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TAXONOMIC NOTES, TYPIFICATION AND BIOSTRATIGRAPHY OF *DIPLONEIS CARPATHORUM* (BACILLARIOPHYCEAE) AND ONE NEW RELATED SPECIES*

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Abstract. Type material of *Diploneis carpathorum* (Pantocesk) Pantocsek from Neogene nonmarine deposits near Dúbravica village in the present-day Slovak Republic was examined by LM and SEM. Its taxonomic description and typification are given, based on the original line drawing and on materials housed in the Pantocsek Collection, Natural History Museum, Budapest. Its synonymy and previous reports of the taxon are discussed. A new related species, *Diploneis balcanica*, is described, differing in morphology from *D. carpathorum*. The descriptions of these two biostratigraphically useful species should help resolve the Neogene history of the continental European basins.

Key words: *Diploneis carpathorum*, *Diploneis balcanica*, new species, Bacillariophyceae, Neogene, Josef Pantocsek Collection

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INTRODUCTION

Navicula carpathorum Pantocsek was described from Neogene nonmarine deposits near Dúbravica village in the present-day Slovak Republic (Pantocsek 1892, 1905). In 1892 only plates were published without the text, and the formal description was printed in 1905. Later, Pantocsek (1913) revised his first description and transferred this species to the genus *Diploneis* Ehrenberg. Josef Pantocsek (1864–1916) accumulated a rich diatom collection. In 1917, after the death of J. Pantocsek, his collection was purchased by the Department of Botany of the Hungarian Natural History Museum, Budapest. Unfortunately, over 4000 slides of this collection were destroyed during the Second World War (Krenner 1980), and only a fifth of the slides could be reconstructed from the remains. At this time, 918 slides are available and the raw material (cleaned unmounted diatoms) remains mostly intact.

For this paper we examined the ultrastructure of the extant species *Diploneis carpathorum* (Pant.) Pant., based on raw material from deposits near Dúbravica village. A specimen has been selected to serve as the lectotype. We separate and describe one new related species of *Diploneis* Ehr. from Neogene nonmarine sediments of the Sofia Basin, Bulgaria, based on morphological differences. These two biostratigraphically useful species should help resolve the Neogene history of the continental European basins.

MATERIALS AND METHODS

The examined materials consist of raw material from Neogene lacustrine sediments near Dúbravica village in the present-day Slovak Republic, belonging to the Pantocsek collection currently housed at the Natural History Museum, Budapest. In addition, more recent collections from Neogene lacustrine sediments in the Sofia Basin, Bulgaria, were also studied.

The raw material from Dúbravica was mounted in

* Dedicated to Dr. Kurt Krammer on the occasion of his 85th birthday

Zrax resin. A Leica DM LB2 (100× HCX PLAN APO) with a Fujifilm Digital Camera (FinePix S2 Pro) was used for LM analysis. Preparation and analysis of the diatom samples from the Sofia Basin followed the standard techniques of Ognjanova-Rumenova (1991). All specimens were examined with a Hitachi S-2600 N scanning electron microscope at the Natural History Museum, Budapest. The terminology used here follows Anonymous (1975) and Ross *et al*. (1979), with a few additions from recent proposals (Idei & Kobayasi 1989; Droop 1994, 1996, 1998).

Observations and discussion

The genus *Diploneis* Ehr. is a large and diverse group, which is distinguished by the presence of longitudinal canals along the axial area and by the arrangement of pores in the canal (Round *et al*. 1990; Droop 1998). Many of the diagnostic details common to other members of the genus are discussed below: the form of the valves, longitudinal canal, central nodule, raphe sternum furrow, and the shape of the central raphe ending. The species of *Diploneis* described below have been separated by more or less obvious morphological differences connected with striation density (position of measurement – close to the longitudinal canal), striae structure, and the striae – divided into chambers (Idei & Kobayasi 1989; Droop 1994, 1996, 1998). The described species also differ in their temporal and geographic distribution (different climate, geology, hydrology and ecology).

Diploneis carpathorum (Pantocsek) Pantocsek 1913 Figs 1–6 & 8–13

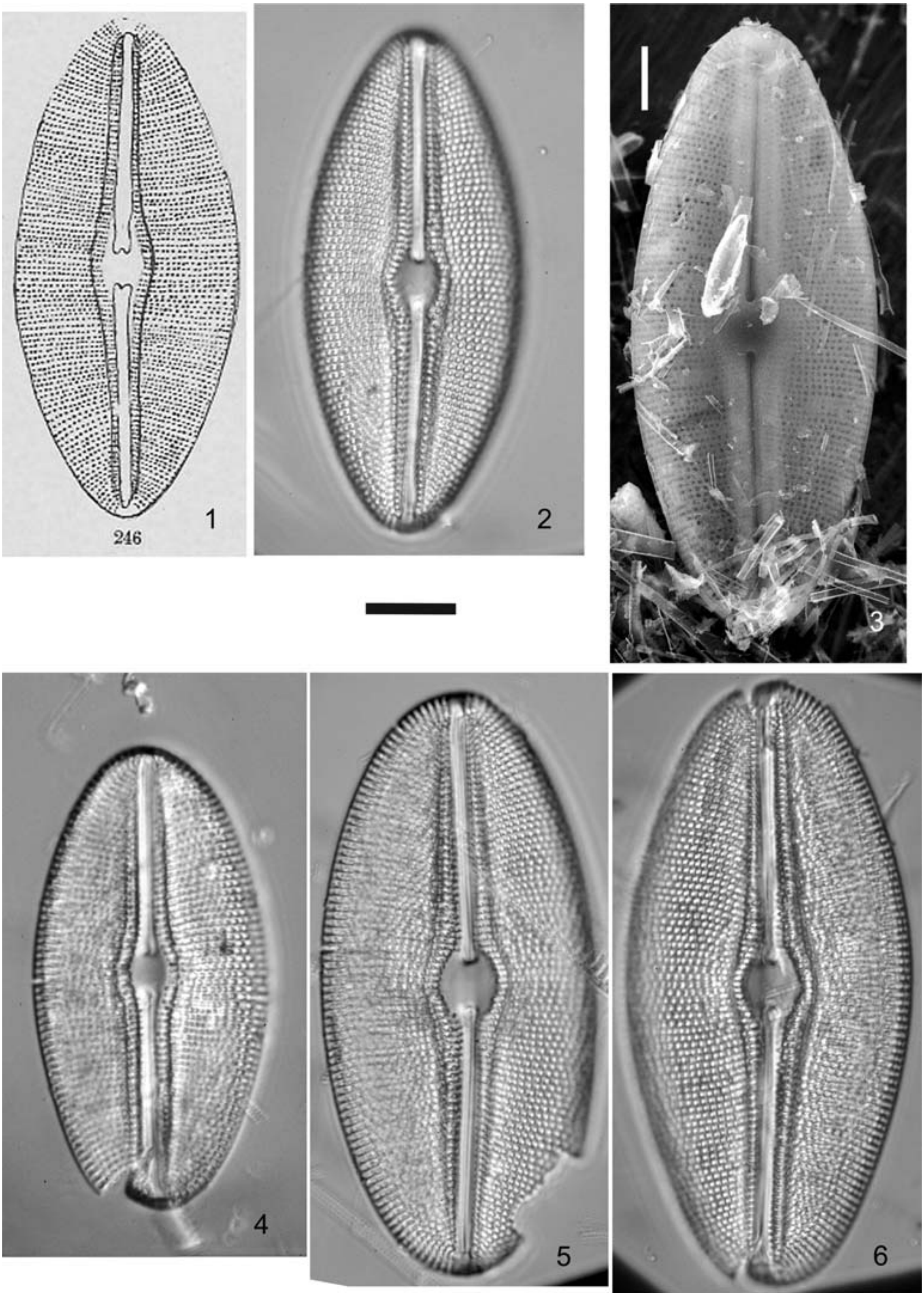
Basionym: *Navicula carpathorum* Pantocsek 1892 (1905): Beiträge zur Kenntnis der fossilen Bacillarien Ungarns. **3**: 65 (Beschreibung neuer Bacillarien, welche in der Parts III der 'Beiträge zur Kenntnis der fossilen Bacillarien Ungarns' abgebildet wurden: Pl. 17, fig. 246).

Lectotype (designated here): SLOVAKIA, Dúbravica 52, Pantocsek Collection, Natural History Museum, Budapest, BP 2203.slide no. 6/2009.11.05. (The original slides were destroyed during the Second World War).

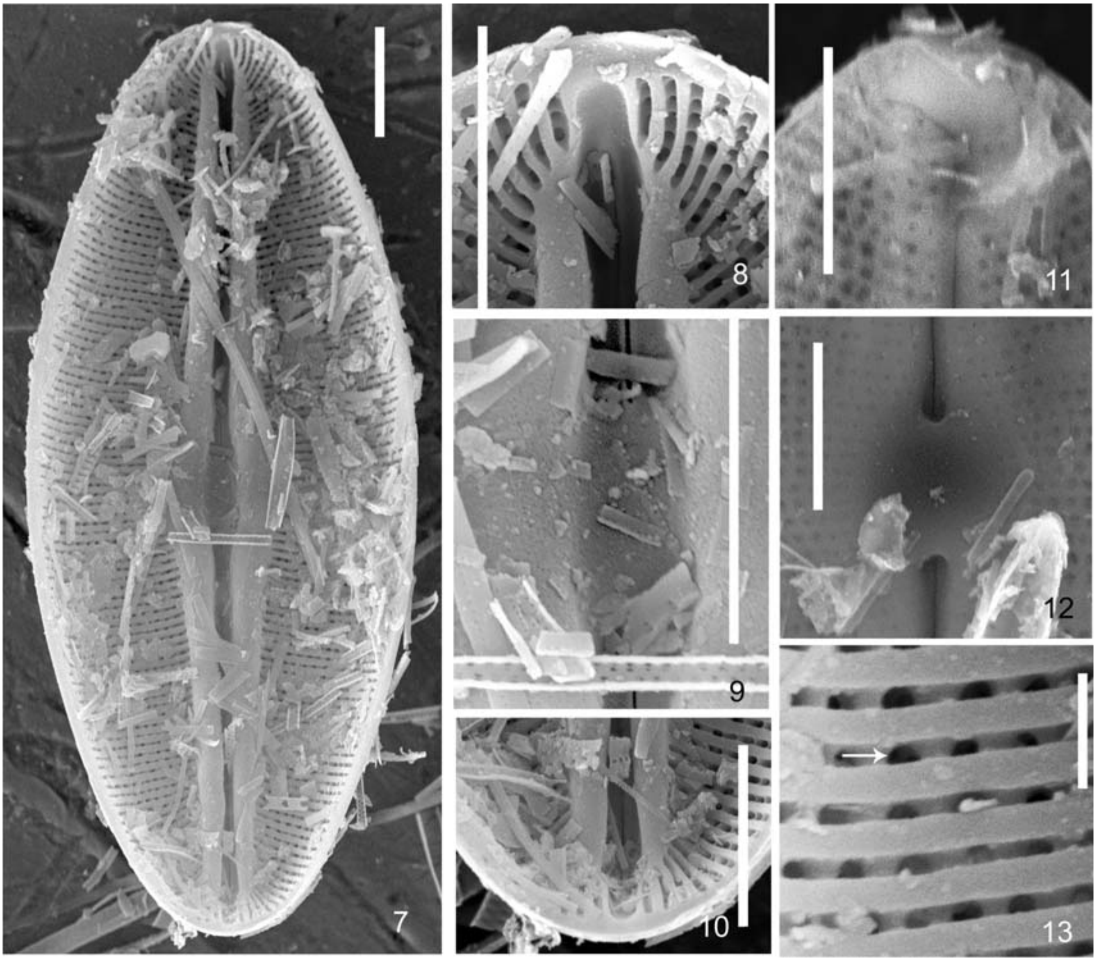
Dimensions. (64)68–87(112) μm length, (30)32–43(46) μm width, striation density 9–10/10 μm.

The valves are large, elliptical in outline, with rounded apices. The longitudinal canals and axial area together form a lanceolate area about one-fourth the width of the valve. The boundary between each longitudinal canal and the rest of the valve has an irregular contour. Striae are composed of a single row of small areolae. On the inner side of the valve the longitudinal canals extend the length of the valve, and the wall of the canals has no openings or poroids. Externally the proximal raphe fissures terminate without curvature (Fig. 12) and the terminal fissures bend sharply to one side of the valve, but do not extend onto the mantle (Fig. 11). Internally the raphe slits are straight and narrow, lying in a groove created by the longitudinal canals. The raphe terminates simply at both ends (Figs 8 & 10). The thick costae on the internal valve face create interstrial depressions or channels in which the areolae are positioned. The interstrial channels are not covered by a hymen and lack an alveolate chamber. Externally each areola is occluded by a cribra, while the interior opening is without a membrane (Fig. 13). The areolae opening into the longitudinal canals on the valve face are smaller than the adjacent areolae.

Remarks. The rare occurrence of this species in the investigated material poses problems, and in some cases the SEM observations are incomplete (i.e., both ends of the terminal fissures are not presented). The present confusion over the identity of *Diploneis carpathorum* is due largely to the opinion of Cleve (1894) and Hustedt (1937) that this species is a synonym of *Diploneis ovalis* (Hilse) Cleve. There are a number of differences between these taxa [see Lange-Bertalot & Reichardt 2000, Pl. 1, figs 1–6; Pl. 2, figs 1–3 (type material for *D. ovalis*)]. The morphology of *D. carpathorum* is distinctive, especially the valve form, dimensions, stria density, the ultrastructure around the longitudinal canals and the internal structure of the interstriae. The thickened costae and depressed interstriae of *D. carpathorum* are more similar to *Diploneis krammeri* Lange-Bertalot & Reichardt



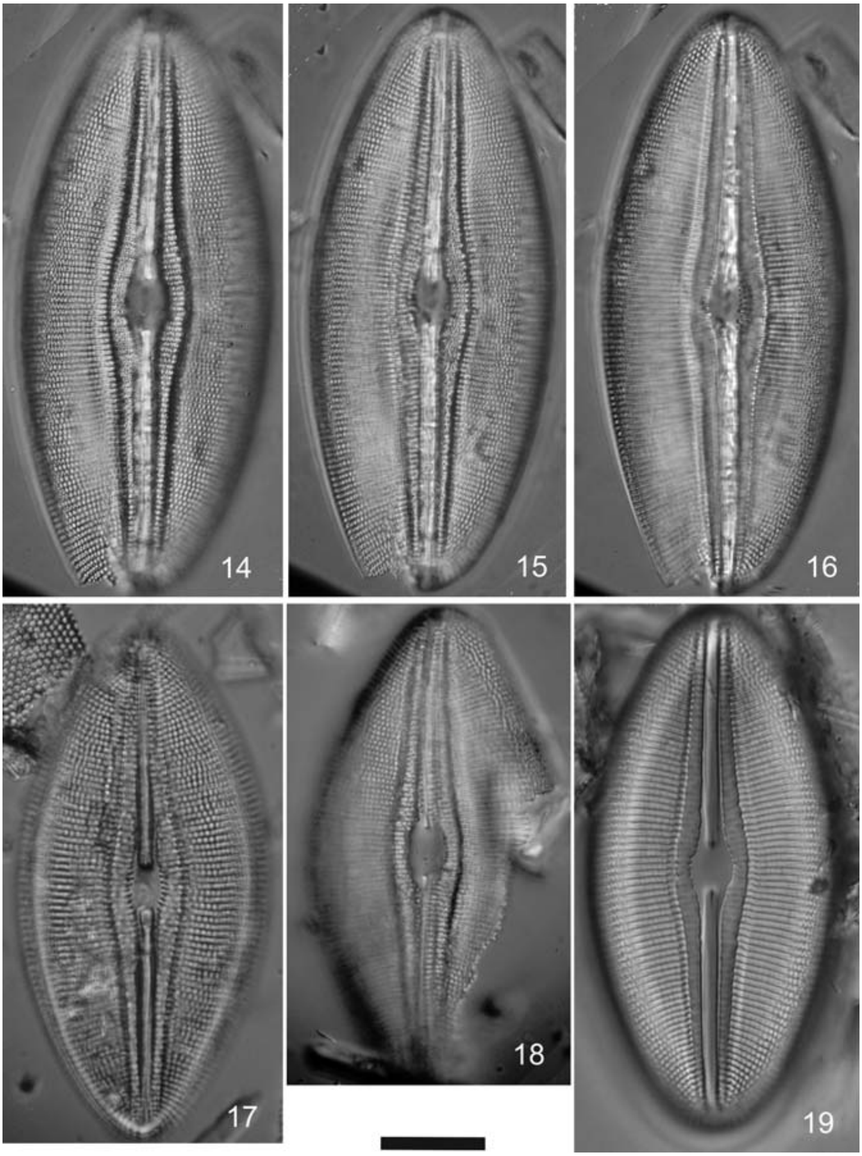
Figs 1–6. *Diploneis carpathorum* (Pantocsek) Pantocsek. 1 – reproduction of Pantocsek's (1892) original illustration (Icon. Table 17, fig. 246); 2 – specimen selected as lectotype in slide prepared from raw material of Dúbravica 52, Pantocsek Collection, Natural History Museum, Budapest; 3 – SEM, external view, whole valve; 4–6 – LM of specimens from the type thanatocoenosis. Scale bars = 10 µm.



Figs 7–13. *Diploneis carpathorum* (Pantocsek) Pantocsek. 7 – internal view, whole valve; 8 & 10 – polar raphe endings; 9 – central part of the raphe; 13 – inner wall of the interstriae; 11 & 12 – external views, raphe fissures, central raphe ending in a round depression, and terminal fissure strongly deflected to one side of the valve; all SEM. Scale bars: 7–12 = 10 μm; 13 = 2 μm.

Table 1. Comparative data for *Diploneis carpathorum* (Pantocesk) Pantocsek, *D. balcanica* Ognjanova-Rumenova & Buczkó *sp. nov.*, *D. ovalis* (Hilse) Cleve and *D. krammeri* Lange-Bertalot & Reichardt.

Taxon / Character	Valve shape	Valve length, μm	Valve width, μm	Striae in 10 μm
Diploneis carpathorum This paper	elliptic	(64–)68–87(–112)	(30–)32–43(–46)	9–10
Diploneis carpathorum Pantocsek 1905	elliptic	85–100	35–40	15
Diploneis balcanica This paper	rhomboid-elliptic	105–111	51.0–60.5	7–9
Diploneis ovalis Lange-Bertalot & Reichardt 2000	rhomboid-elliptic	20–100	10–35	11–14
Diploneis krammeri Lange-Bertalot & Reichardt 2000	linear-elliptic	(10–)20–65	(7–)10 – *ca* 25	10–14

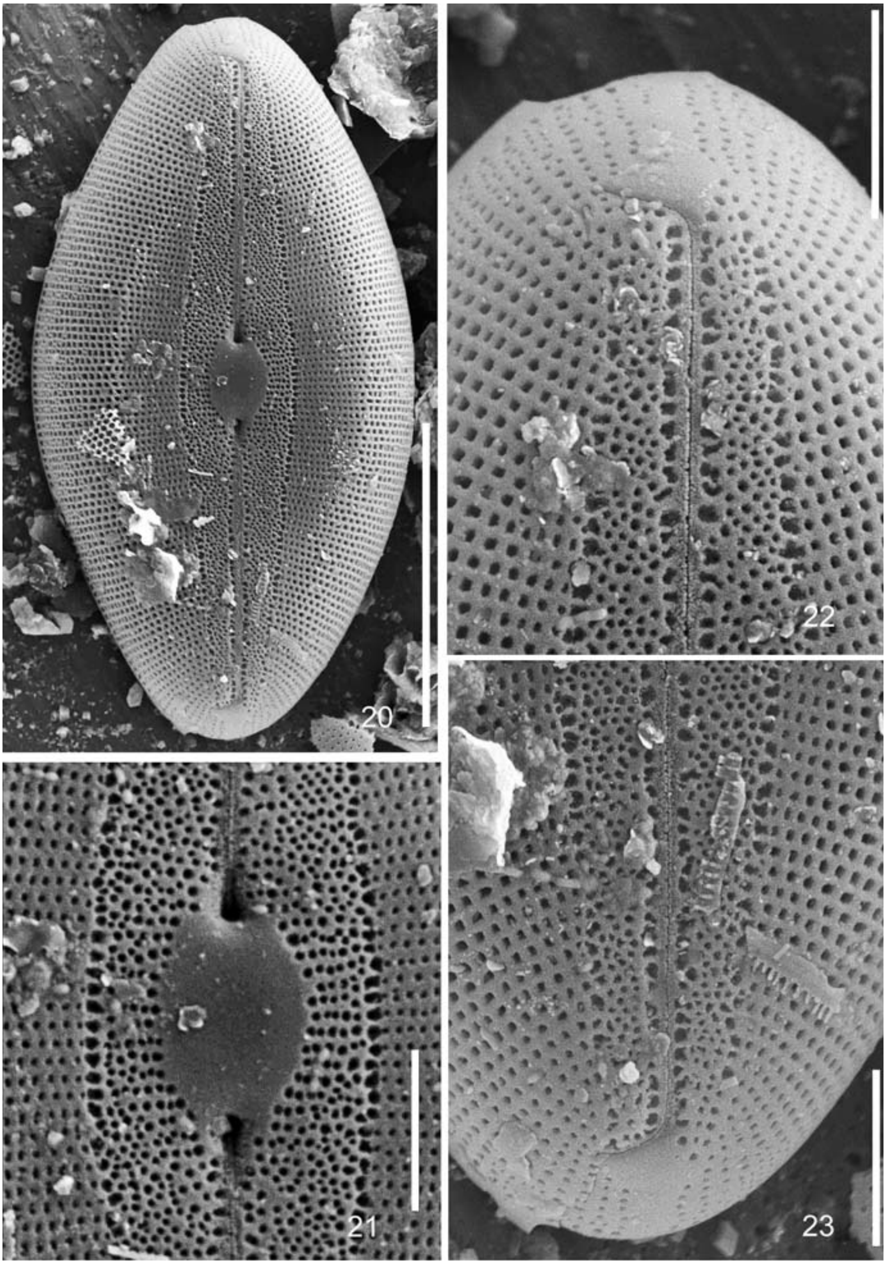


Figs 14–19. *Diploneis balcanica* Ognjanova-Rumenova & Buczkó *sp. nov*. 14–16 – holotype specimen, different focus; 17 & 18 – specimens from the type population; 19 – specimen for different depth sample, v. Goljanovci, core 1, depth 13.50 m; all LM. Scale bars = 10 µm.

(Lange-Bertalot & Reichardt 2000, Pl. 4, figs 1–10 &12; Pl. 5, figs 1–5; Pl. 6, figs 1–5) (Table 1).

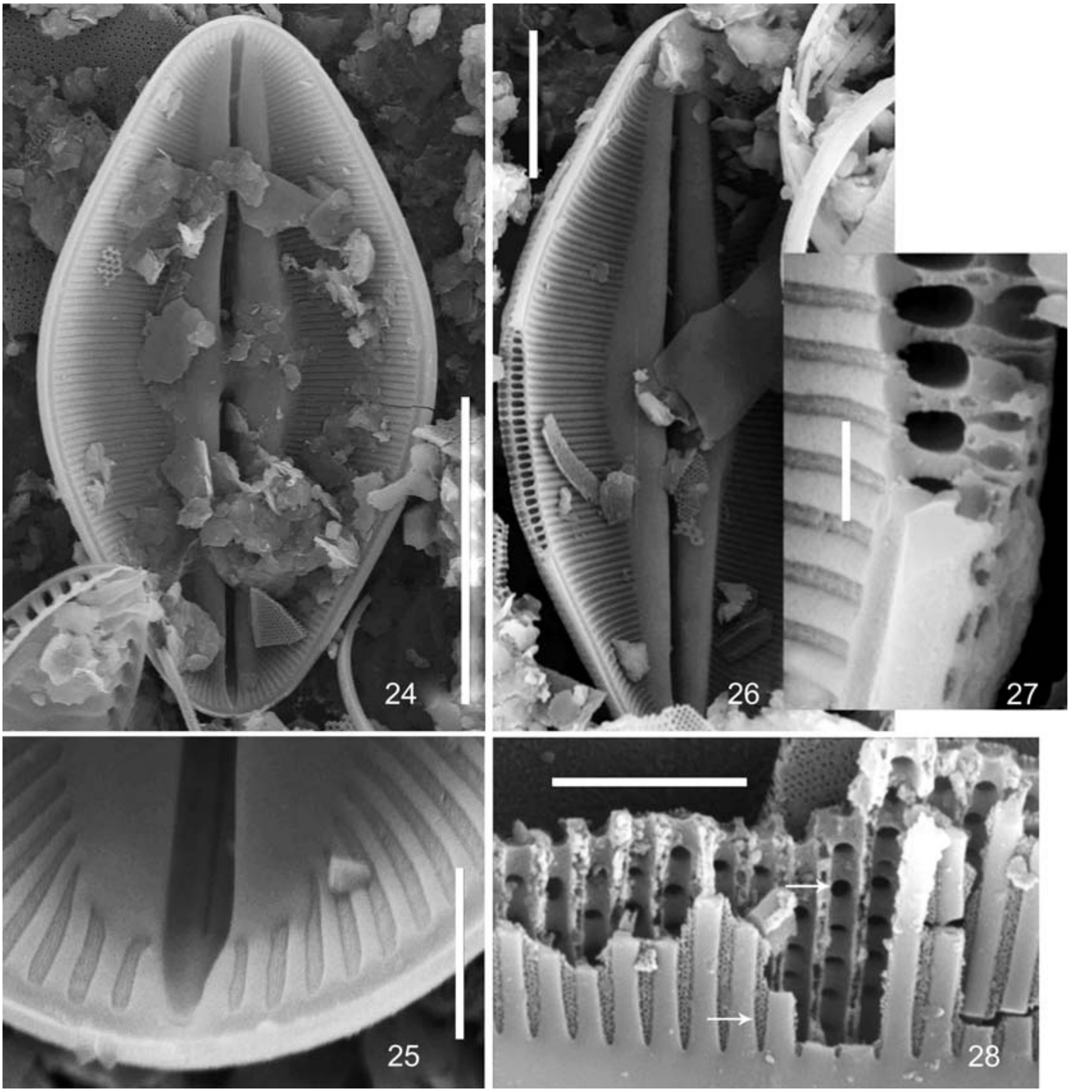
LOCALITIES. Dúbravica, Bory, Farkasfalva, Ihráč, Jastrabá, Močiar.

KNOWN STRATIGRAPHIC RANGE. According to Hajós and Řeháková (1974) the lacustrine sediments near Dúbravica village were deposited in a small lake or swamp within the Central Paratethyan sea during the Sarmatian age. Later, Řeháková (1980) re-examined the different continental deposits in the realm of former Czechoslovakia, including those for the Dúbravica area, and concluded that the chronostratigraphic assignment



Figs 20–23. *Diploneis balcanica* Ognjanova-Rumenova & Buczkó *sp. nov.*, external views of a single valve. 20 – whole valve; 21 – central area; 22 & 23 – terminal raphe fissures; all SEM. Scale bars: 20 = 50 μm; 21–23 = 10 μm.

should be Upper Miocene-Lower Pliocene. The updated correlations for the Miocene in the Central Paratethyan realm based on different fossil data (mammals, planktonic foraminifera, calcareous nannoplankton) as well as isotope stratigraphy and magnetostratigraphic calibration referred the Sarmatian stage to the Middle Miocene (~11–12 Ma) (Harzhauser & Piller 2007).



Figs 24–28. *Diploneis balcanica* Ognjanova-Rumenova & Buczkó *sp. nov.*, internal views. 24 – whole valve; 25 – polar raphe ending; 26 – broken valve; 27 – detail of broken part, showing structure of perforated layer of silica, which is covered internally by a hymen; 28 – broken part showing the internal opening of the areolae and the inner layer of silica (hymen); all SEM. Scale bars: 24 = 50 µm; 26 = 20 µm; 25, 28 = 5 µm; 27 = 2 µm.

Diploneis balcanica Ognjanova-Rumenova & Buczkó, ***sp. nov.*** Figs 14–28

DIMENSIONS. 105–111 µm length, 51.0–60.5 µm width, striation density 7–9/10 µm.

The valves are large, rhomboid-elliptical in outline, with broadly rounded apices (Figs 14–19). The longitudinal canals and axial area together form a rhomboid lanceolate area about one-third the width of the valve. It has an irregular contour. The striae have single rows of small areolae. On the inner side of the valve the longitudinal canals extend the whole length of the valve; the inner wall of the canal has no openings or poroids. The external raphe fissure terminates without curvature

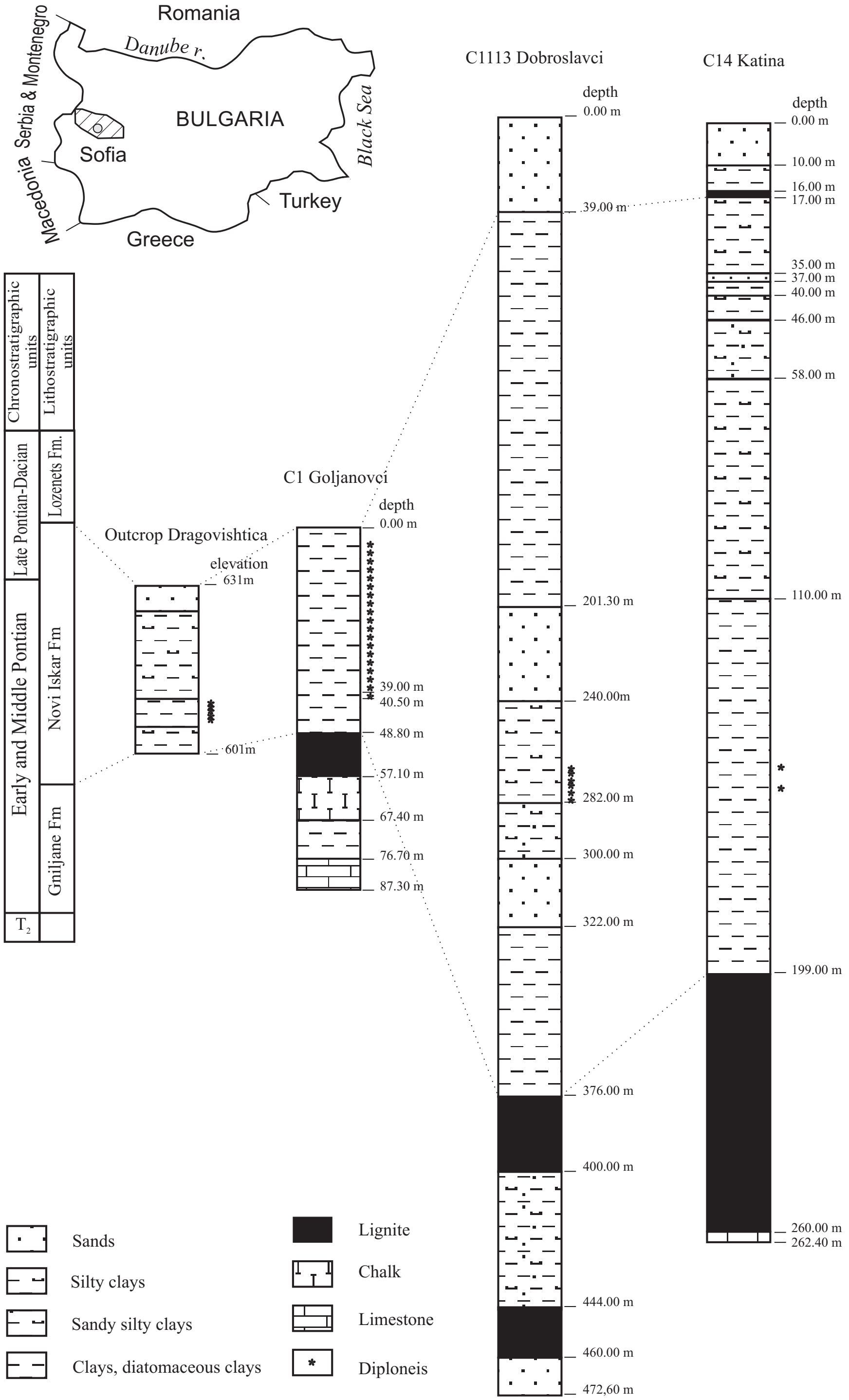


Fig. 29. Biostratigraphic distribution of *Diploneis balcanica* Ognjanova-Rumenova & Buczkó *sp. nov*. within sediments of the Novi Iskar Formation, Sofia Neogene Basin, Bulgaria. Sections of interest are marked '*'.

in a small concavity (Fig. 21). The terminal fissures are sharply bent close to 90 degrees towards the mantle, and both turn in the same direction (Figs 22 & 23). Internally the raphe slits are straight and narrow, lying in the grooves created between the longitudinal canals; they terminate simply at both ends (Figs 24 & 25). A transapically alveolate chamber is formed below the hymen cover of each stria (Figs 26–28). The outer silica wall bears a single row of small areolae.

TYPE: BULGARIA, Goljanovci village, borehole 1 (42°51′00″N, 23°13′48″E), Novi Iskar Formation in the Sofia Neogene Basin, 1985, *leg. Z. Antimova* (HOLOTYPE: Praep. 14/depth 21 m, core 1, v. Goljanovci – in Coll. Ognjanova-Rumenova, Institute of Geology, Bulgarian Academy of Sciences, Sofia; ISOTYPE*:* slide 3/depth 21 m, v. Goljanovci, Pantocsek Collection, Natural History Museum, Budapest, BP 2204).

ETYMOLOGY: *balcanica* – from 'the Balkans' – historical and geographical name used to refer to Southeastern Europe.

REMARKS. *Diploneis balcanica* is distinguished from *D. carpathorum* by the valve form, the form and diameter of the central area, valve dimensions, stria density, and most specifically the interior alveolate formation of the striae. The alveolate-like chambers of the freshwater, elliptic *Diploneis* species are box-like, being occluded externally by an areolate wall and internally by a thin siliceous layer, hymen or rica (Idei & Kobayasi 1986). *Diploneis balcanica* is the same type. The external wall of the alveolus is uniseriate; this is the difference between it and *Diploneis parma* Cl. (Idei & Kobayasi 1986 – Fig. 15). Each alveolus is occluded internally by the hymen, which is similar to that in *D. parma* and *D. ovalis* (Lange-Bertalot & Reichardt 2000). The characteristic data for *Diploneis carpathorum*, *D. balcanica*, *D. ovalis* and *D. krammeri* are compared in detail in Table 1.

Diploneis balcanica is abundant and well preserved in deposits of the Novi Iskar Formation in the Sofia Neogene Basin, Bulgaria (Fig. 29).

LOCALITIES. Borehole C-14, v. Katina, Novi Iskar Formation, depth: 150.0–155.0 m; Borehole C-1113, v. Dobroslavci, Novi Iskar Formation, depth: 268.0–280.0 m; borehole C-1, v. Goljanovci, Novi Iskar Formation, depth 3.0–40.5 m (TYPE LOCALITY); outcrop v. Dragovishtica, Novi Iskar Formation, elevation 606.0–609.3 m (Fig. 29).

KNOWN STRATIGRAPHIC RANGE. Upper Miocene (Pontian stage, Portapherian substage). The stratigraphic range corresponds to mammal zones 12–13 (MN12-13) – *ca* 6–7 Ma (Kojumdgieva *et al*. 1984; Spassov 2000).

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