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PALEOECOLOGY OF THE LATE MIOCENE MAAR LAKES, PODREČANY BASALT FORMATION, SOUTHERN SLOVAKIA, ON THE BASIS OF SILICEOUS MICROFOSSILS

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Abstract: The siliceous microfossils — diatom and chrysophycean stomatocystae — of the diatomite and alginite from two maars (Jelšovec and Pinciná) of the Late Miocene Podrečany Basalt Formation in Southern Slovakia have been studied. The ecological analysis of the microfossils studied points to a shallow lake environment with pH = 7–8, salinity of 0.3–0.5 %, temperate climate. The nutrient spectrum from the Jelšovec maar where diatomite was deposited suggest an oscillation of oligotrophic and eutrophic conditions. In Pinciná maar where alginite was deposited the eutrophic conditions prevailed. The exellent state of *Botryococus braunii* soft bodies preservation points to a stratified water column in the lake with anearobic conditions at the bottom. In the Jelšovec maar organic matter is practically missing. The water column was not stratified, even the bottom water was oxygenated and oligotrophic conditions prevailed.

Key words: Neogene (Pontian), paleoecology, biostratigraphy, maars, diatoms, chrysophycean stomatocystae.

Introduction

Two maars of the Podrečany Basalt Formation are filled by strictly different sediments. Pinciná maar contains alginite rich in organic matter of the *Botryococus braunii* — a taxon of the Algae. Jelšovec maar, situated only few kilometers from Pinciná, contains diatomite poor in organic matter but rich in siliceous armours of *Diatomaceae* another group belonging to the Algae. Looking for the reason for such strong diversity one of us (O.-R.) studied the *Diatomaceae* from both maars.

One of first announcement of the existence of a nonmarine diatom flora in Neogene sediments of the Western Carpathians (Slovakia) was the publication of Pantocsek (1886–1905). Řeháková (1960, 1971, 1980) presented detailed information about the diatom paleontology and biostratigraphy. A preliminary study of diatom flora comming from the diatomite outcropping at the margin of Pinciná maar has been done by Čierna (in Vass & Elečko et al. 1992). The aim of this study is to trace the siliceous microfossil successions (diatom and chrysophycean stomatocystae) in the maars of Jelšovec and Pinciná, Southern Slovakia, and to reconstruct the paleoenvironmental changes during the time of sedimentation in both maars. Former study of Neogene diatoms occurring in similar basalt maars filled by alginite of Western Hungary is this of Hajós (1990). Majority of taxa described by Hajós have also been found in Pinciná maar. The ecological conditions were also found to be identical. Only the salinity seems to be less in the Pinciná and Jelšovec maars.

Material and methods

Eleven samples from three boreholes (VPA-1,2 Pinciná; VJA-2 Jelšovec) were studied. The strata consisted of lapilli tuff, volcanic sandstones, tufaceous clay, diatomitic clay and diatomites and they belonged to the Podrečany Basalt Formation (Fig. 1). Radiometric data from the basalt volcanism responsible for the maars suggested an age of 6.17–6.45 Ma (Balogh et al. 1981).

The preparation and analysis of diatom samples followed the procedure of Ognjanova-Rumenova (1991). Abundance calls

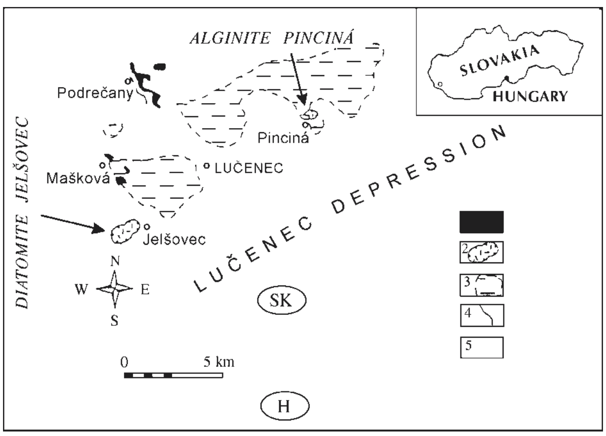


Fig. 1. Relicts of the Podrečany Basalt Formation (Pontian) in the Lučenec Depression. **1** — lava flow, **2** — maar, **3** — Poltár Fm., **4** — lava flow direction, **5** — pre-Pontian rocks.

were made according to Schrader's scale (Schrader 1973). Diatoms were identified mainly using standard floras and selected relative papers. To confirm and document the identifications, some samples were subjected to scanning electron microscopical (SEM) investigation after Hasle & Fryxell (1970). The observations were made on Jeol JSM T 300. The spectra of physico-chemical tolerances based on studies of modern diatoms were used to interpret the paleoecological data (Van Landingham 1967; Abbott & Van Landingham 1972). The ratio between diatom frustules and chrysophycean stomatocystae was determined as a trophic status index in temperate lake sediments (Smol 1985).

Geological setting

The maars of Jelšovec and Pinciná are products of a vast basaltic volcanic activity in the Pannonian Basin (W. Hungary) and at the southern margin of the Western Carpathians (S. Slovakia) at the end of the Miocene and during the Pliocene and Pleistocene. In Slovakia the bulk of the basaltic volcanics is subdivided into the Podrečany and Cerová Basalt Formations. The Podrečany Formation spreads in the Lučenská kotlina Depression and is older—Pontian in age—as is well proved by radiometric ages (7–6 Ma); Balogh et al. (1981), Kantor & Wiegerová (1981) and by palinological data coming from the Poltár sedimentary formation genetically closely related to the Podrečany Basalt Formation (Planderová 1986; Vass & Elečko et al. 1992; Vass et al. 1997). The basalt lava flows interfinger with river deposits of the Poltár Formation. The Pinciná and Jelšovec maars both belong to the Podrečany Basalt Formation (Fig. 1).

A maar, as usual, is formed by a circular or elliptic ring composed mostly of bedded lapilli tuff. The central part of a maar is filled by pelitic sedimentary rocks. There is significant difference between the sedimentary infill of the two maars. The Pinciná maar is filled by dark bituminous laminated pelitic rock — alginite. The dark laminae are rich in *Botryococcus braunii* Kütz. remnants. Finer bright laminae are rich in diatoms. The Jelšovec maar is filled by bright or bright-gray mostly laminated, light pelitic rock rich in diatoms — diatomite.

The pelitic infill was deposited in the maar crater. After cessation of the freatomagmatic eruptions responsible for the origin of the crater and the maar rings the maar was filled by the precipitation water and small lake came to existence. In the lake algae found excellent living condition and lake was quickly occupied by them. On the bottom of the lake, dead algal bodies and/or colonies were deposited together with clay material washed into the lake from the quickly weathered lapilli tuffs of the maar ring. The results of the lake deposition were: in the organic matter rich alginite (Pinciná) and in the siliceous skeletons, or armours of Diatomaceae rich diatomite (Jelšovec).

The pairs of dark and bright laminae in alginite represent annual deposits. The mean thickness of pair is about 2 mm. Because the maximal ascertained alginite thickness in Pinciná maar is 47.1 m (Vass et al. 1997) the deposition time was aprox. 23,550 years.

Schematic profiles of the boreholes, the studied samples come from, are shown in Figs. 7 and 8.

Results and discussion

The diatom flora and community structure

The diatom taxa are presented following the classification order of Glezer et al. (1988) with some inclusions according to Round et al. (1990) and Krammer & Lange-Bertalot (1986-1991) (Table 1). These taxonomical data are accompanied by ecological and distributional information. The tabular summary provides a frame of reference which facilitates the characterization of the diatom flora and permits a more concise conceptual basis for the interpretation of environmental conditions. A total of 181 taxa are observed in the present study. They refer to 35 genera, 128 species, 37 varieties and 6 formae, and belong to 13 families, 4 orders and classes *Centrophyceaea* and *Pennatophyceaea*. Diatoms were identified to species whenever possible; however ten entities could be assigned to genus only. The diatom flora mostly consists of modern species — 92.4 %, but the group of extinct species (7.6 %) is abundant in some levels (i.e. *Pliocaenicus omarensis* (Kütz.) Round & Hak., *Aulacoseira distans* var. *scala* (Ehr.) nov. comb, etc.). In general, pennate forms are the most varied (94.5 %). The species rich genera *Navicula* Bory and *Cymbella* Ag. can be distinguished, they account for 26.5 % of the entire flora. These are followed by the genera *Pinnularia* Ehr. (8.8 %), *Fragilaria* Lyngb. (7.2 %), *Achnanthes* Bory (7.2 %) and *Gomphonema* Ehr. (6.1 %). The class *Centrophyceae* accounts for 5.5 % of the diatom flora. More of its representatives are widely spread, in some levels they are rock-forming and occur as dominants or subdominants.

Chrysophycean stomatocystae are the second major siliceous microfossil group present in the investigated sediments. These are the endogenously-formed siliceous stomatocystae (also called statospores or resting cysts) which are widely believed to be taxon specific. The advances in paleolimnological techniques and taxonomy of the past decade have led to widespread interest in the use of chrysophycean microfossils as paleoindicators. The contribution of chrysophytes to total algal biomass tends to drop with increasing lake productivity, or eutrophication as also suggested by the index of Smol (1985).

Changes in microfloral assemblages with depth have been investigated in three borehole sequences. The diatom diagrams (Figs. 2, 3) have been compiled using taxa with abundances corresponding to 4–5 of Schrader's scale (Schrader 1973).

In the well VPA-1, Pinciná two assemblages can be distinguished in the development of diatom flora. From 26.30 m to 13.20 m the most abundant species is a very small form of genus *Cyclotella* Kütz. (dimensions — Diameter of the discs: 5.4–21.4 µm; Striae: 16–18 per 10 µm; Diameter of the central area: 0.98–4.9 µm). The valve morphology is very similar, but not identical to *C. iris* Brun. & Herib. and allied forms. (Pl. I: Figs. 1–3; Pl. V: Figs. 1–4; Pl. VI: Figs. 1–4). Probably this is a separate species, which will be described. The abundance of the accompanying species is estimated at 2–3 according to Schrader's scale — i.e. the species of genus *Fragilaria* Lyngb. occur occasionally *F. construens* (Ehr.) Grun. and *F. virescens* Ralfs. Within this range we observed poor occurrence of representatives of the genus *Aulacoseira* Thw., but *Gyrosigma*

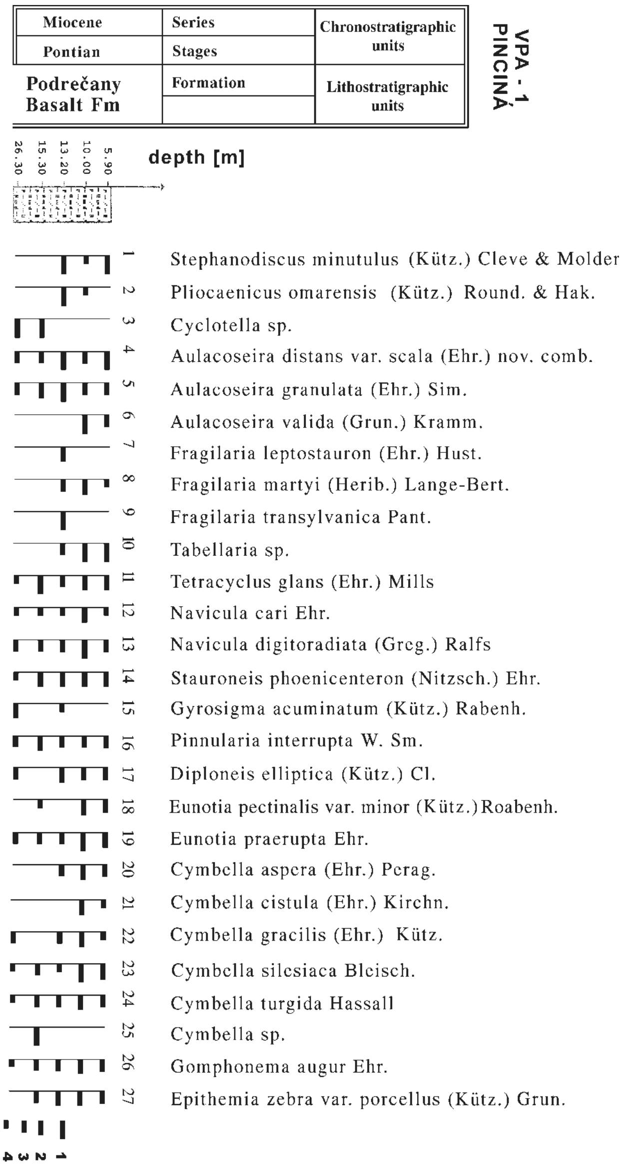


Fig. 2. Diatom diagram from bore-hole VPA-1, Pinciná. **1.** abundant species, **2.** common species, **3.** frequent species, **4.** rare species.

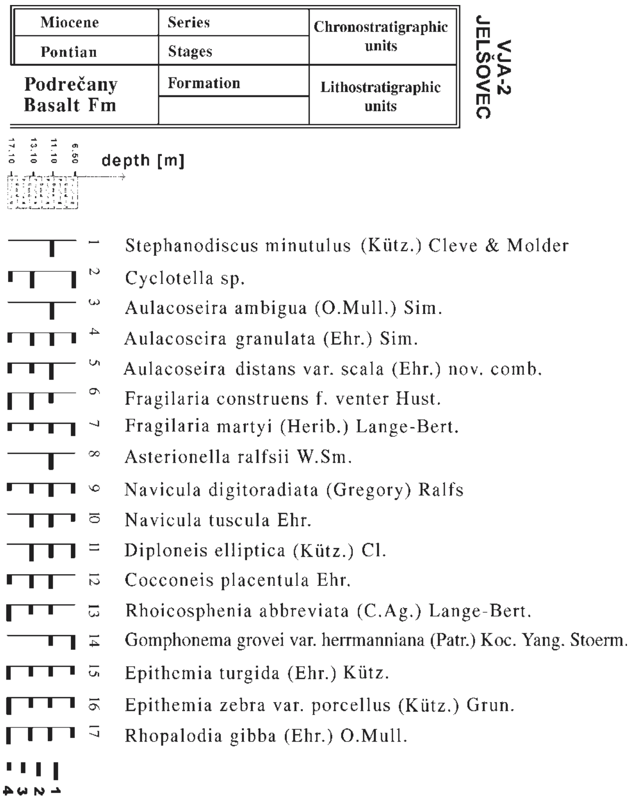


Fig. 3. Diatom diagram from bore-hole VJA-2, Jelšovec. **1.** abundant species, **2.** common species, **3.** frequent species, **4.** rare species.

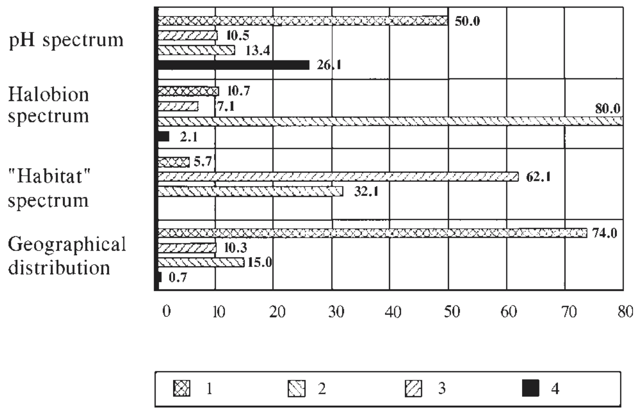


Fig. 4. Histograms (I–IV). Percentage ratio of the ecological groups of diatoms from the Upper Miocene sediments, VPA-1, 3 Pinciná and VJA-2, Jelšovec. **I.** pH spectrum: 1. alkaliphilic, 2. acidophilic, 3. alkalibiontic, 4. indifferent. **II.** Halobion spectrum: 1. halophobous, 2. halophilous, 3. indifferent, 4. mesohalobous. **III.** “Habitat” spectrum: 1. planktonic; 2. periphytic (epiphytic); 3. periphytic (deep water forms). **IV.** Geographical distribution: 1. cosmopolitans, 2. north-alpine forms, 3. boreal forms, 4. tropical forms.

acuminatum (Kütz.) Rabenh. and *Cymbella* sp. are frequent. Their mass development coincides with the increase in the quantity of *Tetracyclus glans* (Ehr.) Mills. Species of other algal remains — *Pediastrum* sp. have also been found in large quantities in the sample at 26.30 m. These species are used as indicators of high carbon percentage (Haworth 1989).

The second assemblage occurs in sediments at the level of 13.20–5.90 m. The representatives of genus *Aulacoseira* Thw. are abundant. Apart from two transition species *A. granulata* (Ehr.) Sim. and *A. distans* var. *scala* (Ehr.) nov.comb., *A. valida* (Grun.) Kramm. is very frequent within this range. It is noteworthy that at this level *Stephanodiscus minutulus* (Kütz.) Cl. & Moller and *Pliocaenicus omarensis* (Kütz.) Round & Hak. are dominant. Their appearance and development coincides with those of species belonging to the genus *Fragilaria* Lyngb.: *F. leptostauron (*Ehr.) Hust., *F. martyi* (Herib.) L.-Bert., *F. transylvanica* Pant. Another interesting find is the occurrence here of an unidentified form of the genus *Tabellaria* Ehr. (Pl. I: Figs. 14–15; Pl. VII: Figs. 1–3) The abundance of the accompanying species *Eunotia* Ehr. is remarkable.

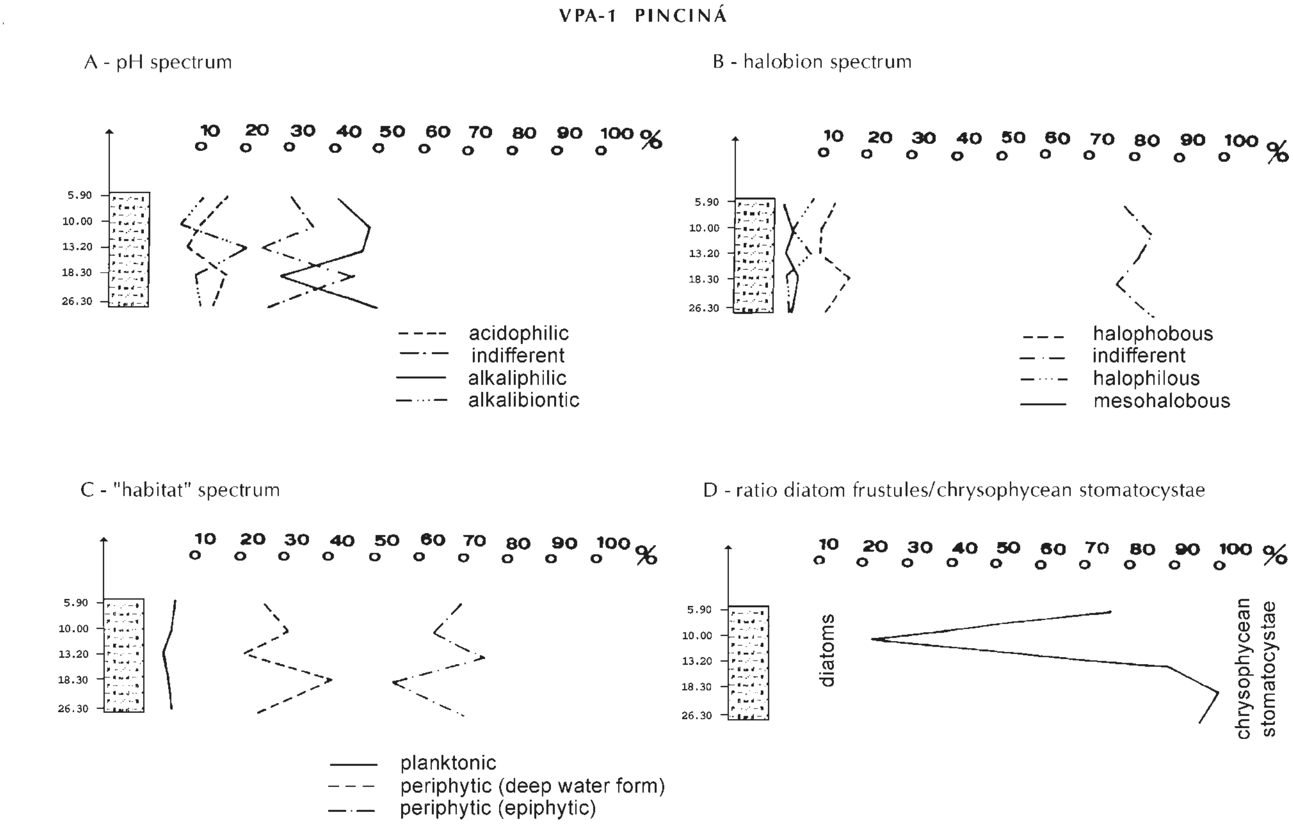


Fig. 5. Percentage diagrams of the ecological diatom groups from borehole VPA-1 Pinciná.

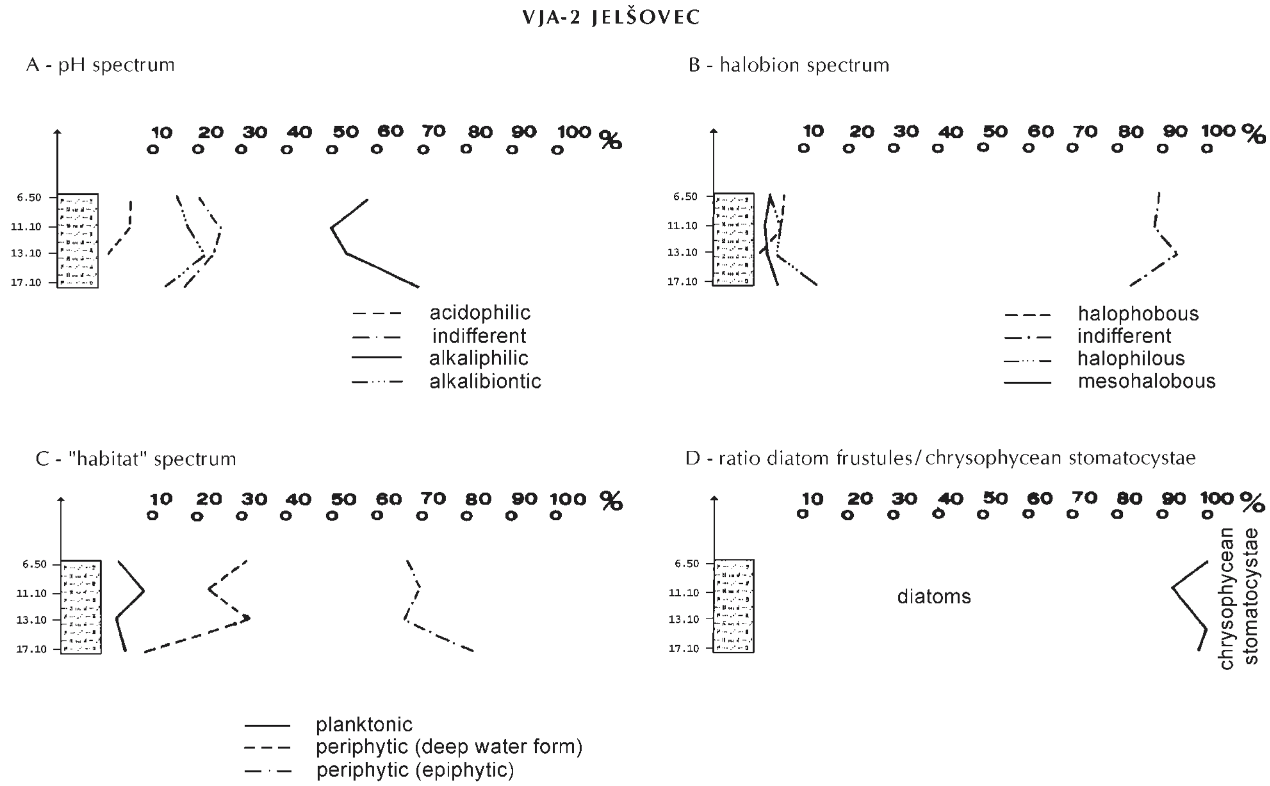


Fig. 6. Percentage diagrams of the ecological diatom groups from borehole VJA-2 Jelšovec.

Table 1: List of the diatom taxa found in this study with their range, abundance in depth and ecology. **Range:** lEo — Late Eocene; Ol — Oligocene; N — Neogene; Mi — Miocene; eMi — Early Miocene; lMi — Late Miocene; Pl — Pliocene; ePl — Early Pliocene; Q — Quaternary; Plei — Pleistocene, Hol — Holocene, R — Recent. **Abundance:** 2 — rare species; 3 — frequent species; 4 — common species; 5 — abundant species. **Ecology: habitat:** pl — planktonic; ep — periphytic (epiphytic); d — periphytic (deep water form); **halobity:** hb — halophobous; I — indifferent; hl — halophilous; mhb — mesohalobous; **pH:** ac — acidophilic; alk — alkaliphilic; albnt — alkalibiontic; I — indifferent; **geographical distribution:** c — cosmopolitans; n-a — north-alpine forms; b — boreal forms; tr — tropical forms.

DIATOMS	RANGE	VPA–1 Pinciná					VPA–3 Pinciná		VJA–2 Jelšovec				Ecology			
		5.90–6.00m	10.00–10.10m	13.20m	18.30m	26.30m	24.50m	37.60m	.6.50–7.00m	11.10m	13.10m.	17.10m	habitat	halobity	pH	geographical distribution
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stephanodiscus *astrea* var. *intermedia* Fricke, 1901	lMi – R				2								pl	i	alk	b
S. minutulus /Kütz./Cleve & Moller, 1878	lMi – R	5	2	5			5			5			pl	i	albnt	c
Cyclotella *sp.*					5	5		5	5		5	3				
Pliocaenicus *omarensis* /Kütz./Round & Hakansson, 1992	Pl		2	5												
Aulacoseira *ambigua* /Grun./Simonsen, 1979	Mi–R						5			5			pl	i	alk	c
A. distans var. *scala* /Ehr./nov. comb.	lMi–Pl	5	3	5	3	3		3		5	3	3				
A. granulata /Ehr./Simonsen, 1979	Ol–R	3	3	5	4	3		4	3	4	4	3	pl	i	alk	c
A. granulata var. *angustissima* /O.Mull./Simonsen, 1979	Ol–R									3			pl	i	alk	c
A. italica /Ehr./Simonsen, 1979	lEo–R					2							pl	i	alk	c
A. valida /Grun./Krammer, 1990	Mi–R	3	5				4						pl	i	alk	n–a
Fragilaria *biceps* /Kütz./Lange-Bertalot, 1991	N–R						3						ep	i	i	c
F. bituminosa Pantoscek, 1889	lMi–Pl											3				
F. brevistriata Grunow, 1885	Ol–R	3		2			4	3	2	3	3		ep	i	alk	c
F. construens /Ehr./Grunow, 1862	Ol–R	3	3	3	3	3	4	3	2	3	3		ep	i	alk	c
F. construens f. *binodis* /Ehr./Hustedt, 1957	Mi–R		3	3			3			2			ep	i	alk	c
F. construens f. *subsalina* /Hust./Hustedt, 1957	Ol–R	2										3	ep	hl	alk	c
F. construens f. *venter* /Ehr./Hustedt, 1957	Ol–R	3	3	3		3	4	4		3	5	5	ep	i	alk	c
F. leptostauron /Ehr./Hustedt, 1931	Ol–R			4			2	3		2			d	hb	alk	b
F. martyi /Herib./Lange-Bertalot, 1993	lMi–R	2	4	3			2	3	4	3	2	2	ep	i	alk	c
F. transylvanica Pantocsek, 1892	lMi–ePl			5						3	3					
F. ulna var. *amphirhynchus* /Ehr./Valeva & Temnisk., 1993	Plei–R		3										ep	i	alk	c
F. virescens Ralfs, 1843	lEo–R		3	2	3				2				ep	hb	i	c
Synedra *rumpens* var. *fragilarioides* Grunow, 1881	Plei–R									2			ep		i	c
Asterionella *ralfsii* W.Smith. 1856	R									5			pl	i	alk	c
Tabellaria *fenestrata* /Lyngb./Kützing, 1844	eMi–R					2	3						ep	hb	ac	c
T. flocculosa /Roth/Kützing, 1844	eMi–R	2					2						ep	hb	ac	n–a
T. poretzkiae Loginova & Chursevich, 1980	ePl	2														
Tabellaria sp.		5	5	3			4				2					
Tetracyclus *emarginatus* /Ehr./W.Smith, 1856	Mi–R	3	3	3	3		3	3		2			ep	i	i	n–a
T. glans /Ehr./Mills, 1835	eMi–R	4	4	3	5	2	5	3	2	2			ep	i	ac	n–a
T. stellare Heribaud, 1903	lMi			2				2								
Navicula *abiskoensis* Hustedt, 1942	Pl–R										2		d	i	i	n–a
N. amphibola Cleve, 1891	Mi–R		2		2	2	3	2			2		d	i	alk	n–a
N. arenariaeformis Pantocsek, 1889	Pl		3		3	3		3								
N. arenariaeformis var. *major* Gasse, 1980	Pl	3	3													
N. cari Ehrenberg, 1836	Pl–R	2	4	2	2	2	3	3		3			ep	i	i	c
N. cincta (Ehr.) Ralfs, 1861	Mi–R											3	d	hl	alk	c
*N. costulat*a Gunow, 1880	Q–R	2	3	3			3		2	3			d	hl	alk	c
N. cryptocephala Kützing, 1844	Mi–R		2										d	i	alk	c
N. cuspidata /Kütz./Kützing, 1844	Mi–R				2					2	3	2	ep	i	alk	c
N. digitoradiata /Greg./Ralfs, 1861	Mi–R	3	5	3	3	3	5	5	3	4	3	2	d	mhb	alk	c
N. gastrum /Ehr./Kützing, 1844	Mi–R	2	2				2	3	3	3	3	3	ep	i	i	c
N. hasta Pantocsek, 1892	Mi–R		2				4	3	3	3	3		d	i	i	c
N. lanceolata /Ag./Ehrenberg, 1838	Mi–R	2			2		3						ep	i	alk	c
N. laterostrata Hustedt, 1925	Pl–R			3									d	i	alk	c
N. menisculus Schumann, 1867	Mi–R		2	2									d	hl	alk	c
N. placentula /Ehr./Kützing, 1844	eMi–R					2	2	2	2				d	i	alk	c
N. platystoma var. *pantocsekii* Wisl. et Kolbe, 1927	Q–R								2	2						
N. protracta /Grun./Cleve, 1894	Pl–R						2	2					d	hl	i	c
N. protracta /Grun./Cl. f. *subcapitata* /Wisl.& Poretz./Hustedt, 1962	Pl–R				2								d	hl		b

DIATOMS	RANGE	VPA–1 Pinciná					VPA–3 Pinciná		VJA–2 Jelšovec				Ecology			
		5.90–6.00m	10.00–10.10m	13.20m	18.30m	26.30m	24.50m	37.60m	.6.50–7.00m	11.10m	13.10m.	17.10m	habitat	halobity	pH	geographical distribution
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N. pseudoanglica Lange–Bertalot, 1985	Mi–R		2		3	2	3	2	3		3		d	i	alk	b
N. pseudolanceolata var. *denselineolata* L.Bertalot, 1985	R						2									
N. radiosa Kützing, 1844	eMi–R	3	3	3									ep	i	i	c
N. reinhardtii Grunow, 1877	Mi–R				2								d	i	albnt	c
N. scutelloides W.Smith, 1856	Mi–R									2			ep	i	albnt	c
N. tuscula Ehrenberg, 1841	Pl–R	2	3	3				3	2	4	4		d	i	albnt	c
Navicula sp. 1					2											
Sellaphora *bacillum* /Ehr./Mann, 1989	Mi–R	3	3	3	3	2	3	4	3	3	2		d	i	alk	b
S. pupula /Kütz./Mann, 1989	Mi–R	3	2										d	i	i	c
S. pupula var. *capitata* /Hust./nova comb.	ePl–R		3											i	i	c
S. pupula var. *rectangularis* /Greg./Ognjanova 1991	Mi–R											2	ep	i	i	c
Anomoeoneis *sphaerophora* /Kütz./Pfitzer, 1871	Mi–R			2							2		ep	hl	albnt	c
Stauroneis *anceps* Ehrenberg, 1843	Mi–R	3	3		3	2	3	3		2			d	i	i	c
S. phoenicenteron /Nitzsch/Ehrenberg, 1843	Ol–R	4	4	4	4	2	5	4		2			ep	i	i	b
S. producta Grunow, 1880	Mi –R									2			ep	hl		
S. smithii Grunow, 1860	Mi–R				2		2			2	2		d	i	i	c
S. smithii var. *incisa* Pantocsek, 1902	Pl–R								3	3	2		d	i	alk	c
Gyrosigma *acuminatum* /Kütz./Rabenhorst, 1853	ePl–R			2		4		3	3	3	2		ep	i	albnt	c
Pinnularia *acrosphaeria* Rabenhorst, 1853	R				2								d	i	albnt	c
P. borealis Ehrenberg, 1843	Mi–R	2			2		2	3					d	i	i	c
P. braunii var. *amphicephala* /Mayer/Hustedt, 1930	Mi–R	3	3	2	3		4	3					d	hb	i	c
P. distinguenda Cleve, 1895	lMi–R	2											d	hl		
P. esox Ehrenberg, 1843	lMi–R		3		2				2				d			c
P. hemiptera f. *densestriata* Tynni, 1976	R				2											
P. interrupta W.Smith, 1853	lMi–R	3	3	3	4	3	3	5					d	i	ac	c
P. macilenta /Ehr./Cleve, 1895	R						3									c
P. maior /Kütz./Rabenhorst, 1853	eMi –R				2			3					d	i	i	c
P. maior var. *lacustris* *Me*ister, 1912	Q–R		2	2												
P. microstauron /Ehr./Cleve, 1891	eMi–R		2						2					i		c
P. microstauron var. *ambigua* Meister, 1912	R									2			d	i	i	b
P. microstauron var. *brebissonii* /Kütz./Mayer, 1912	lEo–R				3								d	i	i	c
P. nobilis var. *neogena* /Grun./Cleve, 1895	eMi–Q	2														
P. viridis /Nitzsch/Ehrenberg, 1843	eMi–R	3	3		2	2	3	3			3		d	i	i	c
P. viridis var. *leptogongyla* /Grun./Cleve, 1895	ePl–R	3	2	2					2	2			d	i	i	b
Caloneis *bacillum* /Grun./Cleve, 1894	ePl–R	2		2		2		3	3	2	2		ep	i	alk	c
C. leptosoma (Grun.)Krammer, 1985	R				2											
C. silicula var. *kjellmaniana* /Grun./Cleve, 1894	Pl–R				2								d	mhb	albnt	b
Diploneis *elliptica* /Kütz./Cleve, 1891	Mi–R	3	3	4	2	3	4	4	4	4	5		ep	i	alk	c
D. marginestriata Hustedt, 1922	Plei–R										2		d	i	alk	n–a
Neidium *affine* /Ehr./Pfitzer, 1871	lMi–R		2							2				i	alk	c
N. ampliatum /Ehr./Krammer, 1985	Pl–R		3		2		3	2					d	i	i	b
N. dubium /Ehr./Cleve, 1894	ePl–R										2		d	i	i	n–a
N. productum /W.Sm./Cleve, 1894	Pl–R	2		2									d	hb	ac	c
Neidium sp.					2											
Frustulia *rhomboides* /Ehr./De Toni, 1891	eMi–R						2						d	hb	ac	n–a
Mastogloia *smithii* Thw. var. *lacustris* Grunow, 1878	Plei–R											3	ep	hl	alk	c
Cocconeis *placentula* Ehrenberg, 1838	Ol – R		3			2				4	4	3	ep	i	alk	c
C. placentula var. *euglypta* /Ehr./Grunow, 1884	Mi–R	2		2			2			2	3	2	ep	i	alk	c
Achnanthes *clevei* Grunow, 1880	R	2											ep	i	alk	c
A. clevei var. *rostrata* Hustedt, 1930	Pl – R								2				d	i	alk	b
A. conspicua Mayer, 1919	Ol–R			2			2						ep	i	alk	b
A. exigua Grunow, 1880	Mi–R					2	3						ep	i	alk	c
A. exilis Kützing, 1833	R	2														c
A. flexella (Kütz.) Brun, 1880	R	3	3	3	3	3	3	3					ep	hb	ac	c
A. hauckiana Grunow, 1880	Mi–R	2		2		2				3	3			hl	albnt	c
A. lanceolata /Breb./Grunow, 1880	Mi–R		2			2							ep	i	alk	c

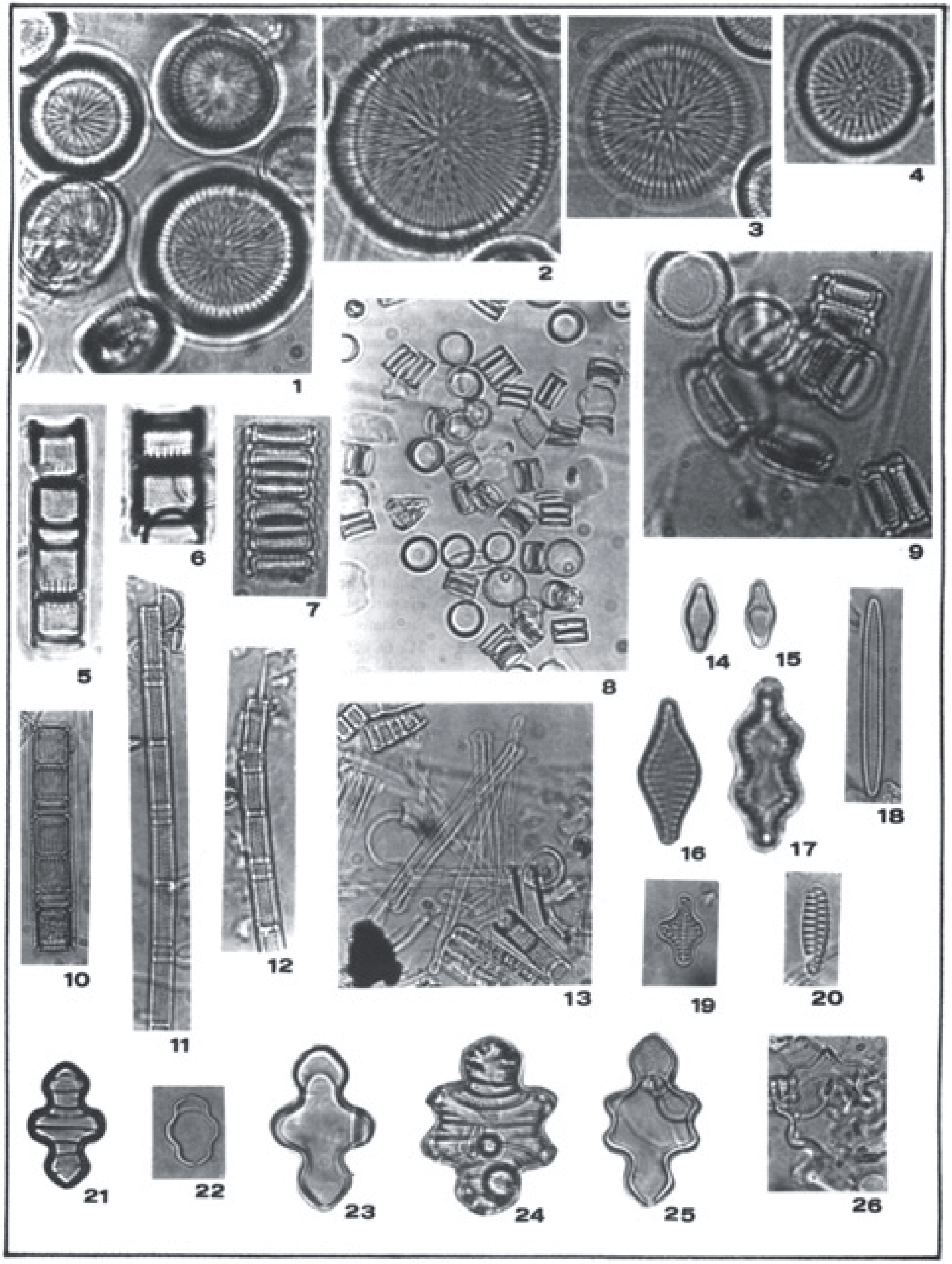
DIATOMS	RANGE	VPA–1 Pinciná					VPA–3 Pinciná		VJA–2 Jelšovec				Ecology			
		5.90–6.00m	10.00–10.10m	13.20m	18.30m	26.30m	24.50m	37.60m	.6.50–7.00m	11.10m	13.10m.	17.10m	habitat	halobity	pH	geographical distribution
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A. lanceolata subsp. *rostrata* /Oestr./Lange Bertalot, 1991	Mi–R							2	2				ep	i	alk	c
A. lanceolata var. *elliptica* Cleve, 1891	eMi–R			2						2			ep	i	alk	c
A. oestrupii (Cleve–Euler) Hustedt, 1930	Pl–R							2					ep	i	i	n–a
Achnanthes sp.1		2														
Achnanthes sp.2					2											
***Eunotia** arcus* Ehrenberg, 1837	Mi–R				2								ep	hb	ac	n–a
E. bilunaris /Ehr./Mills, 1934	R						3						ep			c
E. faba Ehrenberg, 1838	eMi–R						3						ep	hb	ac	c
E. glacialis Meister, 1912	Mi–R	3	3				3			2			ep	hb	ac	c
E. pectinalis var. *minor* /Kütz./Rabenhorst, 1864	lMi–R	3	4		2		3	2	2	2			ep	hb	ac	c
E. pectinalis var. *minor* f. *impressa* /Ehr./Hustedt, 1930	Mi–R					2								hb		
E. polyglyphoides Sheshukova, 1962	N								3	2						
E. praerupta Ehrenberg, 1843	Mi–R	4	5	3	3	3	5	2					ep	hb	ac	c
E. pseudopectinalis Hustedt, 1924	R		2										ep			n–a
***Actinella** brasiliensis* Grunow , 1881	Mi – R		2										ep	i		tr
***Rhoicosphenia** abbreviata* (Ag.) Lange–Bertalot, 1980	Mi–R									3	3	5	ep	i	alk	c
***Cymbella** aspera* /Ehr./Peragallo, 1849	eMi–R	3	4	3			4				2		ep	i	alk	c
C. cistula /Ehr./Kirchner, 1878	Ol–R	2	4						2		2		ep	i	alk	c
C. cistula var. *hebetata* /Pant./Cleve–Euler, 1955	Q–R	2					4									
C. cuspidata Kützing, 1844	eMi–R		3	2	3	3			2	3	3		ep	i	i	c
C. cymbiformis Agardh,1830	Mi–R									3			ep	i	alk	c
C. cymbiformis var. *nonpunctata* Fontell, 1917	Mi–R	3											ep	i		c
C. ehrenbergii Kützing, 1844	Mi–R			2			2	3	3	3	2		ep	i	albnt	b
C. elginensis Krammer, 1981	Mi–R	4	5	2	3	2		5	2	3	3	3	ep	i	i	c
C. gracilis /Ehr./Kützing, 1844	Plei–R	2	4	3		3	4	3					ep	i	alk	c
C. helvetica Kützing, 1844	Mi – R							3		3			ep	i	i	c
C. helvetica var. *curta* Cleve, 1894	Q–R					2							ep	i	alk	b
C. hustedtii Krasske, 1925	Mi–R				3		3	3					ep	i	i	c
C. hybrida Grunow, 1878	R	2											ep	i	albnt	n–a
C. lanceolata /Ehr./Kirchner, 1878	eMi–R			2									ep	i	alk	c
C. naviculiformis /Auersw./Cleve, 1894	lMi–R	3	3	3	3	3	3	3	2				ep	i	i	c
C. obtusa Pantocsek, 1892	lMi											3				
C. perpusilla A.Cleve, 1895	R	2													ac	c
C. silesiaca Bleisch, 1864	eMi–R	3	4	3	3	2	3	3		2	2	3	ep	i	i	c
C. subcuspidata Krammer, 1982	Pl–R		3		3		3	3	3				ep	i	alk	n–a
C. tynni Krammer, 1985	R	2											ep			n–a
Cymbella sp. 1					5		2	5								
Cymbella sp. 2						2										
***Reimeria** sinuata* f. *antiqua* /Grun./Koc.& Stoermer, 1987	lMi–Q		2			2										
***Amphora** bornetti* Heribaud 1903	Mi								3	3	3					
A. delphinea A. Schmidt var. *jamalinensis* /Cl. et Grun./Cleve, 1895	Pl–R								3	2						
A. libyca Ehrenberg, 1840	Mi–R	2	2	3	3		3	3	2	3	3	2	ep	i	alk	c
A. ovalis /Kützing/Kützing, 1844	Mi–R	2											ep	i	alk	c
A. pediculus (Kütz.) Grunow, 1880	Mi–R											3	ep	i	alk	c
A. proteus Gregory, 1857	Q–R		2										ep	mhb		c
Amphora sp. 1					2											
***Gomphonema** acuminatum* Ehrenberg, 1832	Mi–R		3										ep	i	alk	c
G. angustum Agardh, 1831	R	2											ep	i	alk	b
G. augur Ehrenberg, 1843	Mi–R	3	4	3	3	2	3	3		3	3		ep	i	i	c
G. clavatum Ehrenberg, 1832	R	3	3				4			2			d	i		c
G. gracile var. *lanceolata* (Kütz.) Cleve, 1894	ePl–R		3										ep	i	alk	c
G. grovei var. *herrmanniana* /Patrik/ Kociolec, Jang, Stoermer, 1988	Mi–R								4	3						
G. olivaceum (Horn.) Brebisson, 1838	Mi–R									2	2		ep	i	albnt	c

DIATOMS	RANGE	VPA-1 Pinciná					VPA-3 Pinciná		VJA-2 Jelšovec				Ecology			
		5.90–6.00m	10.00–10.10m	13.20m	18.30m	26.30m	24.50m	37.60m	.6.50–7.00m	11.10m	13.10m.	17.10m	habitat	halobity	pH	geographical distribution
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
G. olivaceum var. *calcareum* (Cleve) Cleve, 1894	Pl-R								2				ep	i	alk	b
G. olivaceum var. *minutissima* Hustedt, 1930	Pl-R						3						ep	i	alk	b
G. subtile Ehrenberg, 1843	N-R				3								ep	hb	ac	c
G. truncatum Ehrenberg, 1832	Pl-R	3					3				3	3	ep	i	alk	b
Epithemia sorex Kützing, 1844	Mi-R			2		2		2	3	3	2		ep	i	albnt	c
E. turgida /Ehr./Kützing, 1844	Mi-R			2		2	2		2	3	3	4	ep	i	albnt	c
E. turgida var. granulata (Ehr.) Brun, 1880	Ol-R									3	3	3	ep	i	albnt	c
E. zebra /Ehr./Kützing, 1844	Mi-R			3									ep	i	albnt	c
E. zebra var. *porcellus* /Kütz./Grunow, 1862	Mi-R	3	4	4	3		3	4	3	3	3	5	ep	i	albnt	c
E. zebra var. *saxonica* /Kütz./Grunow, 1862	ePl-R	2	3	3			3	4					ep	i	albnt	c
Rhopalodia *gibba* /Ehr./O.Muller, 1895	Mi-R	3	3	3		3	3	3	3	4	4	5	ep	i	alk	c
Nitzschia *acuta* Hantzsch, 1880	Pl-R										2		d	i	alk	c
N. sinuata var. *tabellaria* Grunow, 1881	Pl-R									2			d	i	alk	c
Hantzschia *amphioxys* /Ehr./Grunow, 1880	Mi-R	2	2	2	2	2	2	3	2	2			ep	i	i	c
H. *amphyoxis* var. *capitata* Pantocsek, 1902	R		2													
Surirella *bifrons* Ehrenberg, 1843	Mi -R							2			2		d	i	i	b
S. biseriata Brebissonii, 1836	Mi-R			2		2		3	2	2			ep	i	alk	c
S. biseriata f. *punctata* /Meister/Krasske, 1925	Pl – R			+	+											
Cymatopleura *elliptica* /Breb./W. Smith, 1851	Mi-R			2					2				d	i	alk	b
C. solea /Breb./W.Smith, 1851	Mi -R		2	3			3	3	2	3	3	3	ep	i	alk	c
Cymatopleura sp.		2														
Campylodiscus *hibernicus* Ehrenberg, 1845	Pl-R		2			2							d	i	alk	b
C. lacus baicali Skvortzow, 1937	Hol-R		2				3							i	i	b

The well VPA-3, Pinciná was represented by two samples with a very long range: 24.50 m and 37.60 m. The determined two diatom assemblages (not illustrated) are not principally different from these described in the sequence of VPA-1, Pinciná. The diatom association described for level 37.60 m corresponds to the first diatom assemblage of VPA-1; that for level 24.50 m—to the second diatom assemblage of VPA-1.

The investigated flora from Jelšovec and Pinciná deposits have a group of common species which allows correlation— 77 species, varieties and formae (42.5 %). The species composition of the diatom flora of VJA-2, Jelšovec is relatively poor, but the character of the two diatom assemblages developed in the sequence is similar to that described for VPA-1, Pinciná. The occurrence of *Cyclotella* sp. shows some peculiarities in depth. At the level of 17.10–13.10 m this species is rock-forming and dominant with some epiphytic accompanying species: *Fragilaria construens* f. *venter* Hust., *Rhoicosphenia abbreviata* (Ag.) Lange-Bert., *Epithemia zebra* var. *porcellus* (Kütz.) Grun, *E. turgida* (Ehr.) Kütz. and *Rhopalodia gibba* (Ehr.) O.Mull. At 11.10 m *Cyclotella* sp. disappears and an association with *Stephanodiscus minutulus* (Kütz.) Cl. & Molder and mass occurrence of *Aulacoseira* species is established. In this seam the planktonic species *Asterionella ralfsii* W.Sm. is dominant, too. Some of the accompanying species in the second association from VPA-1,2 Pinciná—*Pliocaenicus*

Plate I: Fig. 1. *Cyclotella* sp., VJA-2 Jelšovec, 13.10 m, ×2000. **Fig. 2.** *Cyclotella* sp., VJA-2 Jelšovec, 6.50 m, ×2000. **Fig. 3.** *Cyclotella* sp., VJA-2 Jelšovec, 13.10 m, ×2000. **Fig. 4.** *Stephanodiscus minutulus* (Kütz.) Cl. & Mold., VPA-1 Pinciná, 13.20 m, ×2000. **Fig. 5.** *Aulacoseira valida* (Grun.) Krammer, VPA-1 Pinciná, 10.00 m, ×800. **Fig. 6.** *A. valida* (Grun.) Krammer, VPA-1 Pinciná, 10.00 m, ×800. **Fig. 7.** *A. distans* var. *scala* (Ehr.) nov.comb., VPA-1 Pinciná, 5.90 m, ×2000. **Fig. 8.** *A. distans* var. *scala* (Ehr.) nov.comb., VPA-1 Pinciná, 5.90 m, ×800. **Fig. 9.** *A. distans* var. *scala* (Ehr.) nov.comb., VPA-1 Pinciná, 5.90 m, ×2000. **Fig. 10.** *A. ambigua* (Grun.) Sim., VJA-2 Jelšovec, 11.10 m, ×800. **Fig. 11.** *A. granulata* (Ehr.) Sim., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 12.** *A. granulata* (Ehr.) Sim., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 13.** *Asterionella ralfsii* W.S., VJA-2 Jelšovec, 11.10 m, ×800. **Fig. 14.** *Tabellaria* sp. VPA-1 Pinciná, 10.00 m, ×800. **Fig. 15.** *Tabellaria* sp. VPA-1 Pinciná, 10.00 m, ×800. **Fig. 16.** *Fragilaria construens* (Ehr.) Grun., VPA-1 Pinciná, 13.20 m, ×2000. **Fig. 17.** *F. construens* f. *binodis* (Ehr.) Hust., VPA-1 Pinciná, 13.20 m, ×2000. **Fig. 18.** *F. transylvanica* Pant., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 19.** *F. leptostauron* (Ehr.) Hust., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 20.** *F. martyi* (Herib.) L.-Bert., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 21.** *Tetracyclus glans* (Ehr.) Mills, VPA-1 Pinciná, 5.90 m, ×800. **Fig. Fig. 22.** *T. glans* (Ehr.) Mills, VPA-1 Pinciná, 5.90 m, ×800. **Fig. 23.** *T. glans* (Ehr.) Mills (septum), VPA-1 Pinciná, 10.00 m, ×800. **Fig. 24**. *T. emarginatus* (Ehr.) W.Sm., VPA-1 Pinciná, 5.90 m, ×800. **Fig. 25.** *T. emarginatus* (Ehr.) W.Sm. (septum), VJA-2 Jelšovec, 11.10 m, ×800. **Fig. 26.** *T. stellare* Herib., VPA-1 Pinciná, 13.20 m, ×800.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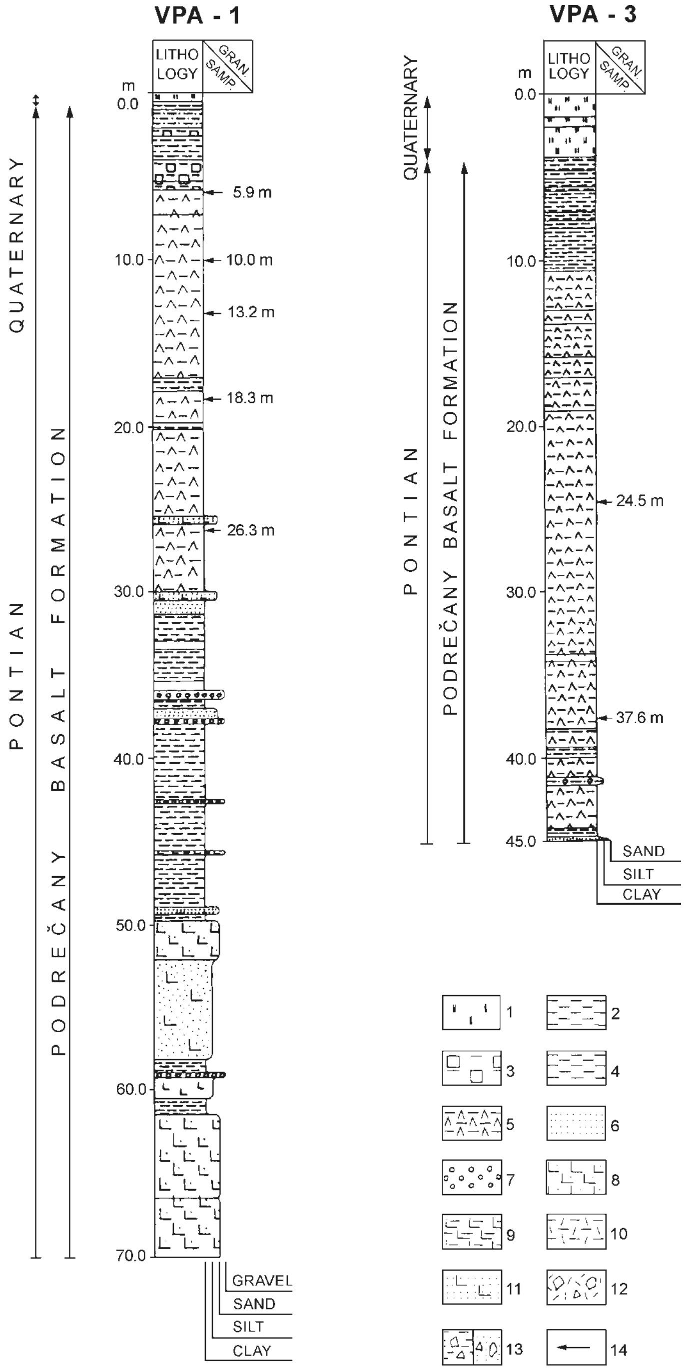


Fig. 7. Sketch of the bore-holes VPA-1 and VPA-3, maar of Pinciná. Explanation: **1** — soil, **2** — clay/loam, **3** — diatomite, **4** — silt/siltstone, **5** — alginite, **6** — tuffaceous sand/sandstone, **7** — conglomerate, **8** — lapilli and asch tuff, **9** — basalt tuff, **10** — tuffaceous clay, **11** — sand tuff with basalt fragments, **12** — pumice tuff, **13** — angular rock fragments, **14** — samples.

omarensis (Kütz.) Round & Hak. and *Tabellaria* sp. are missing here or occur occasionally. At 6.50 m *Cyclotella* sp. appears again in mass. In these deposits subdominants are *Gomphonema grovei* var. *herrmanniana* (Patr.) Koc. Yang. Stoerm. and *Fragilaria martyi* (Herib.) L.-Bert., etc. The development of *Aulacoseira* species significantly decreases (*A. ambigua* (O.Mull.) Sim. and *A. distans* var. *scala* (Ehr., nov.comb.) only *A. granulata* (Ehr.) Sim. is rarely represented.

Ecological analysis of the diatom flora

The objective of this part of the study is to provide information concerning the response of diatoms to different ecological parameters in order to reconstruct the past environment. Many of the taxa in the analysed diatom flora are common and widespread in modern temperate freshwater environments (81.77 %). Only 10 species, varieties and formae have an unknown ecology. The analysis of the ecological spectra shows (Fig. 4):

The Halobion spectrum: Species with oligohalobious habitat form up to 97.9 %. Mesohalobious species such as *Caloneis silicula* var. *kjellmaniana* (Grun.) Cl. and *Amphora proteus* Greg. are rare, except for *Navicula digitoradiata* (Greg.) Ralfs which is present as a subdominant. The changes in the percentage correlation of the halobious groups in depth are presented on Figs. 5B, 6B. The quantitative proportions of these groups are almost constant and the indifferent species predominate.

According to "Habitat spectrum" 94.2 % of the diatom flora is benthic. The epiphytic species are more dominant (62.1 %) than the relatively lower percentage of deep water form (32.1 %). Typical planktonic species such as *Stephanodiscus minutulus* (Kütz.) Cl. & Moller, *Aulacoseira ambigua* (Grun.) Sim., *A. granulata* (Ehr.) Sim., *A. valida* (Grun.) Kramm., *Asterionella ralfsii* W.Sm. are abundant in depth. The variations in the percentage ratio of habitat groups are comparatively the same in both bore-holes: VPA-1 and VJA-2 (Figs. 5C, 6C). At the base of the bore-holes the epiphytic species are present in large numbers, but in the uppermost part the benthic (deep water) forms occur with increasing abundance.

In terms of the active water reaction the alkaliphilic (50 %) and indifferent (26.1 %) species prevail in the diatom flora. The acidophilic species amount to only 10.5 %, but some of them such as: *Eunotia pectinalis* var. *minor* (Kütz.) Rabenh., *E. praerupta* Ehr., *Pinnularia interrupta* W.Sm., *Tetracyclus glans* (Ehr.) Mills have been established in large quantities (Figs. 5A, 6A).

In geographical distribution the cosmopolitan group (74 %) is predominant, followed by boreals (15 %), north-alpines (10.3 %) with the tropicals (0.7 %) coming last.

Results of the relative proportions of diatom frustules/chrysophycean stomatocystae

In the alginite from the well VPA-1, Pinciná tracing the ratio, diatom frustules/chrysophycean stomatocystae we observed one peak in the development of the stomatocystae (Fig. 5D). From 26.30–13.20 m a diatom

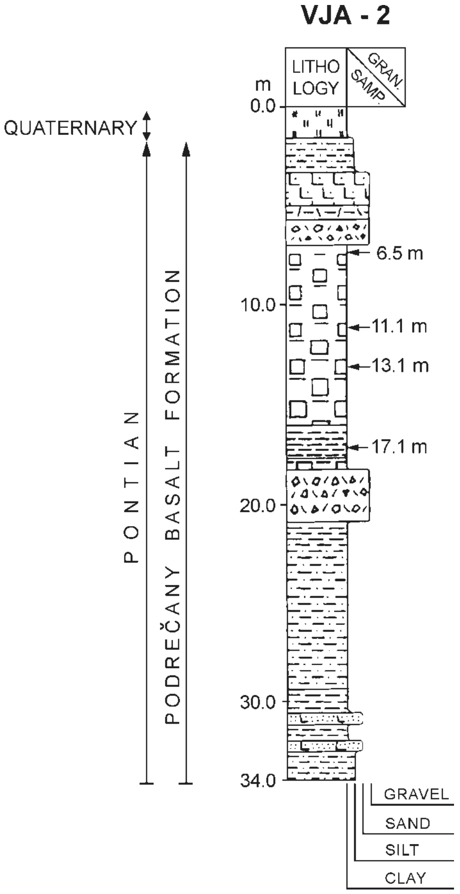


Fig. 8. Sketch of the bore-hole VJA-2, maar Jelšovec. For explanation see Fig. 7.

association with monospecific character is established. Within this range the relative proportion in the algal successions is comparatively constant (varies between 89 and 100 % with the diatom predominating). The ratio in the sample at 10.0 m is different. The quantity of the chrysophycean stomatocystae sharply increases and this coincides with a change in the diatom succession — the second diatom assemblage has developed. Different species of the genus *Aulacoseira* Thw. and also *Stephanodiscus minutulus* (Kütz.) Cl. & Moll. are found indicating an eutrophic environment of the paleolake.

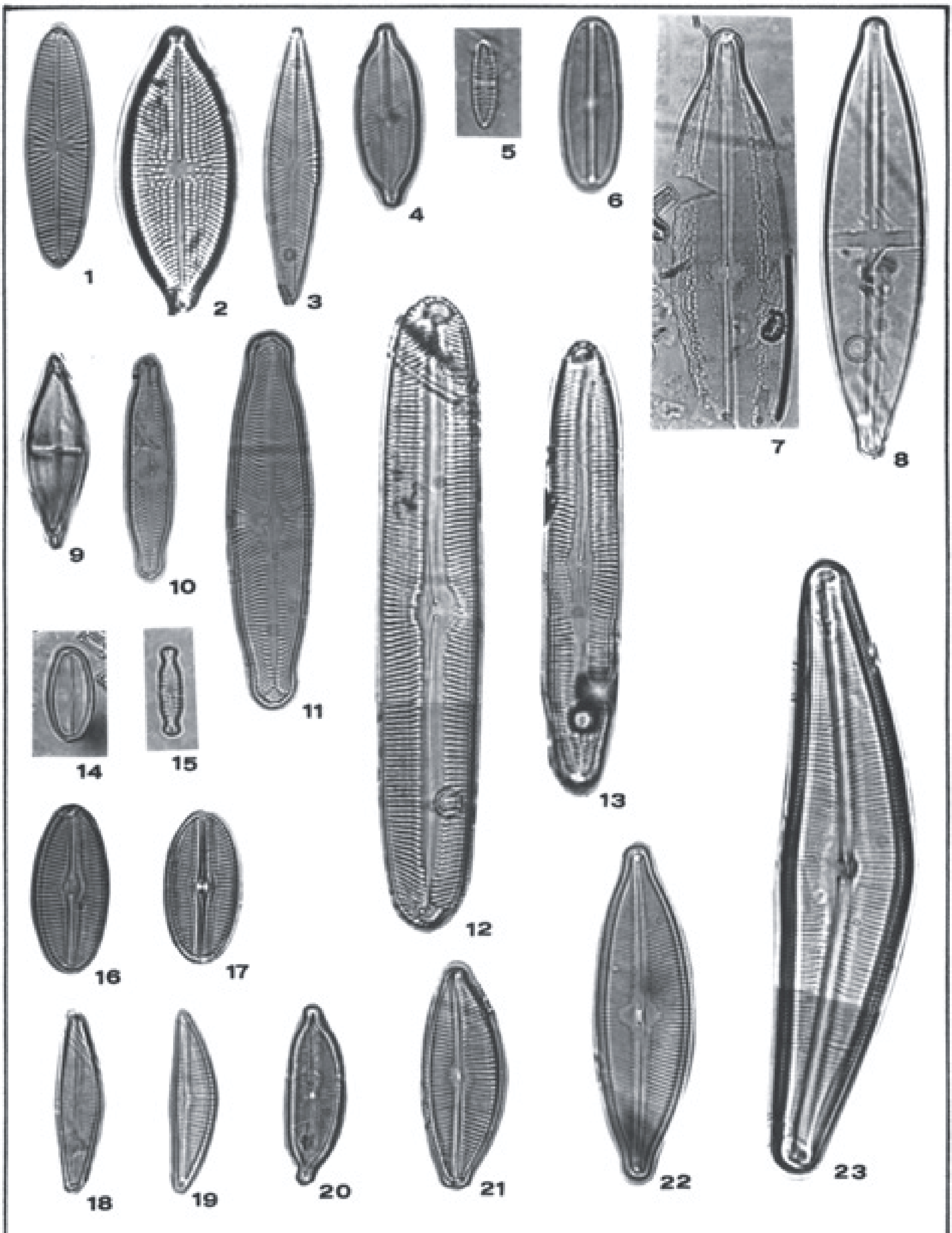
In the diatomite from the well VJA-2, Jelšovec the ratio diatom frustules/chrysophycean stomatocystae in the examined core-drill is relatively constant (Fig. 6D). At 11.10 m there is insignificant increase in the quantity of the stomatocystae. This coincides with the appearance and abundant development of the typical eutrophic species — *Stephanodiscus minutulus* (Kütz.) Cl. & Mold., *Aulacoseira ambigua* (O.Mull.) Sim. In the uppermost part of the borehole the diatoms are dominant (92–100 %). The quantity of *Cyclotella* sp. is increasing again and supports the development of a new oligotrophic stage.

Paleoecological interpretation and conclusion

The ecological analysis of siliceous microfossils (diatom and chrysophycean stomatocystae) gives evidence that the maar sediments of Podrečany Basalt Formation were probably deposited in a comparatively shallow lacustrine environment. The waters of the lake were slightly alkaline (pH = 7–8) with salinity of (0.2) 0.3–0.5 ‰. The climate was temperate. The lake grew progressively shallower because of filling with sediments and increase of the plankton production. The nutrient spectrum suggests that in the beginning of the deposition an olig-

Plate II: Fig. 1. *Navicula digitoradiata* (Greg.) Ralfs, VPA-1 Pinciná, 10.00 m, ×800. **Fig. 2.** *N. tuscula* Ehr., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 3.** *N. menisculus* Schum., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 4.** *N. pseudoanglica* L.-Bert., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 5.** *N. costulata* Grun., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 6.** *Sellaphora bacillum* (Ehr.) Mann, VPA-1 Pinciná, 18.30 m, ×800. **Fig. 7.** *Neidium productum* (W.Sm.) Cl., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 8.** *Stauroneis phoenicenteron* (Nitzsch.) Ehr., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 9.** *S. smithii* var. *incisa* Pant., VJA-2 Jelšovec, 13.10 m, ×800. **Fig. 10.** *Pinnularia braunii* var. *amphicephala* (Mayer Hust., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 11.** *P. interrupta* W.Sm., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 12.** *P. maior* (Kütz.) Rabenh., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 13.** *P. esox* Ehr., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 14.** *Achnanthes flexella* (Kütz.) Brun., VPA-1 Pinciná, 5.90 m, ×800. **Fig. 15.** *Achnanthes* sp., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 16.** *Diploneis elliptica* (Kütz.) Cl., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 17.** *D. elliptica* (Kütz.) Cl., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 18.** *Cymbella gracilis* (Ehr.) Kütz., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 19.** *C. silesiaca* Bleisch., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 20.** *C. naviculiformis* (Auersw.) Cl., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 21.** *C. ehrenbergii* Kütz., VJA-2 Jelšovec, 13.10 m, ×800. **Fig. 22.** *C. subcuspidata* Kramm., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 23.** *C. aspera* (Ehr.) Perag., VPA-1 Pinciná, 10.00 m, ×800.

Plate III: Fig. 1. *Eunotia pseudopectinalis* Hust., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 2.** *E. pectinalis* var. *minor* (Kütz.) Rabenh., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 3.** *E. praerupta* Ehr., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 4.** *E. praerupta* Ehr., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 5.** *E. polyglyphoides* Sheshuk., VJA-2 Jelšovec, 6.50 m, ×800. **Fig. 6.** *Gomphonema acuminatum* Ehr., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 7.** *G. gracile* var. *lanceolata* (Kütz.) Cl., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 8.** *G. clavatum* Ehr., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 9.** *G. grovei* var. *hermanniana* (Patr.) Koc., Yang, Stoerm., VJA-2 Jelšovec, 11.10 m, ×2000. **Fig. 10.** *Epithemia turgida* (Ehr.) Kütz., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 11.** *E. zebra* var. *saxonica* (Kütz.) Grun., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 12.** *E. zebra* var. *porcellus* (Kütz.) Grun., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 13.** *E. sorex* Kütz., VJA-2 Jelšovec, 11.10 m, ×800. **Fig. 14.** *Rhopalodia gibba* (Ehr.) O.Mull., VJA-2 Jelšovec, 11.10 m, ×800. **Fig. 15.** *R. gibba* (Ehr.) O.Mull., VPA-1 Pinciná, 5.90 m, ×800. **Fig. 16.** *Surirella biseriata* Breb., VPA-1 Pinciná, 13.20 m, ×800. **Fig. 17.** *Cymatopleura solea* (Breb.) W.Sm., VJA-2 Jelšovec, 11.10 m, ×800. **Fig. 18.** *Campylodiscus lacus baicali* Skw., VPA-1 Pinciná, 10.00 m, ×800. **Fig. 19.** *Hantzschia amphioxys* (Ehr.) Grun., VPA-1 Pinciná, 5.90 m, ×800. **Figs. 20, 21, 23.** Chrysophycean stomatocystae, VPA-1 Pinciná, 10.00 m, ×800. **Figs. 22, 24, 25.** Chrysophycean stomatocystae, VPA-1 Pinciná, 5.90 m, ×800.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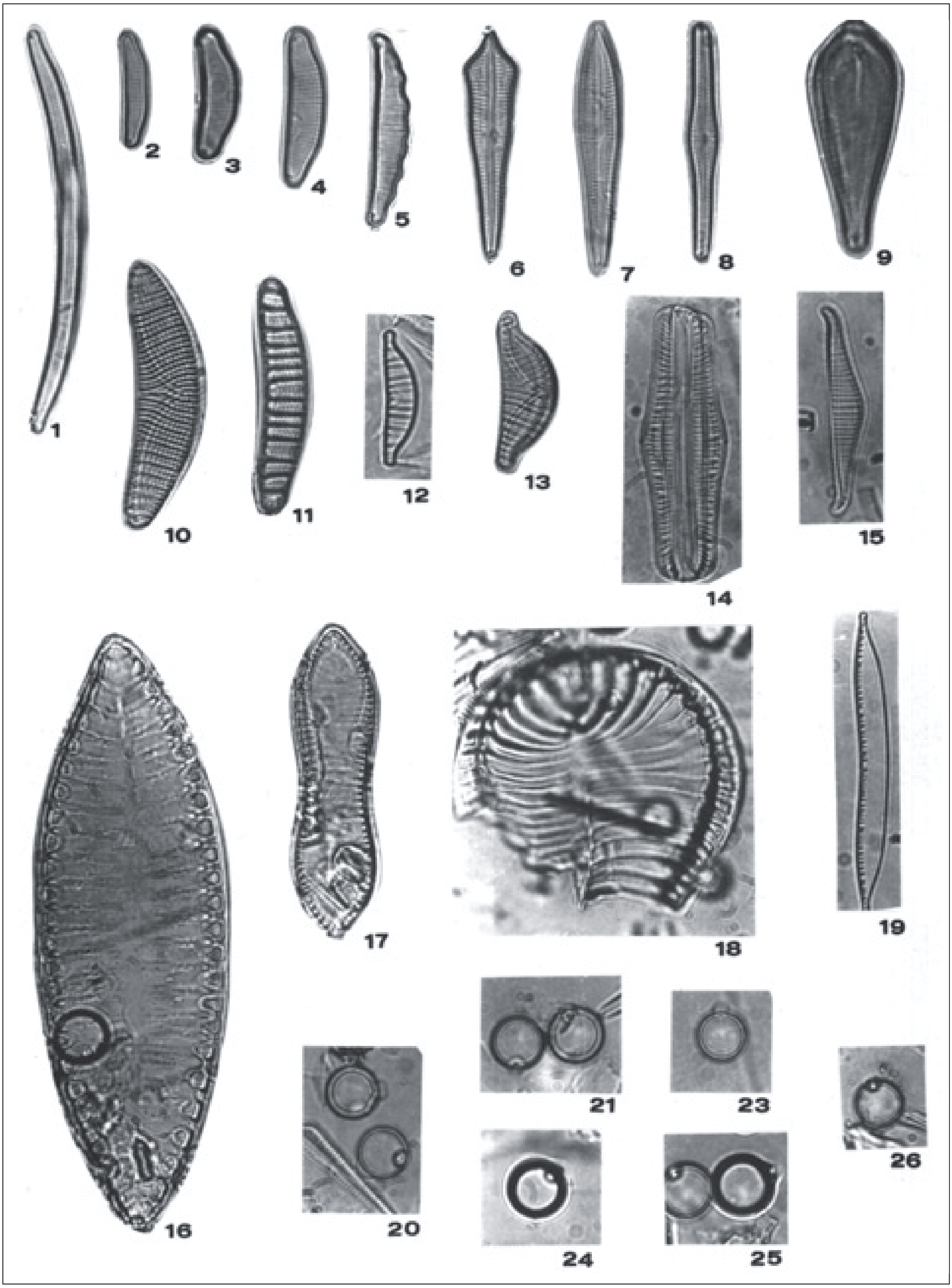
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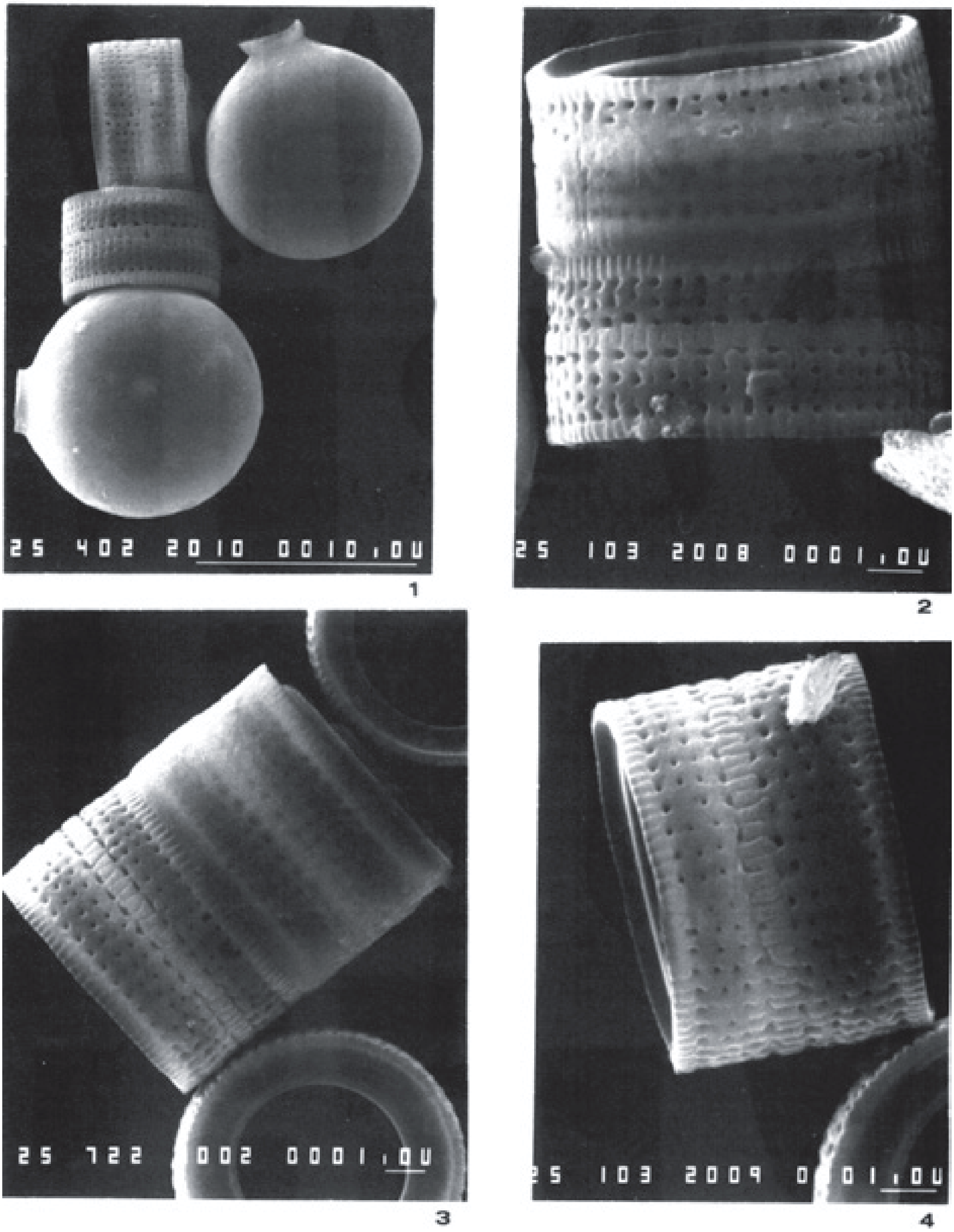


Plate IV: Fig. 1. *Aulacoseira distans* var. *scala* (Ehr.) nov.comb. and chrysophycean stomatocystae, VPA-1, Pinciná, 5.90 m, SEM, ×4000. **Fig. 2.** *Aulacoseira distans* var. *scala* (Ehr.) nov.comb. — VPA-1, Pinciná, 5.90 m, SEM, ×10,000. **Fig. 3.** *Aulacoseira distans* var. *scala* (Ehr.) nov.comb. — VPA-1, Pinciná, 5.90 m, SEM, ×7200. **Fig. 4.** *Aulacoseira distans* var. *scala* (Ehr.) nov.comb. — VPA-1, Pinciná, 5.90 m, SEM, ×10,000.

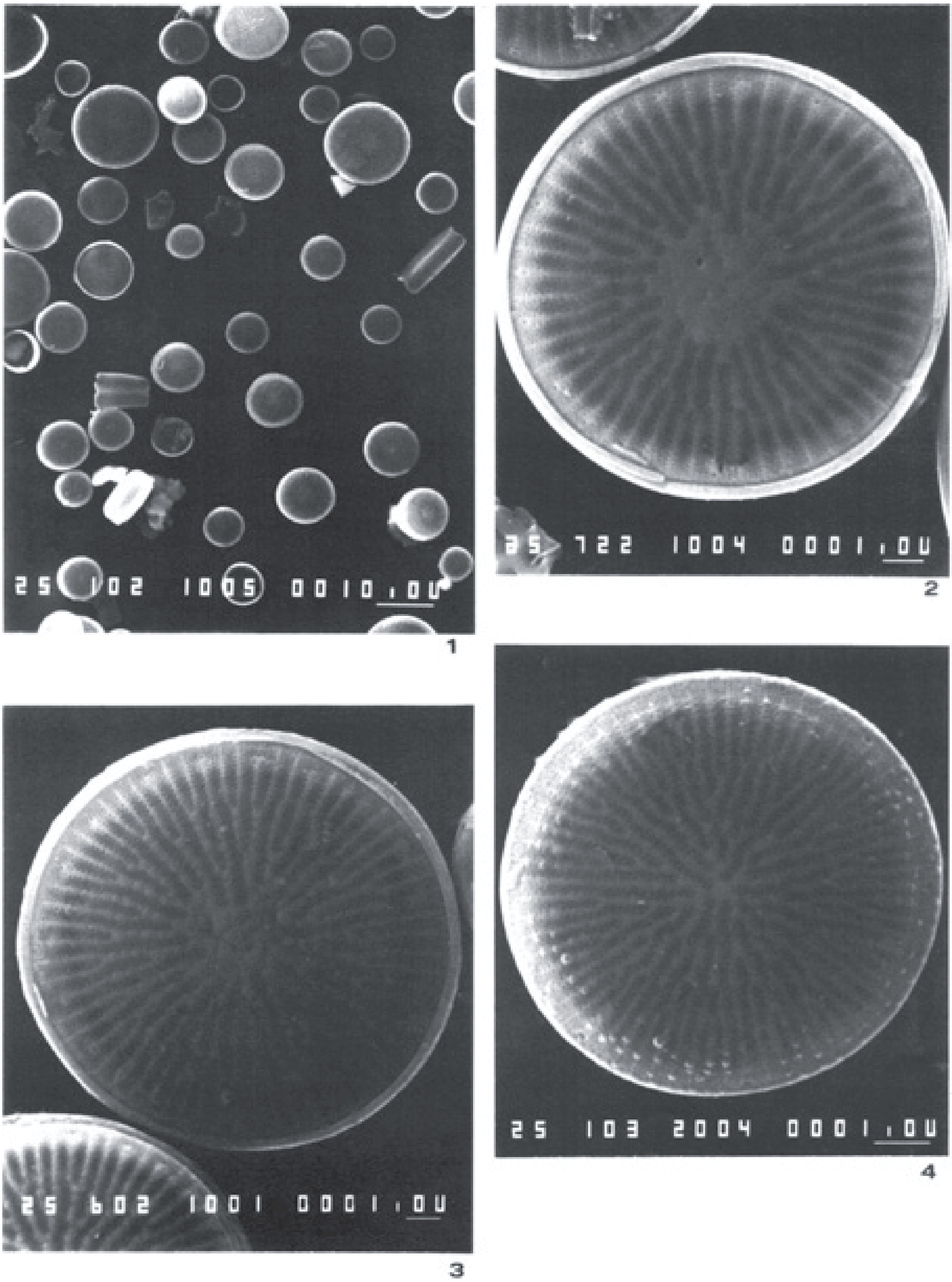
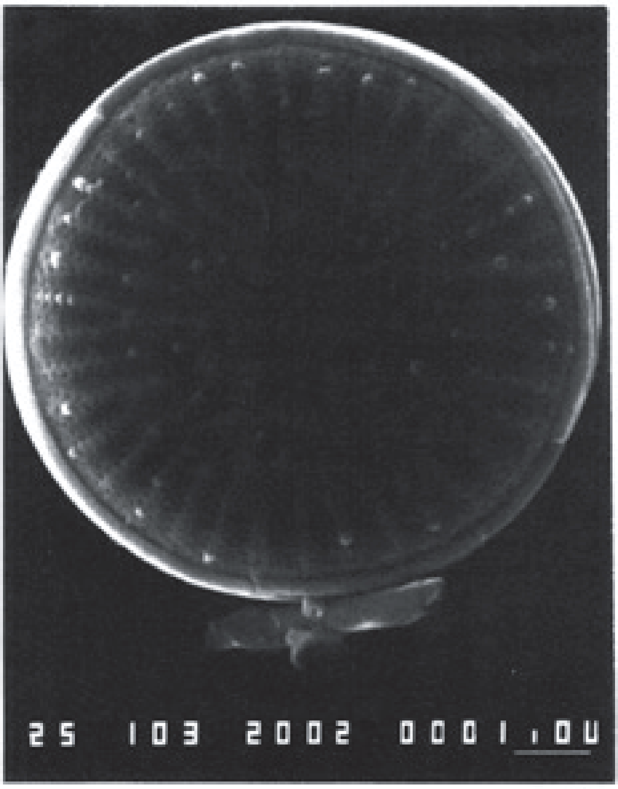


Plate V: Fig. 1. The rock-forming *Cyclotella* sp., VJA-2 Jelšovec, 13.10 m, SEM, ×1000. **Fig. 2.** *Cyclotella* sp., valve exterior, VJA-2 Jelšovec, 13.10 m, SEM, ×7200. **Fig. 3.** *Cyclotella sp*., valve exterior, VJA-2 Jelšovec, 13.10 m, SEM, ×6000. **Fig. 4.** *Cyclotella* sp., valve exterior, VPA-1 Pinciná, 18.30 m, SEM, ×10,000.



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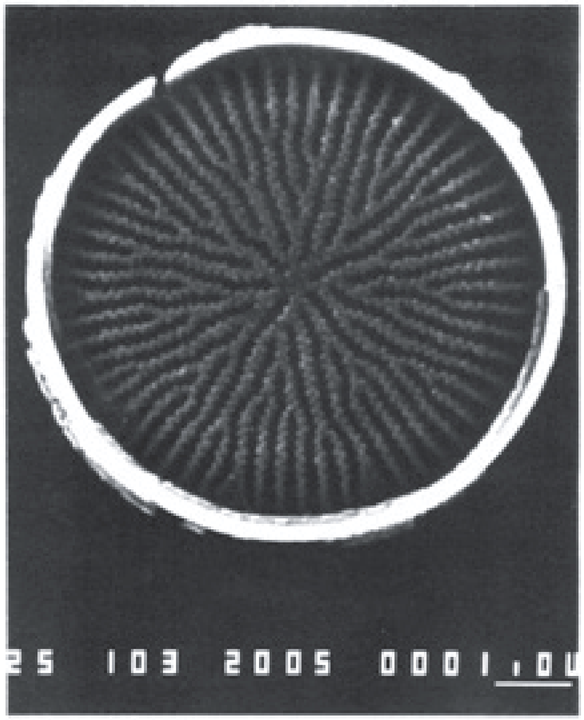

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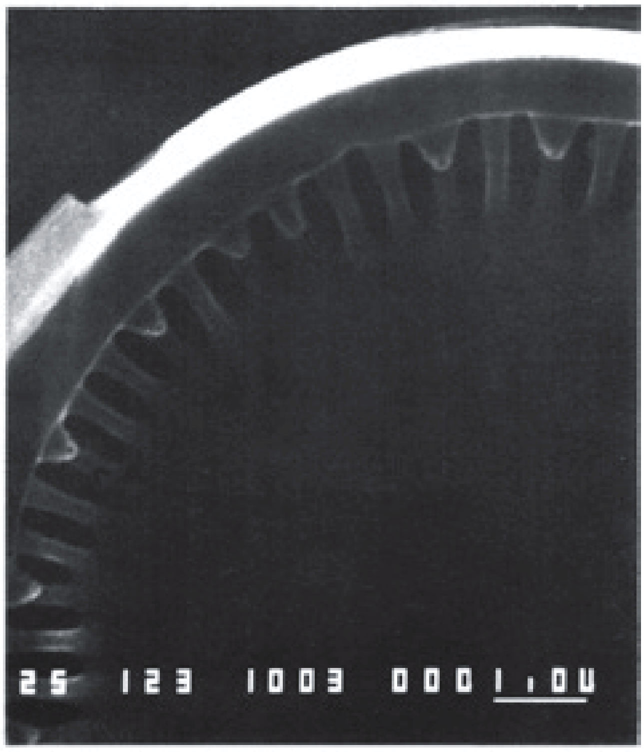

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Plate VI: Fig. 1. *Cyclotella* sp., valve exterior, VJA-2 Jelšovec, 13.10 m, SEM, ×10,000. **Fig. 2.** *Cyclotella* sp., striae pattern, VPA-1 Pinciná, 18.30 m, SEM, ×10,000. **Fig. 3.** *Cyclotella* sp., valve interior, VJA-2 Jelšovec, 13.10 m, SEM, ×5400. **Fig. 4.** *Cyclotella* sp., detail of the valve interior (A-marginal fultoportula with three satelite pores and B-the single rimoportule), VJA-2 Jelšovec, 13.10 m, SEM, ×12,000.

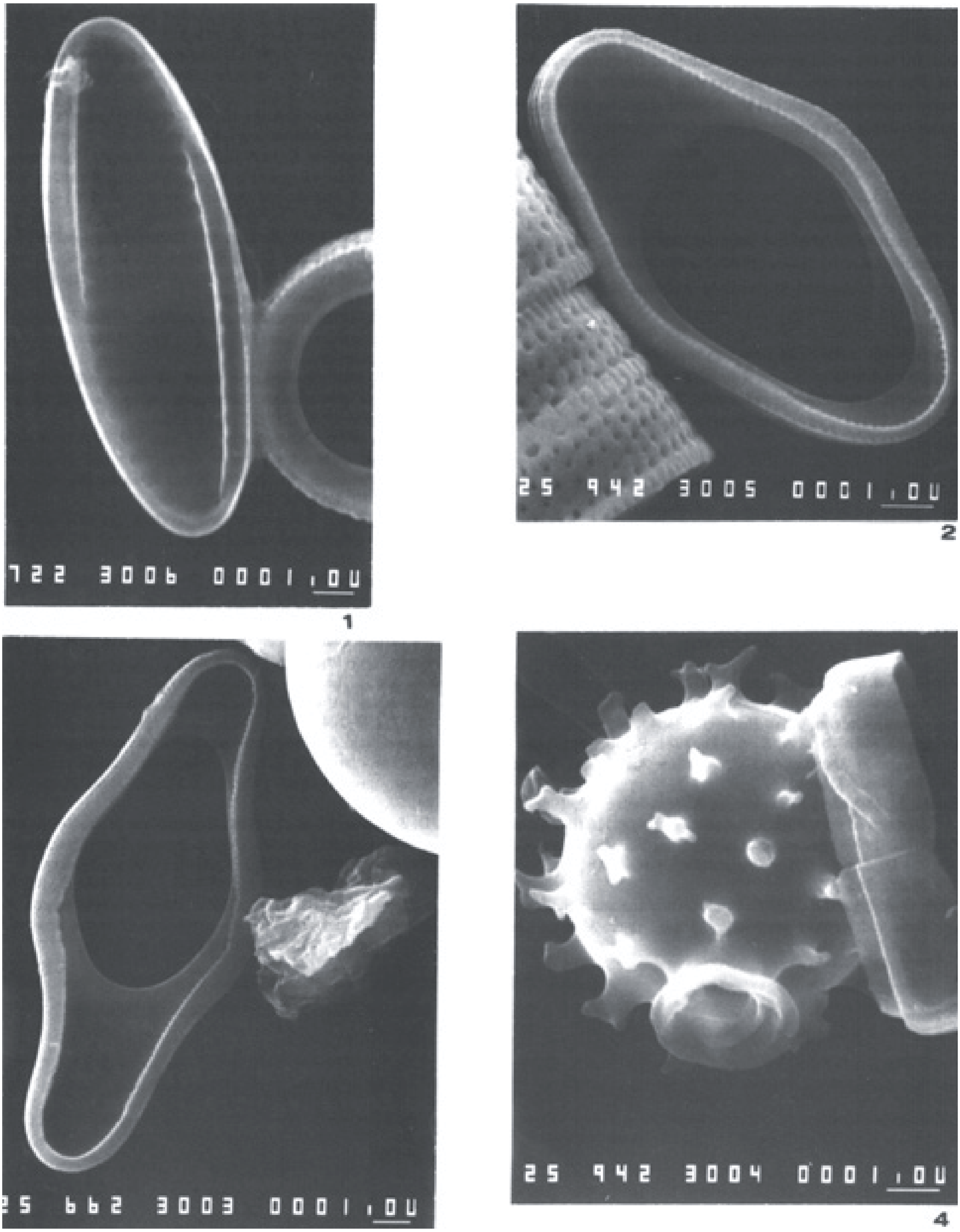

Plate VII: Fig. 1. *Tabellaria* sp., valve interior, VPA-1 Pinciná, 5.90 m, SEM, ×7200. **Fig. 2.** *Tabellaria* sp., septum, VPA-1 Pinciná, 5.90 m, SEM, ×9400. **Fig. 3.** *Tabellaria* sp., septum, VPA-1 Pinciná, 5.90 m, SEM, ×6600. **Fig. 4.** Chrysophycean stomatocysta, VPA-1 Pinciná, 5.90 m, SEM, ×9400.

otrophic phase can be distinguished, which is followed by a eutrophic stage in both bore-hole sequences (VPA-1 Pinciná and VJA-2 Jelšovec). Only in the sedimentation of VJA-2 Jelšovec a probably high influx of water determined a new oligotrophic stage.

Taking into consideration other ecological indicators into account, as well as the ecological demand of diatom assemblages, one can made larger paleoecological interpretations. An oligotrophic phase took place in the Jelšovec maar at the beginning of the depositions. In the Pinciná maar the whole lake fill is crowded by organic matter of *Botryococcus braunii*. For preservation of the organic matter in an excellent state, anaerobic condition in stagnant water with a stratified water column, are assumed. From the beginning of the deposition, eutrophic condition are evident. The oligotrophic phase proved by the diatom assemblage studied from the depth of 13.2–26.3 m (bore-hole VPA-1) must be occasional and not dominant.

The eutrophic, shallow, stagnant water with pH about 7.6 is assumed also by Hajós (1990) for the lakes in which the alginite was originated in Hungary. Salinity in the Hungarian maar lakes was higher (3 ‰) that in the Pinciná maar.

Organic matter is missing from the sedimentary infill of the Jelšovec maar. The deposition could take place in well oxygenated bottom water. The idea is supported by the Diatomaceae assemblages indicating the oligotrophic stage in both the lower and upper portions of the lake filling sediments.

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