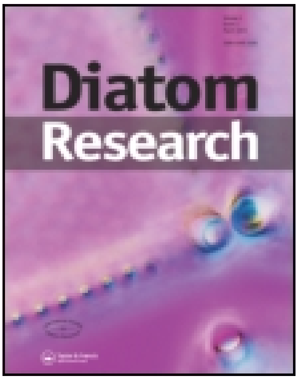

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CAMPYLODISCUS CLYPEUS (EHRENBERG) EHRENBERG EX KÜTZING: TYPIFICATION, MORPHOLOGY AND DISTRIBUTION

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CAMPYLODISCUS CLYPEUS (EHRENBERG) EHRENBERG EX KÜTZING: TYPIFICATION, MORPHOLOGY AND DISTRIBUTION

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Original material of *Campylodiscus clypeus* (Ehrenberg) Ehrenberg ex Kützing, which is also the type of the name of the genus *Campylodiscus* Ehrenberg ex Kützing, was studied and a specimen has been selected to serve as lectotype. The size variation in two populations from two localities from two different times was analyzed. Because of its unusual habitat – a spring flowing out of a diatomite – the geology of the type locality is recapitulated and the taxon's published and unpublished distribution is recorded. This diatom is alive today occurring mainly in waters of higher conductivity but apparently had its peak in subfossil times at least at the type locality.

INTRODUCTION

C.G. Ehrenberg described the taxon *Campylodiscus clypeus* as *Cocconeis ? clypeus* in 1838 (p. 195) from diatomite at the locality Franzensbad in Bohemia, now called Františkovy Lázně Spa in the Czech Republic. He found it again in 1839 (p. 176) dominating the diatomite from Eger, now called Cheb, close to Františkovy Lázně Spa. In this paper he also mentioned the genus name *Campylodiscus* for the first time in the combination *Campylodiscus clypeus*. He introduced the genus name again in 1840 (p. 205) by giving again a description of *C. clypeus* and by describing 3 additional *Campylodiscus* species (*C. noricus* Werneck, *C. remora, C. echeneis)*. But since Ehrenberg never gave a description of the genus *Campylodiscus*, this genus cannot be attributed to him but to Kützing who validated the genus with a description and therefore also Ehrenberg's recombination and additional taxa in 1844 (p. 59). Boyer (1927: 548) chose *C. clypeus* as type of the name of the genus.

For several reasons, we were interested in its true identity and its distribution: 1), it is the type for the name of the genus *Campylodiscus*; 2), it has a very unique type locality; 3), it has been recorded from contradictory habitats and 4), it has only sporadically named in the literature. Therefore, Ehrenberg's original material of *Campylodiscus clypeus* in the Ehrenberg Collection was searched for, then studied for its morphology and size range using the LM and SEM, and a lectotype was designated. In addition, more recent specimens from the same area were compared and its current distribution based on slides and literature was compiled. In

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addition to this publication, the nomenclatural information of the discussed taxon will be made available via the AlgaTerra Information System (Jahn & Kusber 2006).

MATERIALS AND METHODS

The following materials from the following Collections were examined:

A. Ehrenberg Collection, Institut für Paläontologie, Museum für Naturkunde, Humboldt Universität zu Berlin (BHUPM):

1. Mica-preparations of diatomite (Kieselguhr von Franzensbad in Böhmen) from Franzensbad in Bohemia (Františkovy Lázně Spa, Czech Republic); Kasten 43, Buch 1 [4301]; drawing sheet No. 2226 (for the relevant part of it see Fig. 4); sample No. 2814.
2. Mica-preparations of diatomite from Eger (Cheb, Czech Republic); Kasten 43, Buch 2 [4302]; drawing sheet No. 2225 (for the relevant part of it see Fig. 3); sample No. 2815. Ehrenberg (1839) writes about this sample "In einem ..bei Eger entdeckten .. gelblichen Kieselguhr fand sich als Hauptmasse *Campylodiscus clypeus*". This material also served for the statistical analyses of valve length and width and number of costae (see Figs 1, 2).

B. Moravian Museum in Brno, Hydrobiological laboratory, Czech Republic (BRNM):

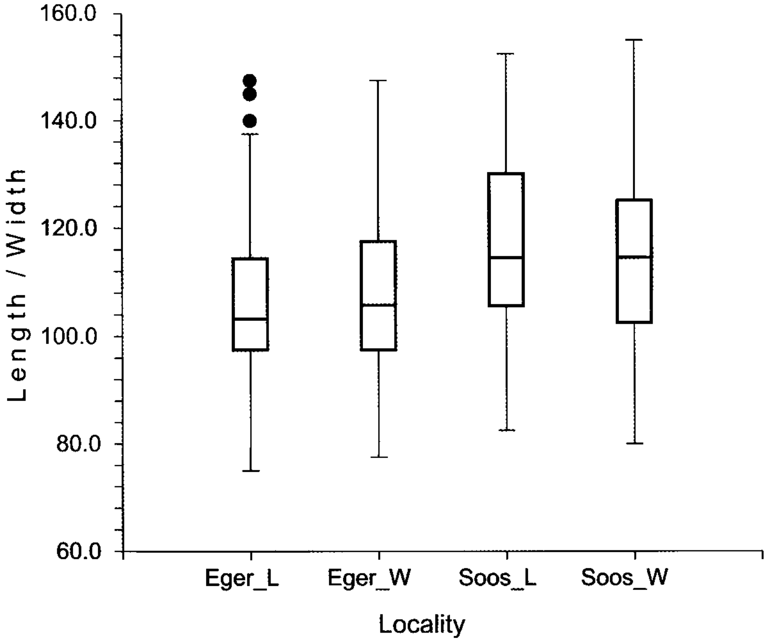
3. J. Bílý Collection; pleurax-preparations of peat bog sample from Soos in Františkovy lázně Spa, slide "Soos, křemelina v rašelině, 13/3 1957". This material also served for the statistical analyses of valve length and width and number of costae (see Figs 1, 2).
4. J. Bílý Collection; pleurax-preparations of water from the rest of saline lake near Čejč (South Moravia, Czech Republic), slide "Čejčské jezero, hlavní svodnice 6/6 1927" and samples of ash from the same locality "BRNM diat 1808" and "BRNM diat 1805"(the data of all 8000 slides from J. Bílý Collection will be published in Skácelová & Konečná 2006).
5. Samples in formaldehyde, collected by O. Skácelová, from National Nature Reserve Soos near Františkovy Lázně Spa; sample "V.1997, the tributary of the Vonšovský Brook" and sample "1995, mofettes – pool above the diatomite".

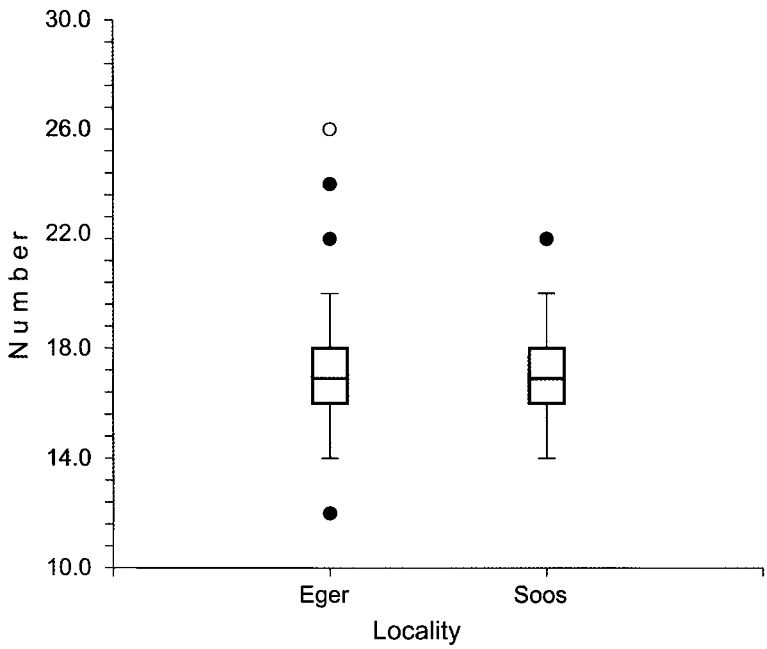
C. Natural History Museum of London (BM):

6. Slide B.M. 67315 – SPA Bohemia, salt deposits. 78 – collected by Ralfs
7. Slide B.M. 67322 – Eger Bohemia – collected by Ralfs
8. Slide B.M. 68367 – Soos Bohemia – collected by Saxton
9. Slide B.M. 68842 – Franzensbad Bohemia – collected by Saxton

Photomicrographs from the Ehrenberg Collection, Humboldt University, Berlin, were taken with an Olympus BX 51 light microscope with an Olympus DP 50 digital camera. The objectives used were Olympus SPlan 80×/N.A.0.75 and UPlan Fl 40×/N.A.0.75. Scanning electron microscopy was done at the Botanical Museum Berlin-Dahlem using a Philips 515 operating at 30 KV.

Three morphometric parameters were measured in each of 200 frustules from material No. 2 and 3: length and width as well as the number of costae per 100 µm. According to the terminology for Surirellaceae (Ruck & Kociolek 2004) cell length was taken along the apical axis – parallel to the central hyaline area – and cell width was taken along the transapical axis – perpendicular to the first one. For statistical analysis (Repeated Measures ANOVA and Paired T-Test) of morphological variability NCSS 2000 software was used.





Figs 1 & 2. Comparison of two populations: Eger/Cheb (material No. 2) and Franzensbad /Soos (material No. 3). **Fig. 1**: cell length (L) and width (W) [in μm]. **Fig. 2**: density of costae [number in 100 μm].

OBSERVATIONS

Ehrenberg's original material from Franzensbad/Soos

***Campylodiscus* Ehrenberg ex Kützing**, Kieselschal. Bacill., p. 59. 1844.

Kützing (1844: 59) gives a short description of the genus, therefore validating it: "Individua singularia, disciformia; discus curvatus l. tortuosus, rotundato-ellipticus radiatus."

***Campylodiscus clypeus* (Ehrenberg) Ehrenberg ex Kützing**, Kieselschal. Bacill., p. 59. pl. 2. figs V. 1–6. 1844.

Basionym: *Cocconeis*? *clypeus* Ehrenberg, Infusionsthierchen, p. 195. 1838.

Campylodiscus clypeus (Ehrenberg) Ehrenberg, Monatsberichte 1838, p. 176, 1839. nom. inval.

Lectotype (designated here): BHUPM, Ehrenberg Collection, Geographical Preparation No. 430103a bl; the valve representing the lectotype is illustrated in Fig. 5; see also Fig. 6 on the same preparation.

Type locality: Kieselguhr von Franzensbad in Böhmen [diatomite from Františkovy Lázně Spa, West Bohemia, Czech Republic].

When validating Ehrenberg's recombination, Kützing (1844) refers to Ehrenberg's (1838) basionym *Cocconeis*? *clypeus*. Ehrenberg (1838 p. 195) describes this taxon as "c. testula orbiculari, ampla, plana, leviter involuta, extus laevi, intua interrupte radiata." The figure was published much later in Ehrenberg's Mikrogeologie (1854) on plate 10; the basis is his drawing on drawing sheet No. 2226 (see Fig. 4). Ehrenberg's original Latin diagnosis included a "?". The question mark means that he was not sure about its future classification within the genus (see also *Navicula*? *arcus*, basionym of *Hannaea arcus* (Ehrenb.) Patr. as described in Bixby & Jahn 2005). Ehrenberg's unpublished original illustration of *Campylodiscus clypeus* (see our Fig. 4) is consistent with the specimens found on the mica No. 430103a bl (Figs 5, 6).

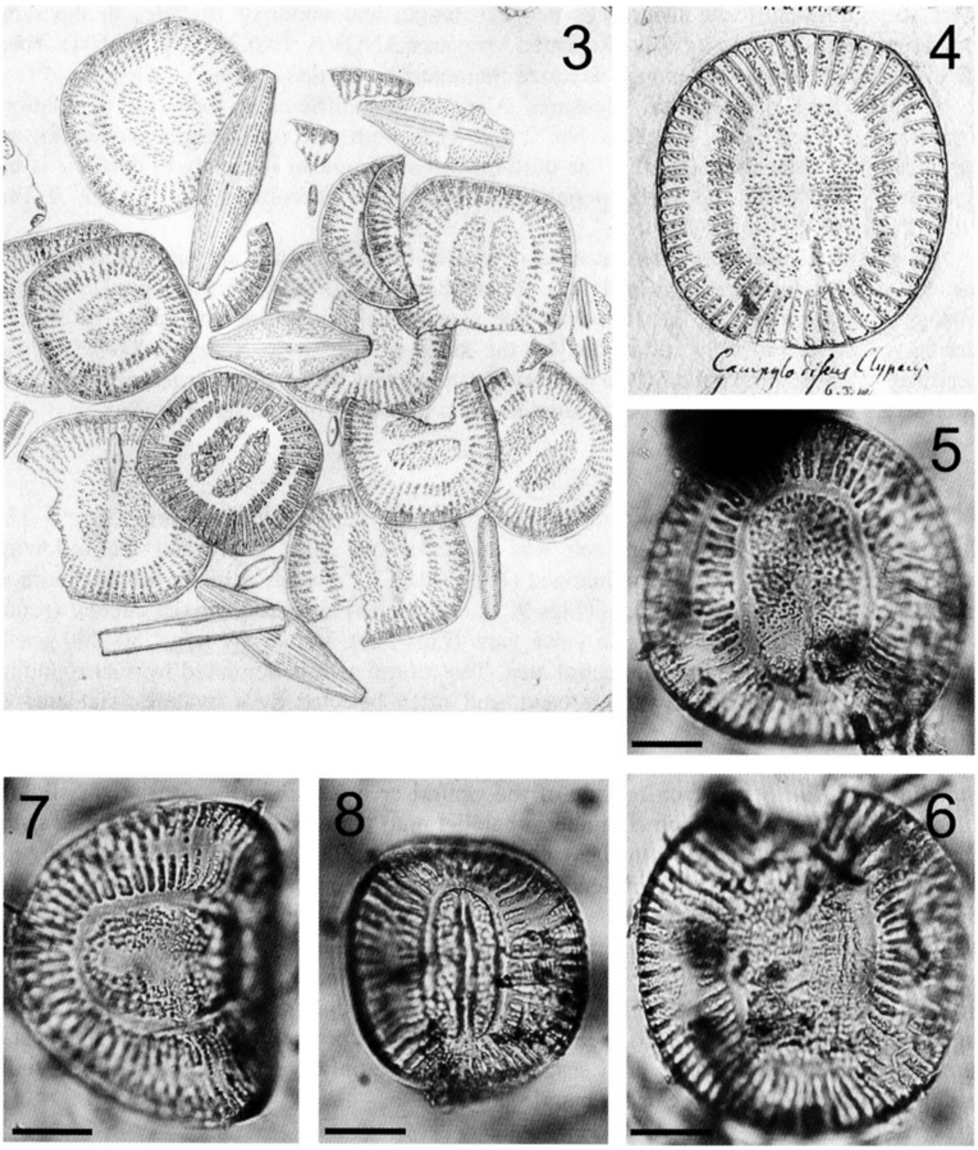
Although Ehrenberg's mica-preparations contain many *C. clypeus* specimens, however, the part of the original sample (No. 2814) used for SEM-observations contained no *C. clypeus* specimens. Instead, the material was dominated by *Pinnularia* sp. We therefore studied the Eger material in detail, where Ehrenberg had found *C. clypeus* dominating the diatomite.

Ehrenberg's material from Eger/Cheb

Shortly after Ehrenberg reported *C. clypeus* from Franzensbad (1838), he found it in Eger (1839) which is located close to Franzensbad and part of the Cheb Basin. The specimens found in this sample are very similar to the Franzensbad's material (Figs 7, 8). Fortunately, the diatomite consists almost completely of this species accompanied by *Anomoeoneis sphaerophora* and shows the full range of morphological variability (Figs 1, 2; see also part of his drawing sheet No. 2225 in Fig. 3). There are no significant differences between the length and width of the frustules, thus this species can be characterized by its diameter (Fig. 1). General and detailed views of the frustule are on the micrographs (Figs 7–18).

Further historical material from Franzensbad/Soos and from Eger/Cheb

The material from Franzensbad/Soos and from Eger/Cheb must have been shared by diatomists across Europe. Although Ehrenberg did not publish his drawings until 1854, Kützing shows a number of typical figures already in 1844 (figs V. 1–6). All slides at the BM in London (see Materials Nos 6–9) were dominated by *C. clypeus,* some variation was observed in the accompanying species. *Pinnularia* sp. was rare in Eger/Cheb (only 1 specimen found in material No. 7); it was more common in the Franzensbad/Soos materials. All slides in BM had *Anomoeoneis sphaerophora* f. *costata* and *A. sphaerophora* f. *sculpta* as accompanying species but these were more diverse and abundant in the Eger/Cheb material.



Figs 3–8. Ehrenberg's diatomite material of *Campylodiscus clypeus* from the Cheb Basin, Bohemia, Czech Republic, in the Ehrenberg Collection (BHUPM); **Fig. 3**: part of drawing sheet No. 2225, Eger/Cheb; **Fig. 4**: part of drawing sheet No. 2226, Franzensbad/Soos; **Figs 5–8**: LM-photographs from mica preparations; scale bars = 30 μm; **Figs 5, 6**: from type locality Franzensbad/Soos, **Fig. 5**: valve on Preparation 430103a bl representing the lectotype; **Fig. 6**: another valve on Preparation 430103a bl. **Figs 7, 8**: valves from locality Eger/Cheb, **Fig. 7**: on Preparation 430201a bl; **Fig. 8**: on Preparation 430201a bl.

Comparison between historical and recent material from Eger/Cheb and Franzensbad/Soos

Materials collected at Soos near Františkovy Lázně Spa by Julius Bíly in 1957 and by Olga Skácelová in 1997 also are similar to Ehrenberg´s material. Material No. 3 collected by Bílý has been used for morphometrical comparison with Ehrenberg's material (Figs 1, 2).

There were no significant differences between length and width of frustules in the same population from the same locality (Repeated Measures ANOVA; $F=0.36$; $P=0.549104$). Thus, one dimension (diameter) is enough as a size characteristic for this species.

On the base of Repeated Measures ANOVA, the differences between populations (localities Eger and Soos; materials No. 2 and 3) in both size (cell length and width) are significant ($F=15.88$; $P=0.000095$). The third measured parameter – density of costae – is not significantly different between populations (localities) according to Paired T-Test ($t\ 0.05(2)=0.6639$; $P=0.508$).

In summary, frustules from recent Franzensbad/Soos material are significantly larger than those from historical material from Eger/Cheb without any significant difference in density of costae (Figs 1, 2). However, the size of cells is inside the range of species variability and is probably influenced by the stage of life cycle. *Campylodiscus clypeus* specimens were accompanied by the same attendant species *Anomoeoneis sphaerophora* as in Ehrenberg's Eger material, thus both materials seem to come from the same deposit.

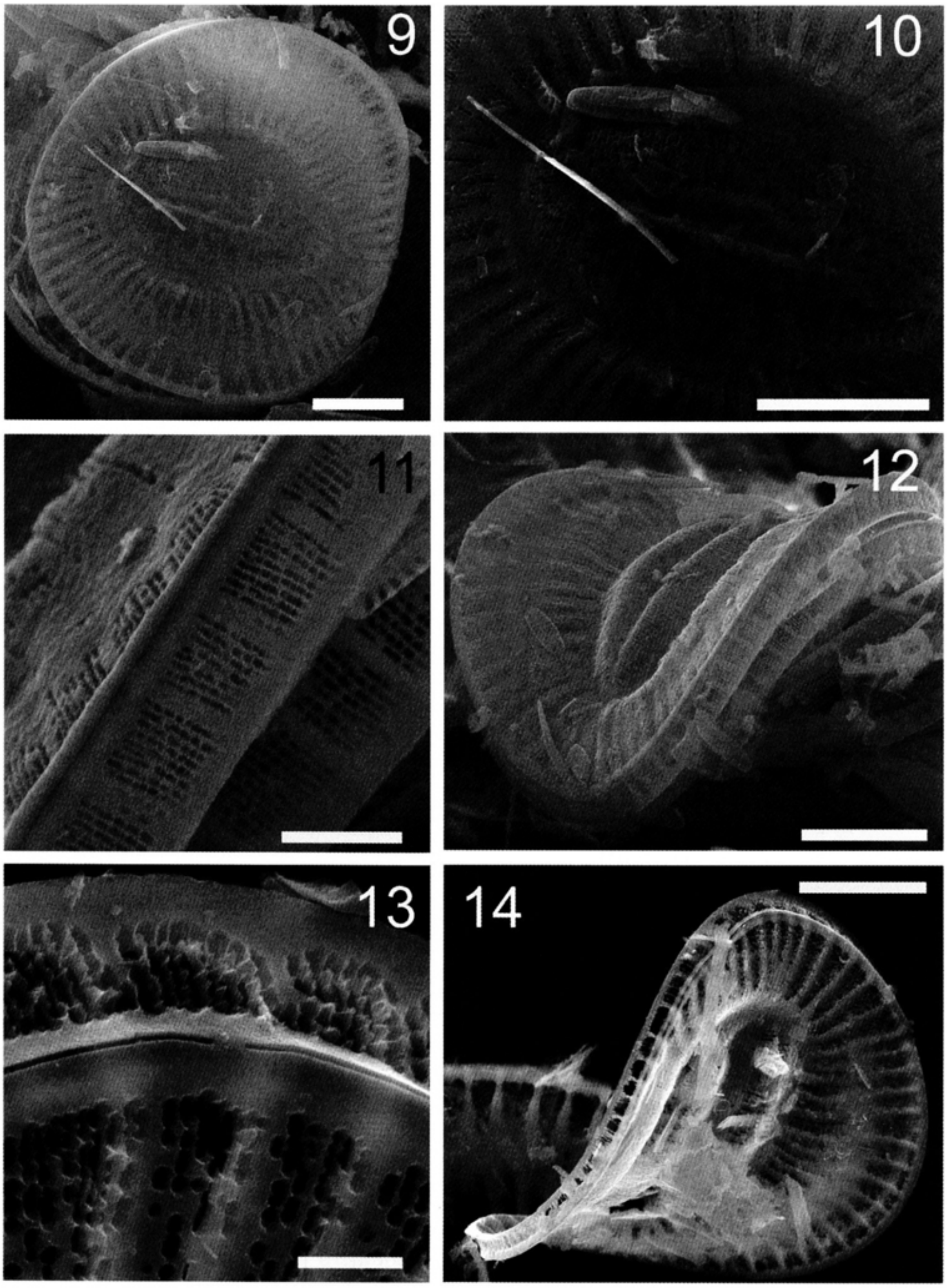
Species description

All frustules from the above localities showed the same general features (Figs 3–18). Ehrenberg's material from Eger/Cheb was used for our SEM study and the following morphological features can be summarized (Figs 9–18). *C. clypeus* exhibits solitary more or less heavily bent saddle-shaped cells (Figs 9, 12, 14, 15, 16) appearing almost circular (round to squarish) in outline when lying in valve view (Figs 5–9). Valves are large, 80–200 µm in diameter with a distinct elliptical central area. The central area is delimited by a surrounding heavily silicified – in LM hyaline – band, and often bisected by a hyaline axial area or silicified axial band (Fig. 10), which are raised internally and depressed externally (Figs 12, 16). The central area contains transapically-directed rows of puncta on either side of the axial area (Fig. 10). The valve face outside of the central area – the skirt – consists of slightly radiating rows of puncta which continue in parallel onto the mantle (Figs 11, 13). The striae are separated at intervals by heavy valve costae (10–20 per 100 µm) which are supporting the valve face by connecting the silicified band of the central part with the skirt and the mantle (Figs 14, 15, 17). In some places the costae and the striae merge and seem to form another hyaline band almost half way between the margin and central area (arrowhead in Fig. 18). The raphe lies around the periphery of the valve at the edge between valve face and mantle (Figs 11, 12) and is interrupted (Fig. 13). On the inside, the marginal raphe opens into a canal which has strongly silicified walls, tied together at intervals not only by the main valve costae but also by additional short fibuloid costae which bridge only the canal but do not continue onto the main part of the valve or the mantle (Fig. 17).

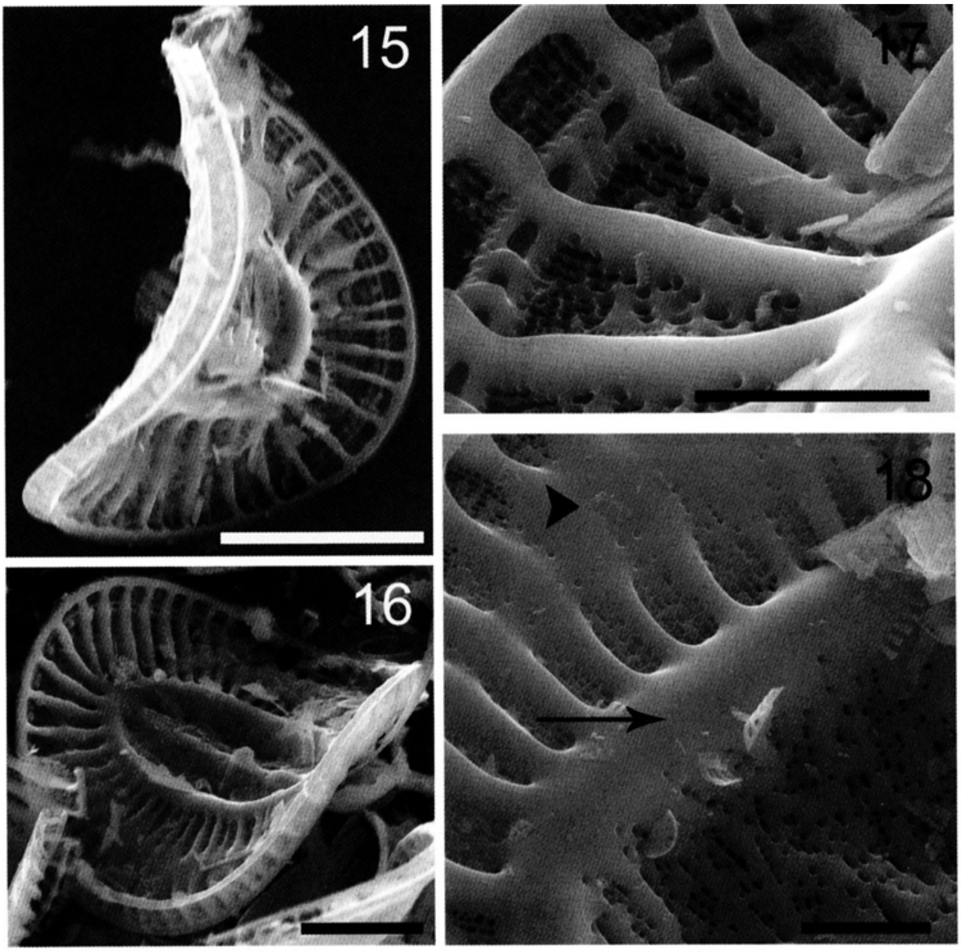
DISCUSSION

Geology of the type locality

The type locality Franzensbad (Františkovy Lázně Spa) is protected since 1992 as a unique saline locality named National Nature Reserve Soos near Františkovy lázně (coordinates 50° 07' 04" N; 12° 19' 35" E), the locality Eger/Cheb is located very close to Franzensbad (coordinates 50° 04' 33" N; 12° 22' 16" E). Both localities are situated in the Cheb basin. The Soos depression development is on the surface of Pliocene sands and sandy clays; it is filled with post-glacial organogenic sediments, i.e. peat, fen-peat and diatomaceous earth. The character of the holocene organogenic sedimentation was strongly affected by the issue and the chemical composition of mineral waters. Spring waters rise from fissures in the crystalline basement of the Cheb basin. From a hydrochemical viewpoint, these



Figs 9–14. Ehrenberg's diatomite material of *Campylodiscus clypeus* from Eger/Cheb. SEM; external view of frustules; **Figs 9, 12, 14**: entire valves in different views, notice the strong saddle shape of the valve; **Fig. 10**: detail of center part with depressed surrounding hyaline band and axial area; **Fig. 11**: detail of valve showing the raphe at the edge of margin and the parallel striae on the mantle; **Fig. 13**: detail of raphe showing the interrupted raphe fissure and corroded punctae of radial striae. **Fig. 14**: heavy valve costae connecting the central area with the mantle. Scale bars = 40 µm (Figs 9, 10, 12, 14), 10 µm (Fig. 11), 5 µm (Fig. 13).



Figs 15–18. Ehrenberg's diatomite material of *Campylodiscus clypeus* from Eger/Cheb. SEM; internal view of frustules; **Figs 15, 16**: entire valve in different views and saddle shapes; **Fig. 16**: showing the heavy valve costae, the depressed axial area and the depressed hyaline band surrounding the central part; **Fig. 17**: details of interior raphe construction with valve costae holding together the valve face and mantle and shorter fibuloid costae bridging only the raphe canal; valve is corroded; **Fig. 18**: details of the hyaline band surrounding the central part of the valve which is heavily silicified (see arrow); places with merging costae and striae, forming another hyaline band (see arrowhead); Scale bars = 40 µm (Fig. 15), 30 µm (Fig. 16), 10 µm (Figs 17, 18).

are waters of three types: sodium sulphate, sodium bicarbonate and calcium-magnesium bicarbonate. Their total dissolved solid contents range from 100 to 6 280 mg l^{-1}. Diatom-bearing sediments have only been deposited in the southern part of the basin. They form a lenticular body with a convex central part known as the diatomite shield, which passes laterally into *Phragmites* and *Carex* fen-peat or peat. Legler (1939) differentiated on floristical grounds three types of diatomaceous earth: "*Anomoeoneis*-Gur", "*Pinnularia*-Gur" and "*Nitzschia*-Gur". *Campylodiscus clypeus* was reported by Řeháková (1990) from "black diatomaceous earth" dominated by *Anomoeoneis sphaerophora*. In the postglacial sediments of the Soos basin she identified more than 120 taxa of subfossil diatoms; she also mentioned, that with only a few exceptions these taxa are still living in the area. It is unclear from her remarks whether she found any specimen of *C. clypeus* alive in her material. Franzensbad is an important locality for *Anomoeoneis sphaerophora* varieties (Krammer & Lange-Bertalot 1986).

Campylodiscus clypeus specimens were collected near Franzensbad over a century later by Julius Bílý in 1957 (unpublished data, see material No. 3 and results) and by other phycologists (Brabez 1941, Procházka 1924) and dead frustules were found there as recently as 1997 by O. Skácelová (unpublished data, material No. 5; see results). However, there is no evidence supporting the occurrence of extent *C. clypeus* at this locality at the present time. All frustules found in samples of Olga Skácelová were morphologically similar to those found in Ehrenberg's and Julius Bílý's material, including accompanying species. In this locality we are supposing the fossil origin of these frustules, which are being washed up from the diatomite in the subsoil or are taken up with gas effluxes (mofettes).

Ehrenberg's materials from Franzensbad/Soos and Eger/Cheb originate from the same Cheb basin but from different types of diatomaceous earth, which can be distinguished according to their typical representatives – *Anomoeoneis* or *Pinnularia* (Legler 1939). Statistical evaluation of the materials from Franzensbad and Eger showed that frustules from Franzensbad were significantly larger (Fig. 1).

Distribution

Besides the Cheb Basin, *Campylodiscus clypeus* was also reported from other places in the Czech Republic: Bílina River (Federle 1938) and Ohře River (Sprenger 1931) in Western Bohemia; fishponds near Lednice (Bílý 1929, Zapletálek 1932) and Lake Čejč (Bílý 1926, 1929, material 4) in Southern Moravia. Moravian saline fishponds have been eutrophicated and most have been destroyed during last century. Although there was a tertiary sea at the same place, the origin of Lake Čejč dates later to the quaternary period (Havlíček & Zeman 1979). The locality Čejč was a saline lake (sulphates 800 mg l^{-1}, chlorides 52 mg l^{-1} according to Bílý 1929) and *C. clypeus* was collected there by Bílý (1929). In addition to some fragments of strongly corroded frustules, he also found some frustules, which seem to be more recent and discussed the possibility of recent occurrence (but no real living cells). His assumption of recent occurrence in Čejč cannot be verified, because the lake has recently disappeared, replaced by arable soil. Although Bílý (1929) reported finding extent *C. clypeus* near Františkovy Lázně (collected by Hoffmann), we are not sure of a recent occurrence of *C. clypeus* in the Czech Republic.

Campylodiscus clypeus has been recorded world-wide and alive in coastal and lagoonal habitats (Halden 1929, Werff & Huls 1961, Archibald 1983, Foged 1984, Witkowski 1990). However, as with many taxa of the brackish coastal zone it is not restricted to the marine environment. It is also commonly found in shallow (meso)-haline inland saline lakes in Africa (Gasse 1986, Flower 1993, Carvalho *et al.* 1995), North America (Fritz *et al.* 1993, Carvalho *et al.* 1995), where the dominant anions are often carbonate and sulphate rather than chloride. Conductivity ranged from 2800 to 30200 μS cm^{-1}. The most frequent accompanying species in East African sites was *Anomoeoneis sphaerophora* f. *costata* (Carvalho *et al.* 1995). Compère (1980) reported it also from the African mountain area L'Air, Nigeria. In contrast to these tropical habitats, it was found in greater numbers at the bottom of an arctic freshwater lake (Metzeltin & Witkowski 1996), and it was identified in a slide from the Murrray River, Australia (BM 68587 collected by Saxton).

In Europe, its recent distribution is connected with marine coastal localities such as the North Sea and the Baltic (Krammer & Lange-Bertalot 1988, Hartley *et al.* 1996) and the Gulf of Napoli, Mediterranean Sea (Güttinger 1987). It is also found in inland saline lakes, like Lake Fertö / Neusiedlersee bordering Hungary and Austria (Bílý 1929 – citing Grunow and Pantoczek –, Hustedt 1930, Schmid 1995, Ács *et al.* 1991, Buczkó & Ács 1997), Lake

Velencei in Hungary (conductivity 2000 – 3000 μS cm^{-1}; Ács *et al.* 1991) and Lake Marjal del Moro in Spain (conductivity 5140 μS cm^{-1}; Eva Ács pers. comm.).

It has also been found in rivers. Bílý (1929) reported the findings of alive *Campylodiscus clypeus* also in the Danube close to Vienna (Rudolfsbrücke); historical slides from the estuary of the Thames River, England, contain *C. clypeus* (BM 66932 collected by Ralfs). *C. clypeus* is very common in Romania in the Danube delta lakes near the Black Sea (flooded by seawater); Cărăus (2002) recorded 13 published localities in Romania which also include saline lakes (Trică 1981, Török 2004). It also has been recorded from Poland, but the majority of records originate from lake or coast bottom sediments and seem to be fossil material (Bogaczewicz-Adamczak & Latalowa 1985, Przybylowska-Lange 1976).

The fossil occurrence of *Campylodiscus clypeus* at brackish-marine sites is most obvious for the Baltic Sea and is the name for a stage in the Baltic development called the *Clypeus* limit or *Litorina* limit, where *Campylodiscus clypeus* is characteristic for a lagoonal brackish-marine water environment in the Baltic (Miller 1986). Further fossil occurrences have been recorded from Chile (Paddock & Sims 1977). Interestingly, valves of this diatom are often broken or eroded not only in fossil material like the original material but also in live material of sediments as Flower (1993) demonstrated.

In summary, *Campylodiscus clypeus* is an epipelic diatom (Round *et al.* 1990) living on the bottom. It seems to be widespread around the world but is not very common except in brackish-marine lagoonal seas or hypersaline lakes. It is alive today, but apparently had its peak occurrence, at least at the type locality, in subfossil times.

Concerning its taxonomy, there seem to be no doubts about the identity of *Campylodiscus clypeus*. The type material corresponds to Ehrenberg's description and drawings, and morphologically there is no difference between *C. clypeus* specimens of the type locality Franzensbad and Eger as well as between material from the type locality collected in the 1830s, 1957 and 1997, except for size, which is dependent on stage of life cycle in diatoms. As far as we have seen in LM voucher slides and as documented in published pictures, no confusion seem to have occurred over time about Ehrenberg's idea of *Campylodiscus clypeus* and his concept corresponds to that found in current floras (i.e. Krammer & Lange-Bertalot 1988).

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REFERENCES

ÁCS, É., BUCZKÓ, K. & LAKATOS, G. (1991). A Velencei-tó és a Fertő nádbevonatának összehasonlító algológiai elővizsgálata [Comparative algological study of the reed-periphyton in Lake Velencei and Lake Fertő]. *Bot. Kozlem*, **78**, 95–111.

ARCHIBALD, R. E. M. (1983). The diatoms of the Sundays and great fish rivers in the Eastern Cape Province of South Africa. *Bibliotheca Diatomologica,* **1**, 1–362.

BÍLÝ, J. (1926). Druhý příspěvek ku poznání květeny moravských rozsivek [Second contribution to the diatom flora of Moravia]. *Sborník Přírodovědného klubu v Brně,* **9**, 83–96.

BÍLÝ, J. (1929). Třetí příspěvek ku poznání květeny moravských rozsivek [Third contribution to the diatom flora of Moravia]. *Sborník Přírodovědného klubu v Brně*, **12**, 1–32.

BIXBY, R. J. & JAHN, R. (2005). *Hannaea arcus* (Ehrenberg) R. M. Patrick: Lectotypification and nomenclatural history. *Diatom Research*, **20**, 219–226.

BOGACZEWICZ-ADAMCZAK, B. & LATALOWA, M. (1985). Pozycja stratygraficzna brachicznych osadów dennych dJeziora Žarnowieckiego [The stratigraphic position of brackish-water bottom sediments from the Lake Žarnowiec (N Poland).]. *Acta palaeobotanica*, **25**, 139–148.

BOYER, C. S. (1927). Synopsis of North American Diatomaceae, Part 1. Coscinodiscatae, Rhizoselenatae, Biddulphiatae, Fragilariatae. In: *Proceedings of the Academy of Natural Sciences of Philadelphia*, **78** (supplement), 1–228.

BRABEZ, R. (1941). Zur Kenntnis der Algenflora des Franzensbader und Sooser Thermenbereiches. *Beihefte zum Botanischen Centralblatt A*, **61**, 137–236.

BUCZKÓ, K. & ÁCS, É. (1997). Zonation of periphytic algae in two Hungarian shallow lakes (Lake Velence and Fertő). *Acta Botanica Hungarica*, **40**, 21–34.

CARVALHO, L. R., SIMS, P. A., BATTARBEE, R. W., COX, E. J. & JUGGINS, S. (1995). *Campylodiscus clypeus* (Ehrenb.) Ehrenb. in inland saline lakes. In: *Landscapes and life: studies in honour of Urve Miller* (A.M. Robertson, S. Hicks, A. Åkerlund, J. Risberg & T. Hackens, eds), *PACT*, **50**, 471–484.

CĂRĂUS, I. (2002). Algae of Romania. A distributional checklist of actual algae. *Universitatae din Bacau Studii si cercetari stiintifice biologie*, **7**, 1–620.

COMPÈRE, P. (1980). Algues de L'Air (Niger). *Bulletin du Jardin botanique national de Belgique*, **50 (3/4)**, 269–329.

EHRENBERG, C. G. (1838). *Die Infusionsthierchen als vollkommene Organismen. Ein Blick in das tiefere organische Leben der Natur*. Leopold Voss, Leipzig.

EHRENBERG, C. G. (1839). Vorläufige Anzeige einer bisher unbekannten, tief organischen Natur der Kreidegebirge und über Spuren derselben im Juragebirge. *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich-Preussischen Akademie der Wissenschaften zu Berlin*, **1838**, 175–177.

EHRENBERG, C. G. (1840). Characteristik von 274 neuen Arten von Infusorien. *Bericht über die zur* Bekanntmachung *geeigneten Verhandlungen der Königlich-Preussischen Akademie der Wissenschaften zu Berlin*, **1840**, 197–219.

EHRENBERG, C. G. (1854). *Mikrogeologie. Das Erden und Felsen schaffende Wirken des unsichtbar kleinen selbstständigen Lebens auf der Erde*. Leipzig.

FEDERLE, E. (1938). Die Kieselalgen des Bielaflusses von der Quelle bis zur Mündung. *Lotos*, **86**, 1–44.

FLOWER, R. J. (1993). Diatom preservation: experiments and observations on dissolution and breakage in modern and fossil material. In: *Proceedings of the Twelfth International Diatom Symposium*, Renesse, 1992 (H. van Dam, ed.), 473–484. Kluwer Academic Publishers, Dordrecht (Hydrobiologia **269/270**).

FOGED, N. (1984). Freshwater and littoral diatoms from Cuba. *Bibliotheca Diatomologica*, **5**, 1–124.

FRITZ, S. C., JUGGINS, S. & BATTARBEE, R. W. (1993). Diatom assemblages and ionic characterization of lakes of the Northern Great Plains, North America: a tool for reconstruction past salinity and climate fluctuations. *Canadian Journal of Fisheries and Aquatic Science*, **50**, 1844–1856.

GASSE, F. (1986). East African diatoms. *Bibliotheca Diatomologica*, **11**, 1–201.

GÜTTINGER, W. (1987). Collection of SEM-micrographs of diatoms, Series 1–3. Pura.

HALDEN, B. E. (1929). Kvartärgeologiska diatomacéstudier belysande den postglaciala transgressionen å svenska Västkusten. In: *Geologiska Föreningens i Stockholm Förhandlingar*, **51**, 311–366.

HARTLEY, B., BARBER, H. G. & CARTER, J. R. (1996). *An Atlas of British Diatoms* (P.A. Sims, ed.). 601 pp. Biopress Ltd., Bristol.

HAVLÍČEK, P. & ZEMAN, A. (1979). Kvartérní poměry mezi Kobylím, Brumovicemi a Čejčí na jihovýchodní Moravě [Quartery sediments between villages Kobylí, Brumovice, Čejč in South-eastern Moravia]. *Sborník geologických věd, Antropozoikum*, **12**, 31–55.

HUSTEDT, F. (1930). Bacillariophyta (Diatomaceae). In: *Die Süsswasserflora Mitteleuropas*, **10** (A. Pascher, ed.). 466 pp. Jena.

JAHN, R. & KUSBER, W.-H. (eds) (2006). AlgaTerra Information System [online]. Botanic Garden and Botanical Musuem Berlin-Dahlem, FU-Berlin, 05 April 2006. Available from <http://www.algaterra.org>.

KRAMMER, K. & LANGE-BERTALOT, H. (1986). Bacillariophyceae. **1** Teil: Naviculaceae. In: *Süsswasserflora von Mitteleuropa* (H. Ettl, J. Gerloff, H. Heynig & D. Mollenhauer, eds), **2** (1), 876 pp. Gustav Fischer Verlag, Stuttgart & New York.

KRAMMER, K. & LANGE-BERTALOT, H. (1988). Bacillariophyceae. **2** Teil: Bacillariaceae, Epithemiaceae, Surirellaceae. In: *Süsswasserflora von Mitteleuropa* (H. Ettl, J. Gerloff, H. Heynig & D. Mollenhauer, eds), **2** (2), 596 pp. Gustav Fischer Verlag, Stuttgart & New York.

KÜTZING, F. T. (1844). *Die kieselschaligen Bacillarien oder Diatomeen.* Nordhausen, 152 pp.

LEGLER, F. (1939). Studien über die Ökologie der rezenten und fossilen Diatomeenflora des Egerer-Franzensbader Tertiärbackens. I. Das Quellgebiet und der Kieselgurschild der Soos. *Beihefte zum Botanischen Centralblatt,* **59**, 1–116.

METZELTIN, D. & WITKOWSKI, A. (1996). Diatomeen der Bären-Insel. Süsswasser und marine Arten. *Iconographia Diatomologica,* **4**, 5–232.

MILLER, U. (1986). Ecology and paleoecology of brackish water diatoms with special reference to the Baltic basin. In: *Proceedings of the Eighth International Diatom Symposium,* Paris 1984 (M. Ricard, ed.), 601–611. Koeltz Scientific Books, Koenigstein.

PADDOCK, T. B. B. & SIMS, P. A. (1977). A preliminary survey of the raphe structure of some advanced groups of diatoms (Epithemiaceae – Surirellaceae). *Beiheft Nova Hedwigia,* **54**, 291–322.

PROCHÁZKA, J. S. (1924). Katalog českých rozsivek [Catalogue of Czech diatoms]. *Archiv Přírodovědného výzkumu Čech,* **17** (2), 1–114.

PRZYBYLOWSKA-LANGE, W. (1976). Okrzemki w dennych osadách zbiorników sodných polskiego pobrzeża Baltiku. I. Jezioro Druzno. [Diatoms of lake deposits from the Polish Baltic coast. I. Lake Druzno.]. *Acta palaeobotanica,* **17**, 35–74.

ŘEHÁKOVÁ, Z. (1990). Biostratigraphy and palaeoecology of diatom-bearing sediments within the Soos basin in western Bohemia, Czechoslovakia. In: *Proceedings of Tenth International Diatom Symposium,* Joensuu 1988 (H. Simola, ed.), 407–418. Koeltz Scientific Books, Koenigstein.

ROUND, F. E., CRAWFORD, R. M. & MANN, D. G. (1990). *The Diatoms. Biology and morphology of the genera,* 747 pp. Cambridge University Press, Cambridge.

RUCK, E. C. & KOCIOLEK, J. P. (2004). Preliminary phylogeny of the family Surirellaceae (Bacillariophyta). *Bibliotheca Diatomologica,* **50**, 1–236.

SCHMID, A. M. (1995). Salt-tolerance of diatoms of the Neusiedlersee (Austria): a model study for palaeolimnological interpretations. In: *Landscapes and life: studies in honour of Urve Miller* (A.M. Robertson, S. Hicks, A. Åkerlund, J. Risberg & T. Hackens, eds), *PACT,* **50**, 471–484.

SKÁCELOVÁ, O. & KONEČNÁ, J. (2006). Katalog sbírky preparátů rozsivek J. Bílého uložené v Moravském zemském muzeu [Diatom Collection of J. Bílý deposited in Moravan Museum, Brno – catalogue of slides]. *Czech Phycology,* **6**, 55–59.

SPRENGER, E. (1931). Ein Beitrag zur Kenntnis der Kieselalgenflora des Bezirkes Komotau. Bd. 1. *Natur,* **6** (13), 57–112.

TRICĂ, V. (1981). Relitii intre faktorii de mediu si organismele care participă la peloidogeneză in lacurile din zona Turda-Durgău, in conditiile actuale de folosire a acestora in balneatie. *Stud. Cerc. Biol., Biol. Anim.,* **33**, 143–152.

TÖRÖK, L. (2004). The diversity of diatoms in type I lakes from the Danube Delta. *Analele IDD,* **10**, 62–69.

VAN DER WERFF, A. & HULS, H. (1961). Diatomeeënflora van Nederland. Aflevering 6, December 1961. Privately published.

WITKOWSKI, A. (1990). Fossilization processes of the microbial mat developing in clastic sediment sof Puck Bay (Southern Baltic Sea, Poland). *Acta Geologova Polonica,* **40**, 1–27.

ZAPLETÁLEK, J. (1932). Hydrobiologická studia rybníků lednických [Hydrobiological study of fishponds near Lednice]. *Sborník Vysoké školy zemědělské v Brně,* **24**, 1–70.

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