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Comparison of diatom successions from Mazovian (Poland) and Alexandrian (Belarus) lacustrine interglacial deposits

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Comparative analysis of two profiles (Gvoznitsa, Malorita district, southwestern Belarus and Krępiec, Lublin Upland, eastern Poland) of Alexandrian and/or Mazovian (=Likhvinian, Holsteinian) age shows different diatom successions which are correlated with pollen data. Various species of *Cyclotella*, *Stephanodiscus* and *Aulacoseira* predominate at Gvoznitsa, while the diatom flora at Krępiec is more diverse and includes also *Synedra, Asterionella,* and *Fragilaria* taxa. Certain apparently extinct taxa of *Cyclotella* (*C. comta* var. *lichvinensis* (Jousé) Loginova, *C. comta* var. *pliocaenica* Krasske, *C. temperiana* (Loginova) Loginova, *C. michiganiana* var. *parvula* Loginova (*C. parvula* Loginova), are typical of the Mazovian and/or Alexandrian Interglacial.

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Key words: Poland, Belarus, Mazovian/Alexandrian (Likhvinian, Holsteinian) Interglacial, diatoms, succession, lake development.

INTRODUCTION

The Institute of Geological Sciences of the Polish Academy of Sciences (IGS PAS, Warsaw) and the Institute of Geological Sciences of the National Academy of Sciences of Belarus (IGS NASB, Minsk) have run joint investigations over the last five years, to correlate Pleistocene interglacial profiles using geological, lithological and palaeobotanical data. One result has been a detailed biostratigraphic correlation of the Matveev Rov 2 profile (Mogilev region, eastern Belarus) of the Alexandrian Interglacial in Belarus with a representative profile of the Mazovian Interglacial of Poland at Adamówka (Sandomierz Basin, southeastern Poland) (Khursevich and Marciniak, 1998).

In the present paper, we compare diatom successions in the Mazovian Interglacial lacustrine deposits at Krępiec (Poland) and in the Alexandrian Interglacial lake sediments at Gvoznitsa (Belarus) and correlate them with palynological data.

SITE DESCRIPTION

GVOZNITSA

Borehole 7 near Gvoznitsa village in the Malorita district of the Brest region (Fig. 1) shows fluvioglacial, lacustrine and alluvial deposits of different ages up to 114.7 m thick (Gruzman *et al.*, 1975). Fossil lake sediments in this profile occur between 37.4 and 17.7 m depths and are represented by sandy diatomaceous clays (37.4–27.6 m), laminated clays (27.6–19.7 m) and sandy humic clays (19.7–17.0 m). These are underlain by fluvioglacial sands of the Berezinian Glaciation, and overlain by fluvioglacial deposits of the Dnieper Glaciation (Fig. 2).

Spore and pollen analysis of the fossil lake stratum carried out by Kondratiene (in: Gruzman *et al.*, 1975) shows that these sediments were deposited at the end of the initial phase of the Alexandrian Interglacial — alk_1, during the pre-optimum time interval — alk_2, the climatic/thermal optimum —

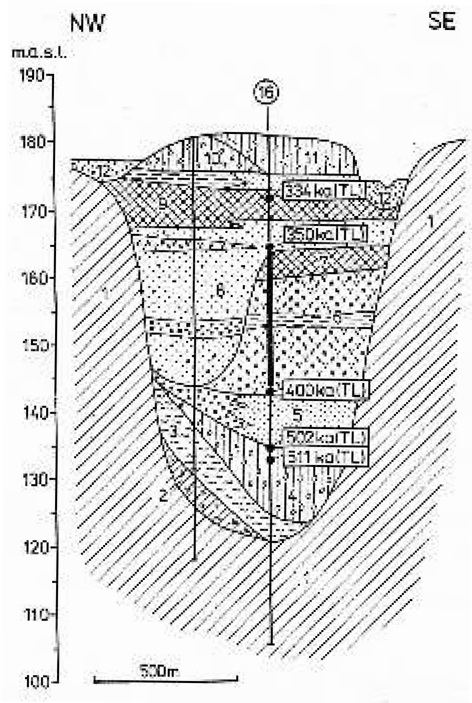

Fig. 1. Location sketch-map of the investigated sites

1 — location of Mazovian Interglacial (Poland) and/or Alexandrian/Likhvinian Interglacial (Belarus) sites with lacustrine deposits; 2 — extent of the Odranian Glaciation (Poland) and/or Dnieperian Glaciation (Belarus, Ukraine)

alk_3 and at the end of this interglacial — alk_5. Pollen zone — alk_4 is absent from this profile due to a sedimentation break. The lithological composition of the lacustrine deposits changes abruptly at 19.7 m depth, where laminated sandy diatomaceous clays are replaced by sandy humic clay. Diatoms were found between 23.7 and 37.4 m depth. This interval was subdivided into three local diatom assemblage zones (L DAZ, GV 1–GV 3; Table 1) by Khursevich and Fedenya (1998).

Table 1

Diatom succession and stages of lake development at Gvoznitsa

L DAZ Khursevich and Fedenya (1998)	Dominant and subdominant diatoms	Description of pollen spectra and pollen zones Gruzman *et al.*(1975)	Stages of lake development (depth)
GV 3b	*Aulacoseira ambigua-A. granulata*	*Abies-Pinus-Picea* and coniferous-deciduous forests, *Carpinus, Alnus* alk_3(=L_3)	IV (24.4–26.0 m)
GV 3a	*Aulacoseira ambigua-A. granulata-Cyclotella krammeri*		III (26.0–31.4 m)
GV 2b	*Aulacoseira-Cyclotella krammeri-Stephanodiscus minutulus-S. immemoratus* et var. *minor-S. rotula-Asterionella formosa*	*Picea-Pinus-Picea* and *Picea-Pinus-Betula* forests with admixture of deciduous trees, *Alnus* alk_2(=L_2)	
GV 2a	*Cyclotella krammeri-C. yclopuncta-C. comta* et var. *lichvinensis-Aulacoseira ambigua-Stephanodiscus niagarae* var. *insuetus-S. rotula*		II (31.4–34.4 m)
GV 1d	*Cyclotella schumannii-C. krammeri-C. comta* et var. *pliocaenica*		I (34.4–37.4 m)
GV 1c	*Cyclotella cyclopuncta-C. krammeri-C. comta* with varieties-*Aulacoseira ambigua*		
GV 1b	*Cyclotella schumannii-C. michiganiana* var. *parvula*		
GV 1a	*Cyclotella schumannii-C. comta*	*Pinus-Betula* forests alk_1(=L_1)	

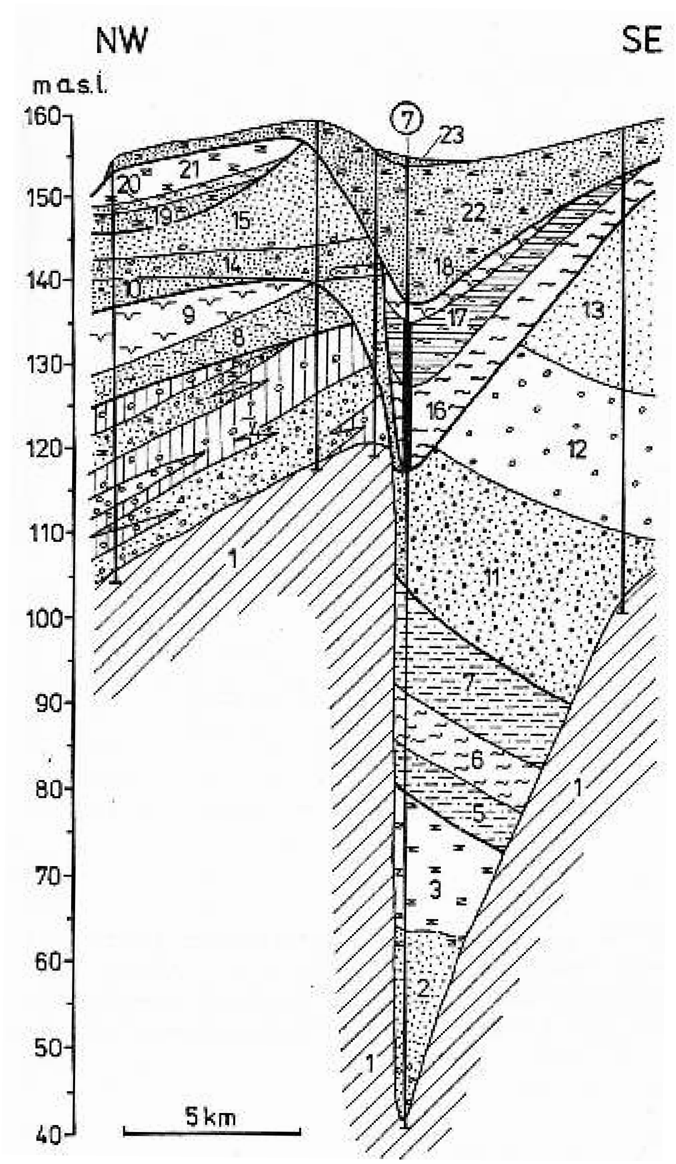

Fig. 2. Schematic cross-section of the region at Gvoznitsa (after Gruzman *et al*., 1975)

Cretaceous: 1 — marl; **Berezinian Glaciation?**: 2 — sands with gravel, 3 — loam; **Berezinian Glaciation**: 4 — till (clay with gravel) and sands with gravel; **Venedian (Ferdynandovian?) Interglacial**: 5 — sandy siltstone, 6 — sandy silts, 7 — sandy siltstone, 8 — sands and silts, 9 — humic clay; **Okanian Glaciation**: 10 — sands and gravels, 11 — sands of varying grain size, 12 — sands with gravels and pebbles, 13 — sands, 14 — sands with gravels and silts, 15 — sands with pebbles; **Likhvinian Interglacial**: 16 — diatomaceous clay, 17 — diatomaceous sandy clay, 18 — humic clay, 19 — sands with loam, 20 — sands and silts, 21 — loam; **Dnieperian Glaciation**: 22 — fluvioglacial sands; **Holocene**: 23 — sands; bold line — part of section 7 with palynological and diatom data (Gruzman *et al*., 1975)

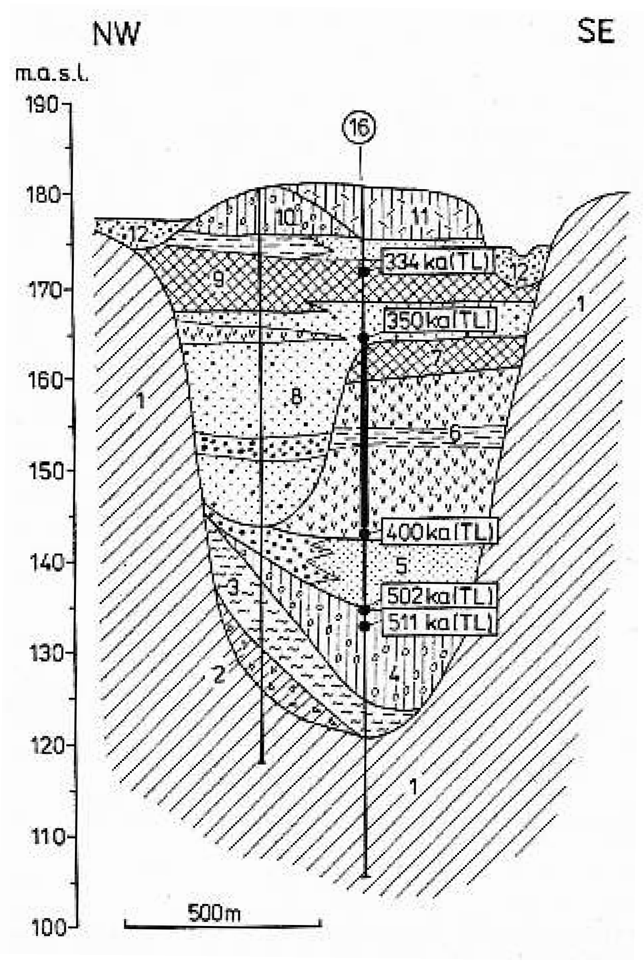

Fig. 3. Geologic cross-section of the region at Krępiec near Lublin (after Harasimiuk and Henkiel, 1981; with TL-dates after Harasimiuk *et al*., 1988; with age interpretation after Lindner and Marciniak, 1998)

Cretaceous: 1 — marl; **pre-Pleistocene**: 2 — rock debris, clay and waste clay; **Pleistocene**: **Sanian 2 (?) Glaciation**: 3 — ice-dammed silt, 4 — till; **Mazovian Interglacial**: 5 — fluvial and slope sand and gravel, 6 — silt and diatomite, 7 — peat and gyttja; **Liviecian (?) Glaciation and Zbójnian Interglacial**: 8 — fluvial sand and gravel with diatomite (silt?) intercalation, 9 — humus sand with silt and peat intercalations as well as silt and sand in uppermost part; **Odranian Glaciation**: 10 — till; **Vistulian Glaciation**: 11 — loess; **Holocene**: 12 — fluvial sand and gravel; bold line — part of section 16 with palynological (Janczyk-Kopikowa, 1981) and diatom data (Marciniak, 1980, 1998)

KRĘPIEC

At Krępiec, Lublin Upland (Fig. 1), the lake deposits (profile Krępiec 16) of the Mazovian Interglacial described by Harasimiuk and Henkiel (1981) fill a valley cutting Cretaceous marls (Fig. 3). These deposits rest on fluvial sands and gravels lying on till of the Sanian 2 Glaciation. The comprise silts and diatomites with intercalations of peat, overlain by peats and gyttja. The lake deposits are overlain by sands, fluvial gravels and humic sands, and higher up there is a till of the Odranian Glaciation and loess of the Vistulian Glaciation (Marciniak, 1980, 1982, 1998).

Janczyk-Kopikowa (1981) here described four pollen zones (I–IV) and related them to the Mazovian Interglacial (Janczyk-Kopikowa, 1991). A rich diatom microflora from depths between 20.4 and 41.35 m was divided by Marciniak (1998) into four local diatom assemblages zones (L DAZ, K-1–K-4) correlated with the pollen zones I–IIIa, b (Table 2).

Table 2

Diatom succession and stages of lake development at Krępiec

L DAZ Marciniak (1998)	Dominant and subdominant diatoms	Description of pollen spectra and pollen zones Janczyk-Kopikowa (1981)	Stages of lake development (depth)
K-4b	Periphyton-*Fragilaria* spp.-*Synedra*-*Aulacoseira italica*	*Carpinus, Abies* IIIb	IV (20.40–23.00 m)
K-4a	Periphyton-*Aulacoseira italica*-*Fragilaria* spp.		
K-3b	*Cyclotella*-*Stephanodiscus*-Periphyton-*Asterionella formosa*	*Taxus, Picea, Alnus* IIIa	III (23.00–28.80 m)
K-3a	*Cyclotella*-*Stephanodiscus*-*Synedra*		
K-2b	*Stephanodiscus*-*Cyclotella*-Periphyton-(*Aulacoseira*)	*Picea, Alnus* II	II (28.80–33.35 m)
K-2a	*Stephanodiscus*-*Cyclotella*-(*Aulacoseira*)-*Synedra*-*Asterionella formosa*		
K-1b	*Stephanodiscus*-*Cyclotella*-Periphyton-*Synedra*-*Fragilaria crotonensis*	*Betula, Pinus* I	I (33.35–41.35 m)
K-1a	*Stephanodiscus*-*Synedra*-*Fragilaria crotonensis*-*Cyclotella*		

DIATOM SUCCESSION AND LAKE DEVELOPMENT

The lacustrine deposits containing diatoms in the profiles at Krępiec (Poland) and at Gvoznitsa (Belarus) were deposited almost in the same time interval of the Mazovian Interglacial of Poland and/or the Alexandrian Interglacial of Belarus according to pollen analysis: from the initial phase up to the climatic (thermal) optimum inclusive. However, the four stages of diatom succession show differences (Tables 1 and 2). Characteristic *Cyclotella* and *Stephanodiscus* taxa from Gvoznitsa and Krępiec are illustrated in Figs. 4–7.

STAGE I

In the Gvoznitsa 7 profile the first stage of lake development (local diatom assemblage zone — L DAZ GV 1) is comparable with the local diatom zones (L DAZ A 1–A 2b) in the Adamówka I profile (Marciniak, 1998) and L DAZ MR 1 (pollen zone alk_1 and the beginning of zone alk_2) in the Matveev Rov 2 profile (Khursevich and Fedenya, 1998) on the basis of dominant *Cyclotella: C. schumannii* (Grunow) Håkansson or *C. vorticosa* Å. Berg, *C. comta* (Ehrenberg) Kűtzing var. *comta*, *C. comta* var. *lichvinensis* (Jousé) Loginova, *C. comta* var. *pliocaenica* Krasske, *C. cyclopuncta* Håkansson *et* Carter and *C. krammeri* Håkansson. This diatom assemblage reflects an oligotrophic, moderately deep palaeolake in the first stage of its existence.

At that time in the Krępiec 16 profile (Marciniak, 1998) the diatom flora in L DAZ K-1 (pollen zone I) is characterised by diverse planktonic diatoms represented by various species of *Stephanodiscus*, *Cyclotella*, *Synedra*, with common *Fragilaria crotonensis* Kitton and *Asterionella formosa* Hassall. This is evidence of deep, meso-eutrophic palaeolake conditions and seasonal cyclicity of diatom development.

STAGE II

This stage — L DAZ GV 2a (middle part of pollen zone alk_2) in the Gvoznitsa 7 profile is marked by abundant and diverse diatoms including *Cyclotella krammeri, C. cyclopuncta*, *Aulacoseira ambigua* (Grunow) Simonsen, *Stephanodiscus niagarae* var. *insuetus* Khursevich et Loginova and *S. rotula* (Kűtzing) Hendey, indicating eutrophication and a high lake level of palaeolake.

Stage II in the Krępiec 16 profile (L DAZ K-2, pollen zone II) shows equal amounts of *Stephanodiscus* and *Cyclotella* species and an increased content of *Aulacoseira granulata* var. *angustissima* (Műller) Simonsen, typical of eutrophic lakes. This increase corresponds to the preoptimal part of the Mazovian Interglacial.

STAGE III

The diatom assemblage in stage III at Gvoznitsa (L DAZ GV 2b–GV 3a, end of pollen zone alk_2 and the first half of zone alk_3) is characterised by an increase of *Aulacoseira* (*A. ambigua* up to 58% and *A. granulata* (Ehrenberg) Simonsen up to 22%) and by a decrease in the percentages of *Cyclotella* and *Stephanodiscus* species. The latter includes *S. immemoratus* Khursevich *et* Pirumova var. *immemoratus* and *S. immemoratus* var. *minor* Khursevich (probably extinct taxa). This diatom assemblage indicates eutrophication.

At the beginning of the stage III at Krępiec (L DAZ K-3a, lower part of pollen zone IIIa) *Cyclotella* is abundant (up to 40%) and *Stephanodiscus* taxa are less frequent, probably indicating a decrease in eutrophication and higher water level. Later on (L DAZ K-3b, upper part of pollen zone IIIa) the number of planktonic diatoms diminished and the periphyton increased. This was associated with a slight shallowing of the palaeolake.

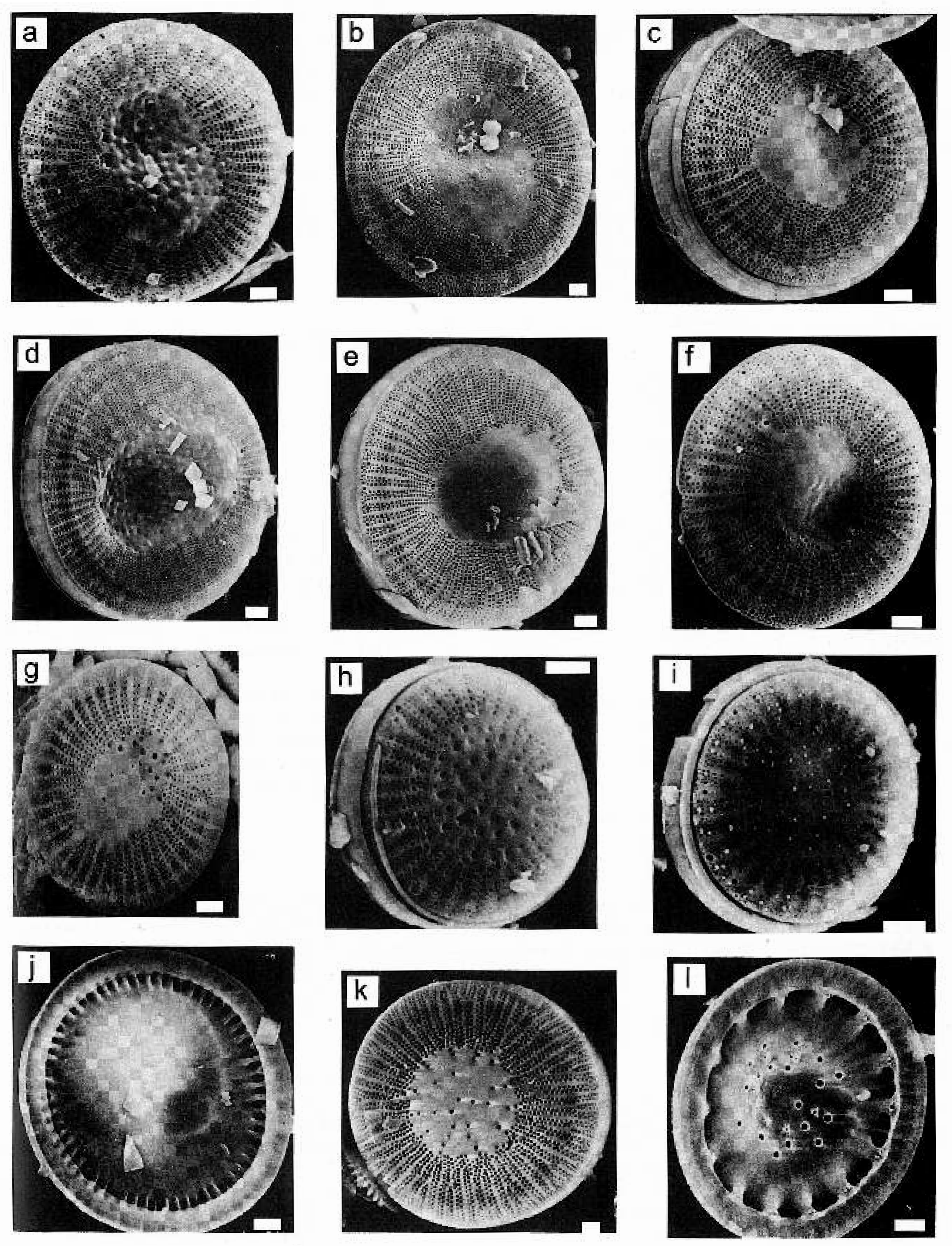

Fig. 4. Dominant species of *Cyclotella* from Gvoznitsa profile

a–f, j — *Cyclotella schumannii* (Grunow) Håkansson (a–f — external view, j — internal view), g — *Cyclotella michiganiana* var. *parvula* (Loginova) Loginova (external view), h and i — *Cyclotella cyclopuncta* Håkansson et Carter (external view), k and l — *Cyclotella comta* var. *lichvinensis* (Jousé) Loginova (k — external view, l — internal view); scale bar —1 μm

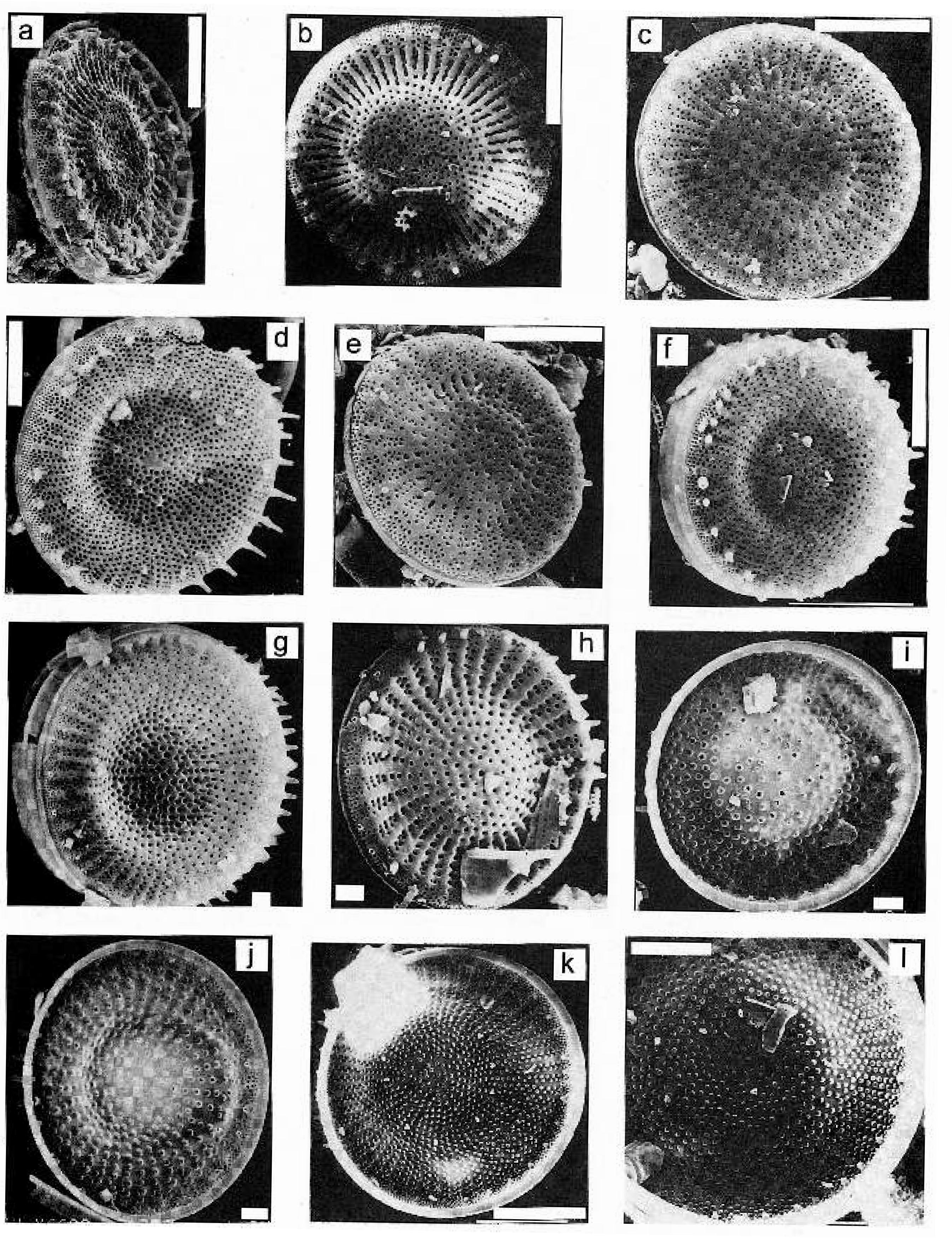

Fig. 5. Dominant species of *Stephanodiscus* from Gvoznitsa profile

a–e, k — *Stephanodiscus niagarae* var. *insuetus* Khursevich et Loginova (a–e — external view, k — internal view), f and l — *Stephanodiscus rotula* (Kűtzing) Hendey (f — external view, l — internal view), g — *Stephanodiscus immemoratus* Khursevich et Pirumova var. *immemoratus* (external view), h–j — *Stephanodiscus immemoratus* var. *minor* Khursevich (h — external view, i and j — internal view); scale bars: a–f, k and l — 10 μm, g–j — 1 μm

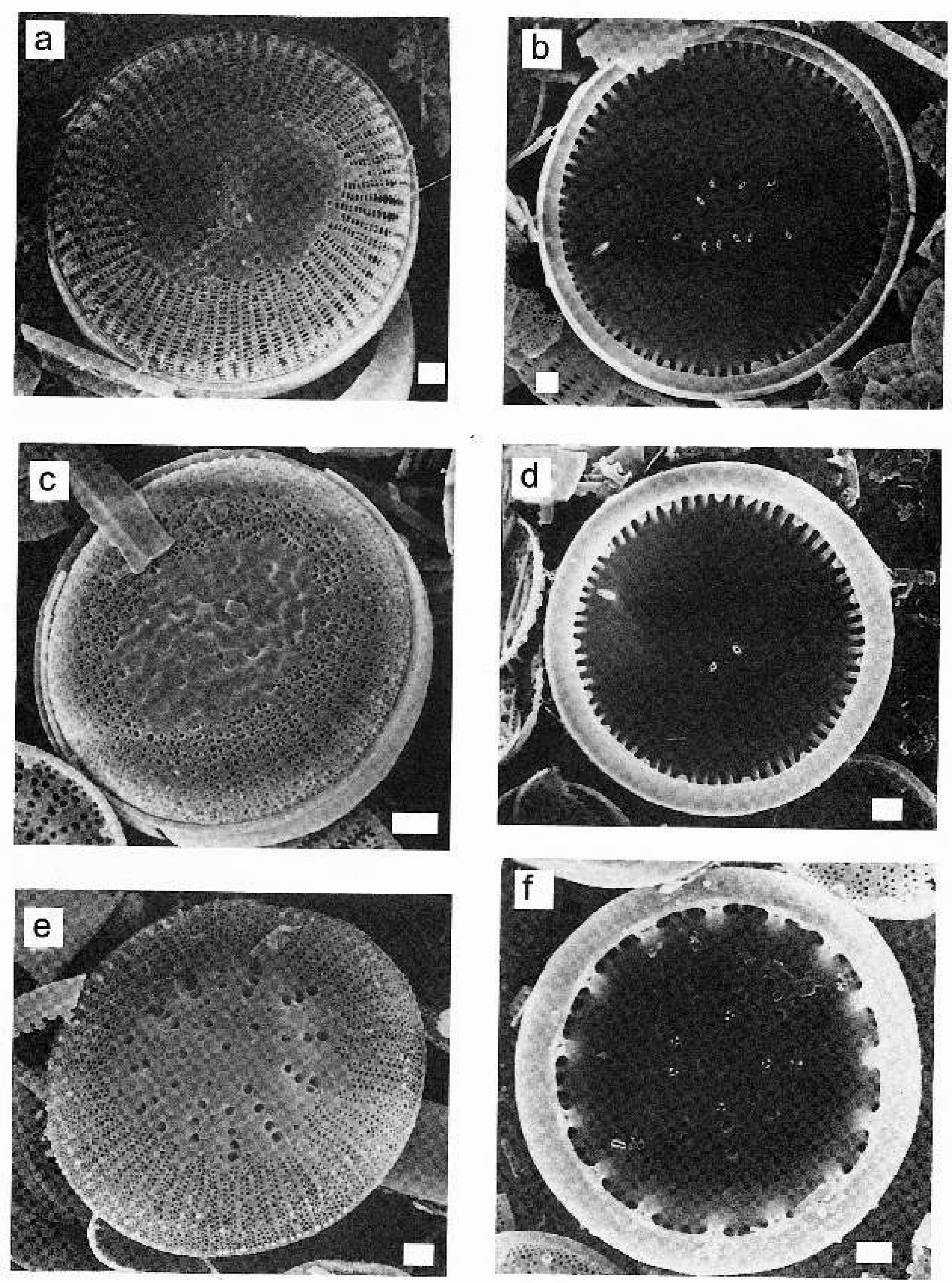

Fig. 6. Dominant species of *Cyclotella* from Krępiec profile

a and b — *Cyclotella schumannii* (Grunow) Håkansson (a — external view, b — internal view), c and d — *Cyclotella* aff. *michiganiana* var. *parvula* (Loginova) Loginova (c — external view, d — internal view), e and f — *Cyclotella comta* var. *lichvinensis* (Jousé) Loginova (e — external view, f — internal view); scale bar: a–f — 1μm

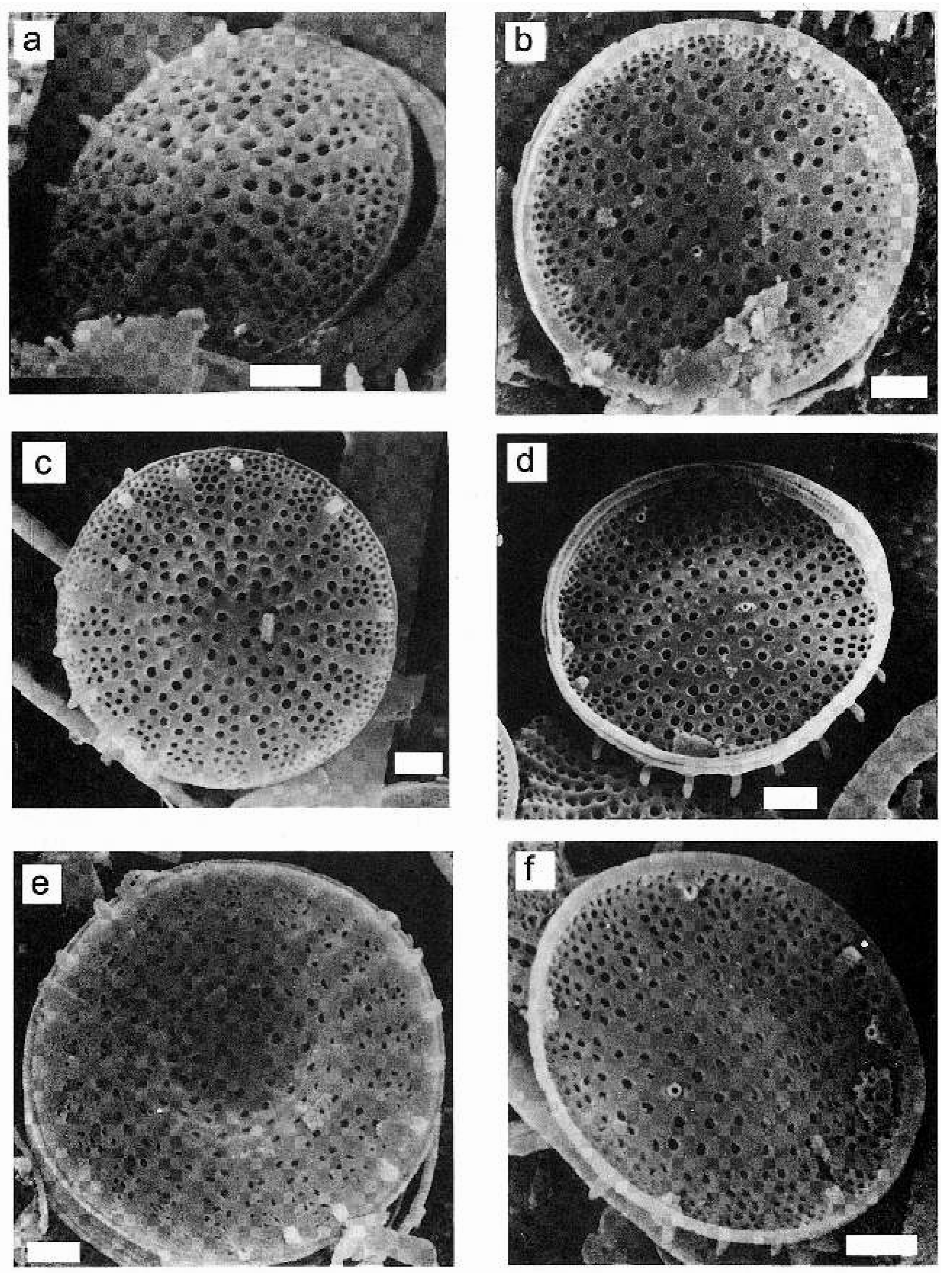

Fig. 7. Dominant species of *Stephanodiscus* aff. *binatus* Håkansson et Kling from Krępiec profile

(a, c, e —external view, b, d, f — internal view); scale bar: a–f — 1 μm

STAGE IV

At Gvoznitsa the diatom flora of stage IV (L DAZ GV 3b, second half of pollen zone alk_3) shows the highest percentage values of *Aulacoseira* species (*A. ambigua* up to 73% and *A. granulata* up to 41%). At present these usually develop in highly eutrophic lakes.

At Krępiec the first part of stage IV (L DAZ K-4a, pollen zone IIIb) is characterised by a dominance of periphytic diatoms (*Epithemia*, *Rhopalodia*, *Navicula* and to a lesser degree *Fragilaria* spp.). *Aulacoseira italica* (Ehrenberg) Simonsen comprises up to 35% of the assemblage. In the second part of this stage (L DAZ K-4b, pollen zone IIIb) a rise in the frequency of *Fragilaria* spp. suggests overgrowth and shallowing of the lake.

FINAL REMARKS

Two types of diatom successions in the interglacial deposits of Mazovian and/or Alexandrian (=Likhvinian, Holsteinian) age are distinguished. One is represented at Gvoznitsa by the following succession: 1. *Cyclotella*–2. *Cyclotella-Aulacoseira-Stephanodiscus*–3.*Aulacoseira-Cyclotella-Stephanodiscus* –4. *Aulacoseira*. This is a planktonic and oligo-meso-eutrophic type of diatom succession reflecting conditions in a deep lake during four stages (I–IV) of lake development during the Alexandrian Interglacial (pollen zones alk_1–alk_3).

The profile at Krępiec shows another type of diatom succession: 1. *Stephanodiscus-Synedra-Fragilaria crotonensis-Cyclotella*–2. *Stephanodiscus-Cyclotella-Aulacoseira*–3. *Cyclotella-Stephanodiscus-Synedra-Asterionella formosa*–4. *Periphyton s.l-Aulacoseira-Fragilaria* spp. This is a planktonic-benthic/periphytic and meso-eutrophic type of diatom succession from a moderately deep-water lake (during stages I–III of lake development, pollen zones I–IIIa) toward a shallow and overgrown basin in the last stage (IV) of the Mazovian Interglacial (pollen zone IIIb).

The profiles at Adamówka and at Matveev Rov show a third different type of diatom succession represented mainly by two genera: *Cyclotella-Fragilaria* (Khursevich and Marciniak, 1998). There is a planktonic-benthic/periphytic, generally oligo- and meso-eutrophic type of diatom succession reflecting lake changes from moderately deep to shallow lakes at both sites during Mazovian/Alexandrian time (at Adamówka — pollen phytophases I–IIIa, b; at Matveev Rov — pollen zones alk_2–alk_4; Shalaboda, 1989).

The Mazovian/Alexandrian age of the lacustrine sediments is confirmed by the presence of various representatives of the genus *Cyclotella* (Kűtzing) Brébisson including such typical, probably extinct taxa as: *C. comta* var. *lichvinensis*, *C. comta* var. *pliocaenica*, *C. temperiana* (Loginova) Loginova, *C. michiganiana* var. *parvula* Loginova (C. parvula Loginova), (Figs. 4–6).

The deposits of the Alexandrian Interglacial include species of *Stephanodiscus* (*S. alexandriensis* Khursevich, *S. niagarae* var. *insuetus*, *S. immemoratus* var. *immemoratus* et var. *minor*, Fig. 5) which most probably died out at the end of Middle Pleistocene (Khursevich, 1989, 1999).

In the Mazovian profile at Krępiec various small *Stephanodiscus* species are characteristic including *S.* aff. *binatus* Håkansson et Kling (Marciniak, 1998 and Fig. 7 a–f). In our SEM material we could not observe the location of the rimoportula and spine at the same costa on the external valve surface as it is shown by Håkansson and Kling (1990, figs. 1–8). This species is similar to *Stephanodiscus* cf. *minutulus* (Ktzing) Cleve et Möller *sensu* Håkansson and Kling (1990, figs. 29–32).

Many transitional forms of *Cyclotella* and *Stephanodiscus*, difficult to identify, occur in different sites of the Likhvinian/=Alexandrian, Mazovian Interglacial fossil lakes in Russia, Belarus and Poland (Loginova, 1979, 1982; Khursevich and Loginova, 1980; Marciniak, 1986, 1998). Nevertheless, the (probably extinct) taxa noted above, of these genera are broadly useful in biostratigraphy.

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