khurs., *S. peculiaris* Khurs., *S. raripunctatus* Khurs & Log., *S. styliferum* Khurs, which are found in the stratotype profiles of this interglacial in Belarus (Khursevich, Loginova 1986; Velichkevich et al. 1997; Khursevich 1999), Poland (Khursevich et al. 1990; Marciniak 1990), and Russia (Antsiferova 1991). This shows that the examined diatom flora from Brus is younger than the Ferdynandowian (Byelovezhian) but older than the Eemian (Muravian, Mikulinian), as the Eemian diatom flora resembles the modern one, and it does not contain extinct taxa typical of the diatom communities from the Middle Pleistocene.

The composition of diatom flora from the Brus profile resembles most of all that of the Mazovian flora from the Adamówka profile in Poland, and from the Matweev Rov-2 profile in Belarus (Bińka et al. 1987; Khrusevich, Fedenya 1998; Khursevich, Marciniak 1998; Marciniak 1998). The mentioned three profiles are closely correlated, as is evidenced by the occurrence of common dominant and subdominant diatoms of the *Cyclotella* (Kütz.) Breb. genus, including the extinct taxon *C. comta* var. *lichvinensis* (Jouse) Log. The extinct taxon – *C. comta* var. *pliocaenica* Krasske – is also found in all these profiles. However, several extinct taxa, which are recorded in the Adamówka profile (*Cyclotella* cf. *temperiana* (Log.) Log.) and in the Matweev Rov-2 profile (*Cyclotella michiganiana* var. *parvula* (Log.) Log., *C. temperiana* (Log.) Log., and *Stephanodiscus alexandriensis* Khurs.) are not found in the fossil lake at Brus. The extinct taxon *Stephanodiscus niagarae* var. *insuetus* Khurs. & Log., abundant in the Mazovian diatom flora in the Gvoznitsa profile (Khursevich, Fedenya 1998), is not numerous in the Brus profile.

The differentiated diatom communities found in many profiles of the Mazovian Interglacial deposits in Poland and Belarus were probably associated with various genetic types of the fossil lakes which developed in different ways (Khursevich, Marciniak 1998; Marciniak 1998).

A very good correlation between the pollen assemblage zones and the diatom assemblage zones in the Brus profile suggests that the natural evolution of the fossil lake proceeded as follows:

Shallow oligotrophic lake	L DAZ BR 1	L PAZ Br 1
Lake of medium depth	L DAZ BR 2	L PAZ Br 2
Lowering of water-level	L DAZ BR 3	L PAZ Br 3
Unstable water conditions in the lake	L DAZ BR 4	L PAZ Br 4
Rise of water-level	L DAZ BR 5	L PAZ Br 5
Lowering of water-level, eutrophication	L DAZ BR 6 and BR 7	L PAZ Br 6 and Br 7
Low water-level, eutrophication	L DAZ BR 8	L PAZ Br 8
Rise of water-level	L DAZ BR 9	L PAZ Br 9
Shallowing of eutrophic lake	L DAZ BR 10	L PAZ Br 10
Rise of water-level, cold oligotrophic lake		L PAZ Br 11 and 12

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PLATES

PLATE I

1. *Cyclotella comta* var. *lichvinensis* (Jouse) Log. sample 23.3 m (external view) 4.5 mm = 1 μ
2. *Fragilaria brevistriata* Grun. sample 23.3 m (chain of frustules) 3.2 cm = 10 μ
3. *Cyclotella distinguenda* Hust. sample 23.3 m (external view) 4 mm = 1 μ
4. *Stephanodiscus niagarae* var. *insuetus* Khurs.&Log. sample 13.3 m (external view) 2.9 cm = 10 μ
5. *Cymbella ehrenbergii* Ktz. sample 15.4 m (external view) 7 mm = 10 μ
6. *Aulacoseira granulata* (Ehr.) Sim. sample 13.3 m (external view) 2.5 cm = 10 μ

photos by G. K. Khursevich

PLATE II

1. *Cyclotella cyclopuncta* Håkansson & Carter sample 15.4 m (morphotype 1, external view) 5.5 mm = 1 μ
2. *Stephanodiscus rotula* (Kütz.) Hencley sample 16.4 m (external view) 2 cm = 10 μ
3. *Cyclotella schumanni* (Grun.) Håkansson sample 23.3 m (external view) 5 mm = 1 μ
4. *Cyclotella schumanni* (Grun.) Håkansson sample 23.3 m (internal view) 5 mm = 1 μ
5. *Aulacoseira ambigua* (Grun.) Sim. sample 13.3 m (external view) 3.5 mm = 1 μ
6. *Aulacoseira* – flora sample 13.3 m (external view) 2.5 cm = 10 μ

photos by G. K. Khursevich

STRESZCZENIE

Korelacja wyników szczegółowej analizy pyłkowej uzupełnionej o analizę glonów z gromady zielenic oraz analizę okrzemek, występujących obficie w osadach kopalnego jeziora w Brusie na Polesiu Lubelskim, pozwoliła nie tylko na jednoznaczne wykazanie wieku badanej serii osadów organogenicznych, które dotychczas były sytuowane w różnych pozycjach stratygraficznych, lecz również na odtworzenie rozwoju jeziora i zmian panujących w nim warunków paleoekologicznych. Historia roślinności zapisana w osadach z Brusa obejmuje okres od późnego glacjału sanu 2 poprzez cały interglacjał mazowiecki *s.s.* po wczesny glacjał liwca. Na tle rozwoju roślinności lądowej opisano przemiany zachodzące w fitoplanktonie jeziornym oraz roślinności wodno-szuwarowej. Obecność licznych taksonów wskaźnikowych oraz wysoka zgodność wyników wspomnianych analiz pozwoliły na rekonstrukcję warunków termicznych, troficznych a także wnioski dotyczące wahań poziomu wody w różnych okresach funkcjonowania zbiornika jeziornego.