

Taxonomical re-investigation of Sarmatian diatoms from NE Bulgaria, hosted in the Pantocsek Collection (Budapest)

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Abstract. In the present paper, material collected from the vicinity of Balchik (NE Bulgaria) and housed in the Pantocsek Collection at the Hungarian Natural History Museum (Budapest) has been studied. Ten characteristic diatom species of regional and local importance were revised using scanning electron microscopy in order to clarify their identity. The purpose of the present paper is to elaborate on and photographically document the morphological variability of the examined taxa, and to compare the species composition with previously published data. The presence of *Surirella comis* Schmidt has been recognized for the first time from Bulgaria, as either fossil or recent form. Species characteristic for the association of the *Achnathes baldjickii* var. *podolica* Subzone have been indicated. Its stratigraphic range is within the Sarmatian Stage (Bessarabian Substage).

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Key words: Diatoms, Sarmatian Stage (Bessarabian Substage), Balchik, Bulgaria, Pantocsek Collection, Budapest.

INTRODUCTION

The fossil diatom microflora from sediments in the area of the Town of Balchik, NE Bulgaria, has been the subject of previous investigations. These deposits have been known to the diatomists for about 150 years, and new fossil diatom species were established in the classical phycological works of Brightwell (1859), Grunow (1862, 1880, 1886), Schmidt (1874–1959), Cleve (1894, 1895), Pantocsek (1892, 1905). From this early period of investigations, fifty-four species and varieties of diatoms are known, among which a great number of new species named after Balchik (see Temniskova-Topalova, 1994). Hustedt (1927–1966) presented descriptions and critical notes on certain fossil diatom species from this area. Ross (1963) made the first revision of the fossil diatoms from Balchik, hosted in the Diatom Collection at the Natural History Museum (London), but he misinterpreted the age of the sediments as Pliocene.

During the last decades, many palaeoecological and stratigraphical studies have been carried out, based on synthesis of diatom assemblages from the Varna-

Balchik region (NE Bulgaria). Continuous sequences, from series of cores and outcrops, were studied by Temniskova-Topalova (1994). Temniskova-Topalova (1990) established local diatom biostratigraphic zones and correlated them with mollusk, foraminiferal and ostracod zones. The stratigraphic distribution of index taxa has been traced within the boundaries of the Eastern and the Central Paratethys (Temniskova-Topalova, 1982; Kozyrenko, Temniskova-Topalova, 1990; Olshtynskaya, 2001).

Several interesting species have been revised and new species belonging to the genera *Amphora* and *Diploneis* have been described (Temniskova-Topalova, Economou-Amilli, 1989; Droop, 1998; Levkov, 2009).

In the present paper, material collected from the vicinity of Balchik and housed in the Pantocsek Collection at the Hungarian Natural History Museum (Budapest) has been studied. Characteristic diatom species of regional and local importance were revised, e.g., *Actinocyclus* (?) *podolicus* (Missuna) Kozyrenko, *Caloneis sectilis* (A.S.) Cl. var. *boryana* (Pantocsek) Cleve, *Campylodiscus limbatus* var. *astralis* Eulenstein, *Surirella baldjickii* Norman,

Podosira loczyi Pantocsek. The purpose of this investigation is to bring clarity and to document photographically the morphological variability of the studied taxa, as well as to compare the species composition with previous finds.

MATERIAL AND METHODS

The examined material consists of raw material from Neogene brackish-marine sediments near the Town of Balchik, NE Bulgaria, housed in the Pantocsek Diatom Collection at the Hungarian Natural History Museum (Budapest). The raw material was used for permanent slides (BP 2247-2251) and SEM stubs. We have no information about the cleaning and possible sieving method of Pantocsek. Permanent microscope diatom slides were mounted, using Zrax resin. Preparations were examined with scanning electron microscope (SEM); coating with gold-palladium was accomplished, using a XC7620 Mini Sputter Coater. A Hitachi S-2600N scanning electron microscope operated at 20 kV and 5–8 mm distance was used.

The terminology used in this study principally follows that of Anonymous (1975), Ross et al. (1979) and

Round et al. (1990). The validity of the taxa was checked in Algaebase (Guiry, Guiry, 2016).

GEOLOGY OF THE BALCHIK LOCALITY

Neogene sediments in NE Bulgaria fill the shallow inland Bay of Varna-Balchik of the Euxinian Basin. Four structural and palaeogeographic regions were distinguished in NE Bulgaria by Kojumdgieva, Popov (1981): 1) Silistra-Ruse region (eastern end of the Dacian basin); 2) Southern Dobrudzha strait; 3) Border region of the Varna-Balchik depression; and 4) Varna-Balchik depression with two parts: Varna (south part) and Balchik (north part). Popov, Kojumdgieva (1987) introduced seven formal and two informal lithostratigraphic units for the Miocene of the area.

The diatom assemblages from the Varna-Balchik depression were identified in detail in the succession in different stratigraphic levels by Temniskova-Topalova (1994). Local diatom biostratigraphical zones were introduced by Temniskova-Topalova (1990). The investigated material was presumably collected from the diatomite deposits of the Evxinograd Formation, stratigraphic range: Bessarabian, Sarmatian s.l. (Fig. 1.1–6).



RESULTS AND DISCUSSION

Ten characteristic diatom species of regional and local importance were selected in the examined material. Apart from the list given below, several other siliceous microfossils were present in the studied samples, e.g., ebridean (Fig. 3.5). The morphological variability of the identified taxa, coupled with photographic documentation by SEM and short taxonomical descriptions, are given herein.

Taxonomic notes

Actinocyclus octonarius Ehrenberg, 1838

(Figs. 2.5–6)

1838. *Actinocyclus octonarius* Ehrenberg, p. 172, Pl. 21, Fig. 7.

1861. *Actinocyclus ehrenbergii* Ralfs in Pritchard, p. 834.

Description. Valvae circular, flat or shallowly convex, with a broadly raised margin. Valvae centre small, irregular, often filled with scattered puncta. Diameter 45.5 μm . Areolae round, in radial rows, 14 in 10 μm . Areolae rows grouped in broad fascicles set off by continuous rows. Valve mantle finely areolate (about 22–24 in 10 μm). Pseudonodule large, well-defined, annulate-operculate, located on the edge of the valve face.

Stratigraphic and geographic distribution. This species is present in the Sarmatian deposits in the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994), cosmopolitan, common in modern brackish-marine coastal areas.

Actinocyclus podolicus (Missuna) Kozyrenko, 1959

(Figs. 2.1–4)

1913. *Aulacodiscus beringensis* Mann var. *podolicus* Missuna, p. 11, Fig. 53.

1913. *Aulacodiscus beringensis* Mann var. *molokischianus* Missuna, p. 11, Fig. 51.

1959. *Actinocyclus* (?) *podolicus* Kozyrenko, Pl. 1, Fig. 4.

2003. *Actinostephanos podolicus* (Missuna) Kozyrenko, p. 126, Figs. 1–8.

2008. *Actinostephanos podolicus* (Missuna) Kozyrenko, p. 33, Pl. 46, Figs. 1–10.

Description. Valvae circular, nearly flat with slightly raised centre. Diameter ranging between 35 μm and 57 μm . Areolae about 15–17 in 10 μm , small, round,

arranged in subparallel to radial rows. Areolae rows grouped into fascicles set off by continuous subparallel rows. Hyaline stripes mark the areolae fascicles on the valve face (one in 10 μm). Valvae centre is small, irregular hyaline area. Valvae mantle finely areolate (about 20 in 10 μm). Pseudonodule of medium size, easily visible between the hyaline stripes. Labiate processes not observed.

Notes. *Actinocyclus podolicus* was introduced as a variety of *Aulacodiscus beringensis* Mann var. *podolicus* Missuna by Missuna (1913). She described two varieties within *Aulacosidiscus berginensis* Mann in the materials from the area of Molokish (Crimean Peninsula, former USSR). The main differences between these two varieties are the valvae dimensions, which are larger in *Aulacodiscus beringensis* Mann var. *molokischianus* Missuna, the pattern of fasciculation, as well as the number of the hyaline stripes in 10 μm , the number of the areolae rows in 10 μm , and the form of the central area. Kozyrenko (1959) combined these two varieties within the genus *Actinocyclus* Ehr. as *Actinocyclus* (?) *podolicus* Koz. After revision and SEM investigations, Kozyrenko (2003) placed this taxon in the genus *Actinostephanos* Khursevich due to the lack of pseudonodule, which is the main morphological difference between the genera *Actinocyclus* Ehr. and *Actinostephanos* Khursevich. The illustrations in her publication (Kozyrenko, 2003, Figs. 1–8), based on her own collections from the Crimean Peninsula, included forms very similar only to *Aulacodiscus beringensis* Mann var. *molokischianus* Miss. (Missuna, 1913, Fig. 51). The new LM illustration was included in the last publication of Kozyrenko in Strelnikova (2008, Pl. 46, Fig. 1), which is very similar to the figure of Missuna (1913, Fig. 51) of *Aulacodiscus beringensis* Mann var. *podolicus* Missuna. Our specimens are very similar to this illustration. Most importantly, in these specimens, the structures of the pseudonodule are visible, which is one of the most important morphological features of *Actinocyclus* Ehr. (Round et al., 1990). Our detailed examination of the fine structure supports its placement in the genus *Actinocyclus* Ehr. – as *Actinocyclus podolicus* (Missuna) Kozyrenko. Re-examination of the original material is urgently needed, however, before its taxonomic affinities can be assessed.

Stratigraphic and geographic distribution. The species is present in the Middle Sarmatian (Bessarabian) deposits in the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994).

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Fig. 1. Original Dr J. Pantocsek materials and micas from the J. Pantocsek Collection hosted in the Natural History Museum, Budapest.

1. Dr Jozef Pantocsek (1846–1916).

2, 3. Original micas and slides from the J. Pantocsek Collection.

4. Pantocsek's original drawings.

5. Raw materials.

6. Raw material – diatomaceous earth from Balchik (NE Bulgaria).

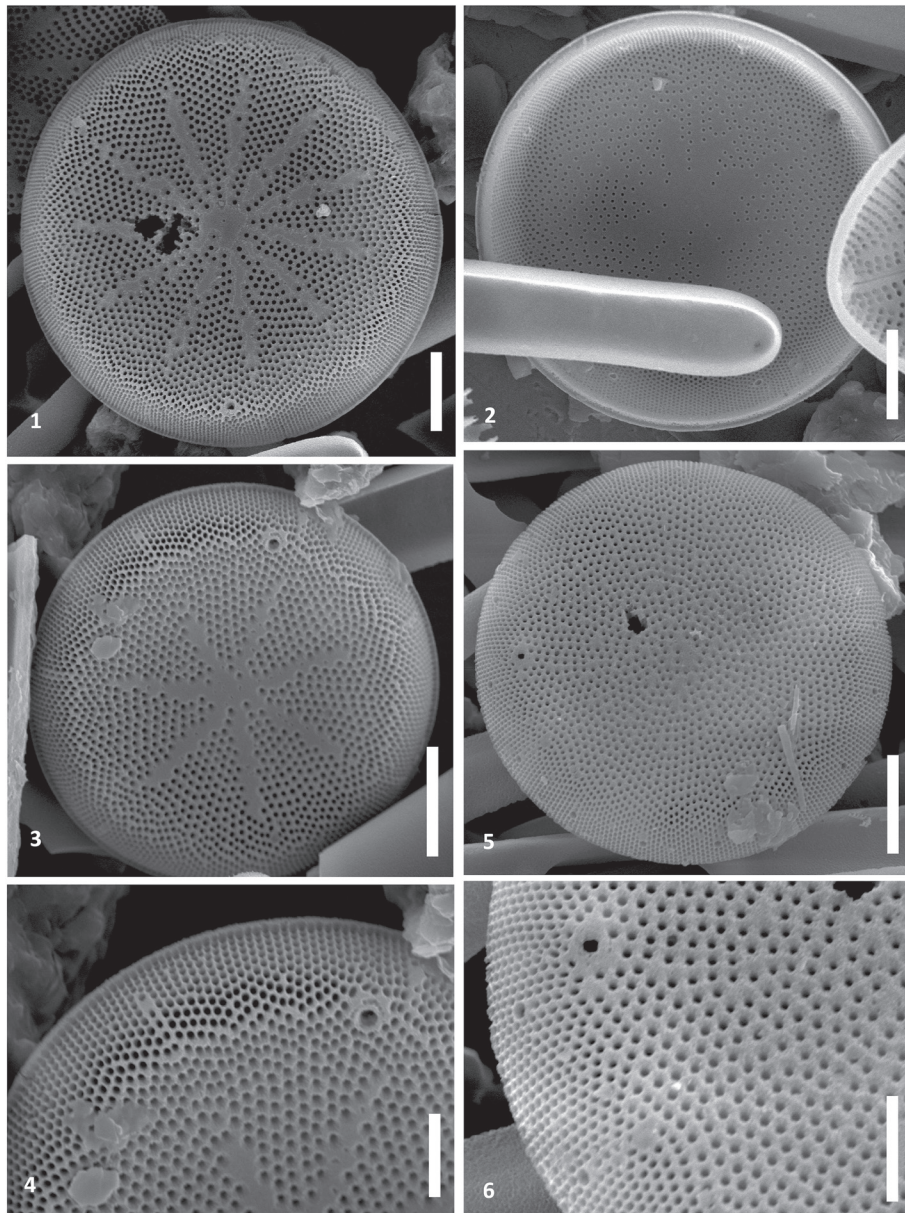


Fig. 2. Species of the genus *Actinocyclus* Ehrenberg.

1–4. *Actinocyclus podolicus* (Missuna) Kozyrenko. 1–3) External valve view. Note the position of the hyaline strips and the place and form of the pseudonodule; 4) Internal view with position of the pseudonodule.

5–6. *Actinocyclus octonarius* Ehrenberg – external valve view. 6) External view of annulate pseudonodule and exit of the labiate processes.

Scale bars = 5 μm (4, 6); 10 μm (1–3, 5).

***Caloneis sectilis* (A.S.) Cl. var. *boryana* (Pantocsek)
Cleve, 1894
(Fig. 3.4)**

1894 *Caloneis sectilis* (A.S.) Cl. var. *boryana* (Pantocsek)
Cleve, p. 60.

1889 *Navicula boryana* Pantocsek, Pl. 28, Fig. 407.

Description. Valvae elongate to elongate-elliptical, with rounded apices, 120 μm long, 27 μm wide, with

8–9 striae in 10 μm . Raphe straight, axial area broadly lanceolate, widening towards the large round to elliptical central area. Straight markings on either side of the central nodule. Striae are almost parallel in the centre, radiate at the ends.

Stratigraphic and geographic distribution. The species is present in the Lower–Middle Sarmatian (Volhynian–Bessarabian) deposits in the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994).

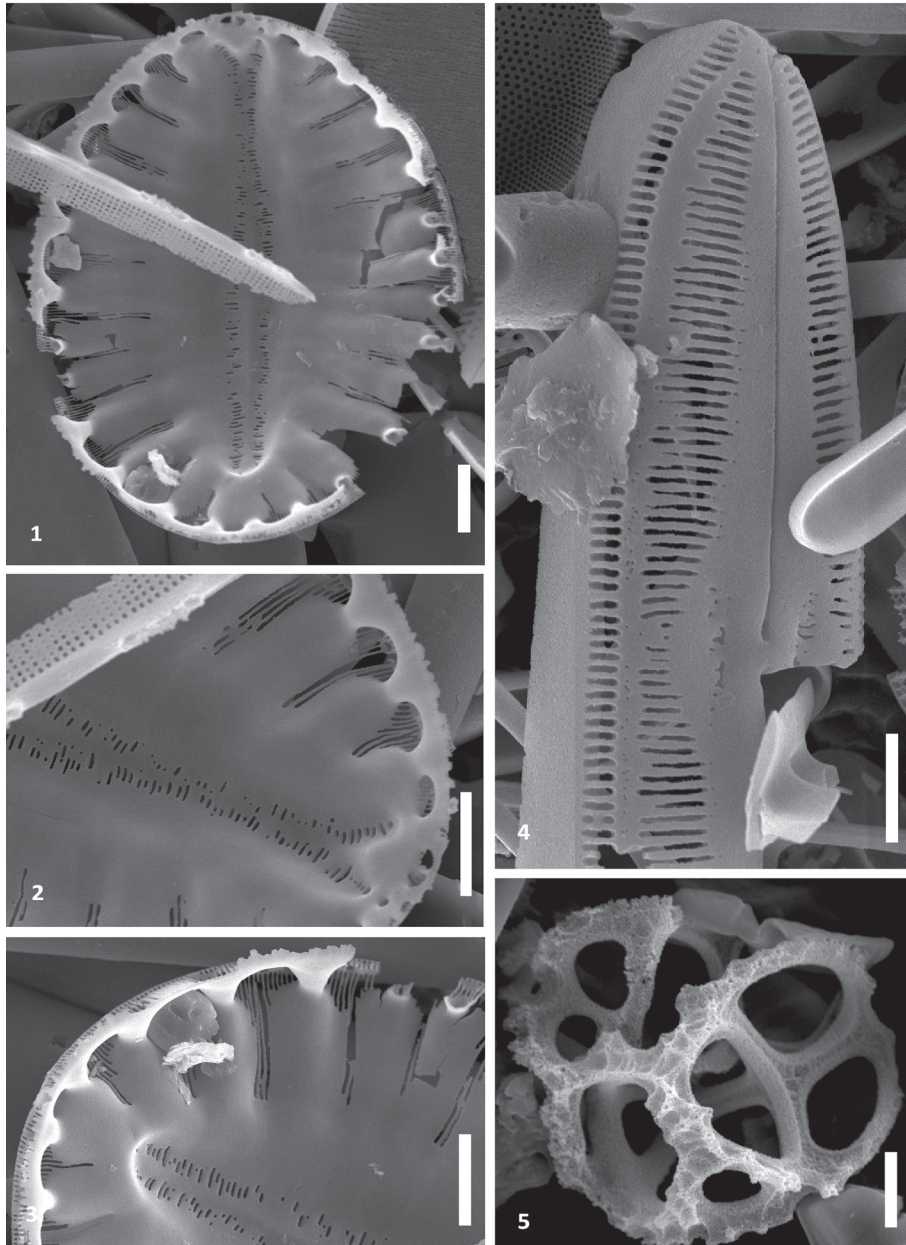


Fig. 3. 1–3. *Surirella comis* Schmidt, internal valve view.
 4. *Caloneis sectilis* (A.S.) Cl. var. *boryana* (Pantocsek) Cleve.
 5. Ebridian.
 Scale bars = 5 μm (5); 10 μm (1–4).

***Campylodiscus limbatus* var. *astralis* Eulenstein, 1875**
 (Fig. 4.1)

1875. *Campylodiscus limbatus* var. *astralis* Eulenstein in Schmidt et al. (1874–1959), Pl. 17, Fig. 1.

Description. Valvae subcircular, weakly saddle-shaped, 200 μm in diameter, with a distinct, large central area. Marginal costae (five in 10 μm) extending over one-third of the valve radius. Median area of valve large, hyaline, with elliptical form, crossed by one striated ridge.

Stratigraphic and geographic distribution. The species is present in the Lower–Middle Sarmatian (Volhynian–Bessarabian) deposits in the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994).

***Climacosphenia moniligera* Ehrenberg, 1841**
 (Fig. 5.4)

1841. *Climacosphenia moniligera* Ehrenberg, (1843), p. 411, Pl. 2, Fig. 6: 1.

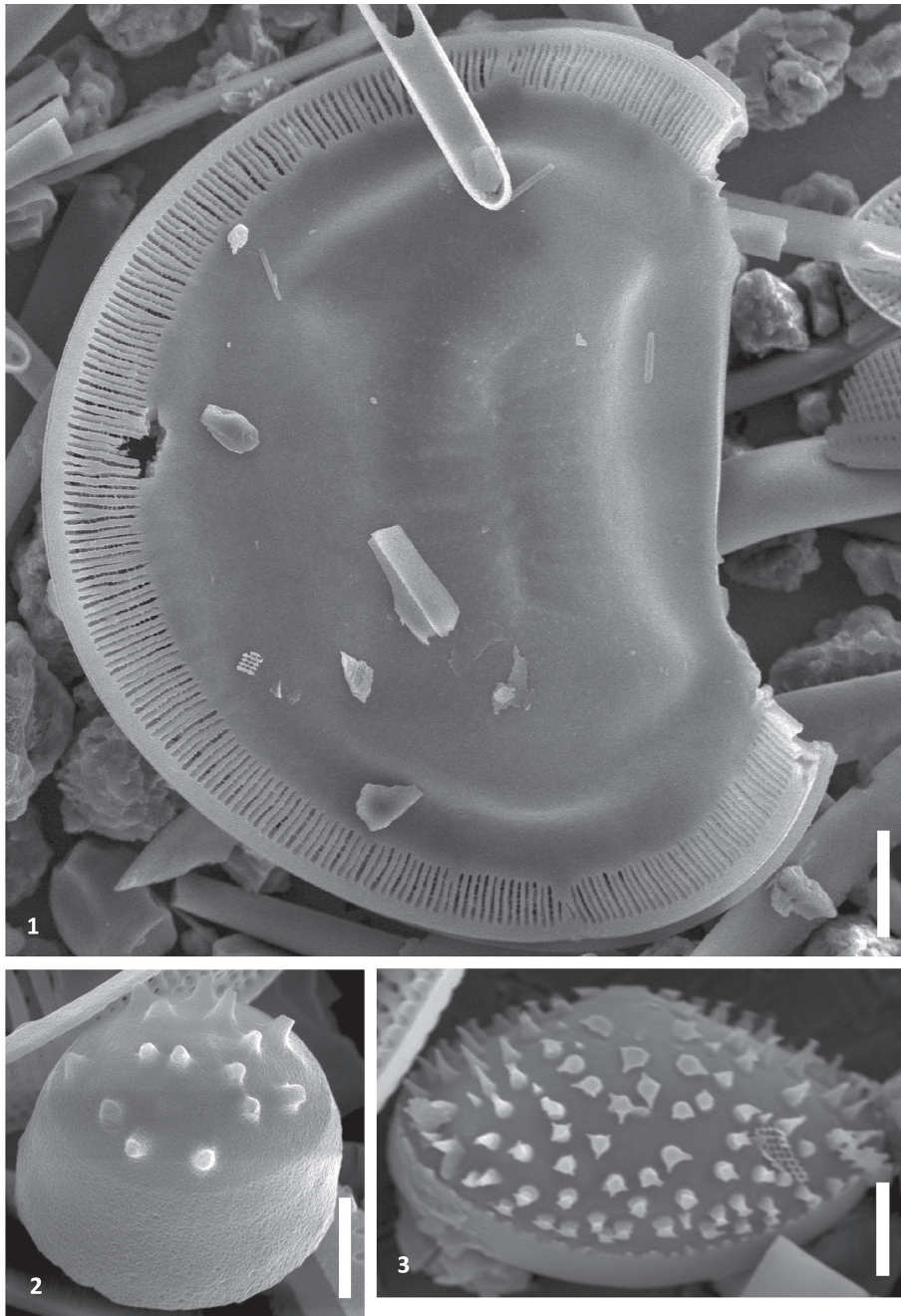


Fig. 4. *Campylodiscus limbatus* var. *astralis* Eulenstein (1), and resting spores of *Chaetoceros* (2–3). Scale bars = 5 μ m (2–3); 20 μ m (1).

Description. Frustules in girdle view wedge-shaped with straight margins. Intercalary bands with numerous septa. Valvae heteropolar, club-shaped with rounded apices, gradually narrowing towards the foot-pole; more than 400 μ m long (broken frustules), 22 μ m wide (in the widest part). Sternum absent, transapical striae above the foot pole, 13–15 in 10 μ m. Cingulum composed of a fimbriate volvocopula bearing transverse septa and two copulae.

The septa are solid, with complete bars towards the head-pole and finger-like joints towards the base-pole.

Stratigraphic and geographic distribution. The species is present in the Lower–Middle Sarmatian (Volhynian–Bessarabian) deposits in the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994), common in modern brackish-marine coastal areas.

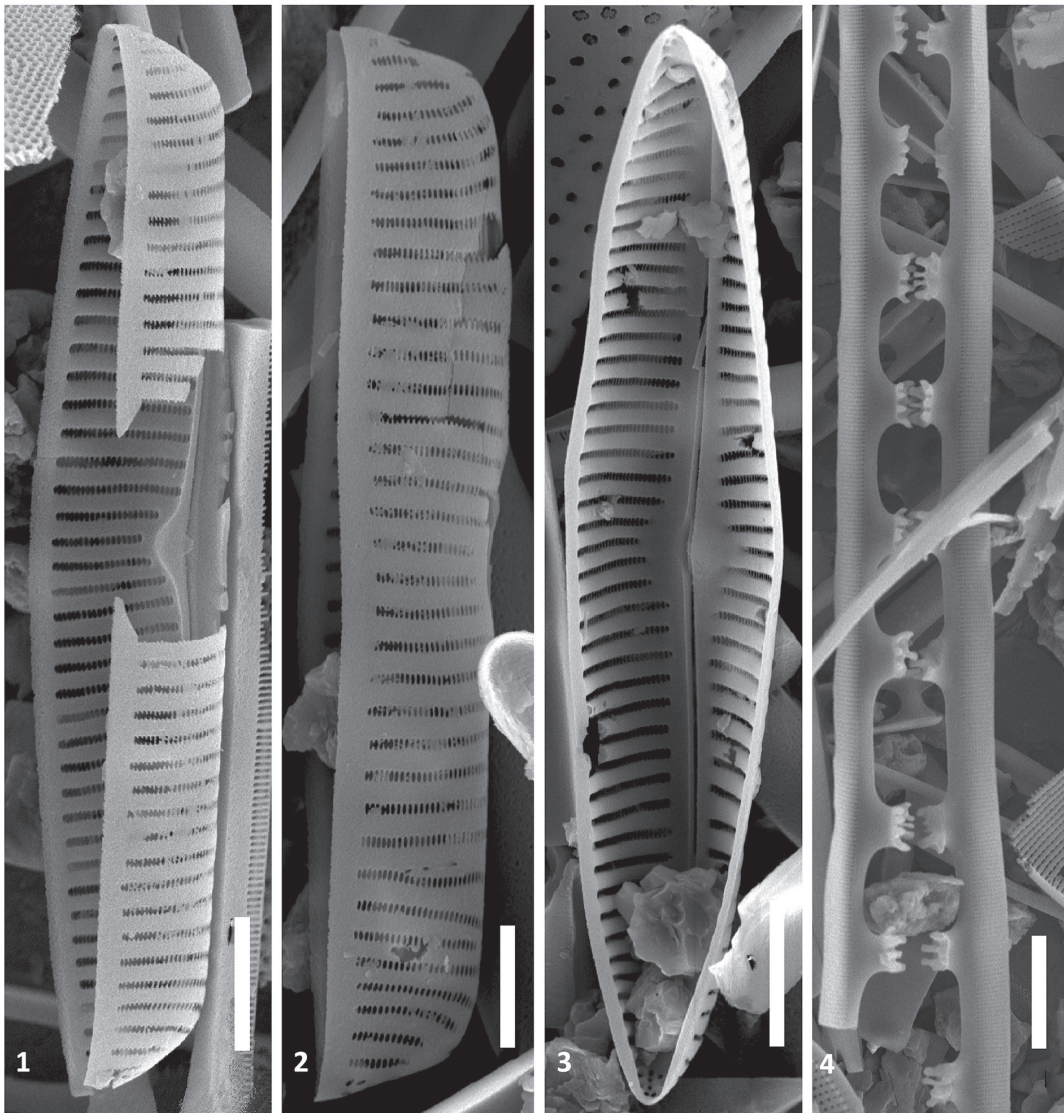


Fig. 5. *Navicula cancellata* Donkin (1–3), and *Climacosphenia moniligera* Ehrenberg (4). Scale bars = 10 μm (1–3); 20 μm (4).

***Grammatophora insignis* var. *doljensis* Grunow, 1886**
(Figs. 6.1–5)

1886. *Grammatophora insignis* var. *doljensis* Grunow in Pantocsek, p. 38, Pl. 26, Fig. 238.

Description. Frustules rectangular to square in girdle view, elliptical in valve view, with slightly convex sides. Valvae are 108–133 μm long, 12.5–18.0 μm wide. Striae density: 22 in 10 μm . Striae distinctly punctuate, uniseriate, arranged in parallel rows. Sternum very narrow, linear. Each apex is occupied by an apical pore field. Slightly undulate septa are distinctive in girdle view, with a characteristic elliptic opening in the centre. The presence of a rimoportula is distinguishable.

Stratigraphic and geographic distribution. The species is present in the Lower–Middle Sarmatian (Volhynian–Bessarabian) deposits in the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994).

***Navicula cancellata* Donkin, 1872**
(Figs. 5.1–3)

1872. *Navicula cancellata* Donkin (1873), p. 55, Pl. 8, Fig. 4.

Description. Valvae linear-lanceolate, with almost parallel sides and cuneate, sub-acute apices. Valve dimensions: length 65–75 μm , width 15.5 μm . Axial area linear, narrow; central area small, rounded, assy-

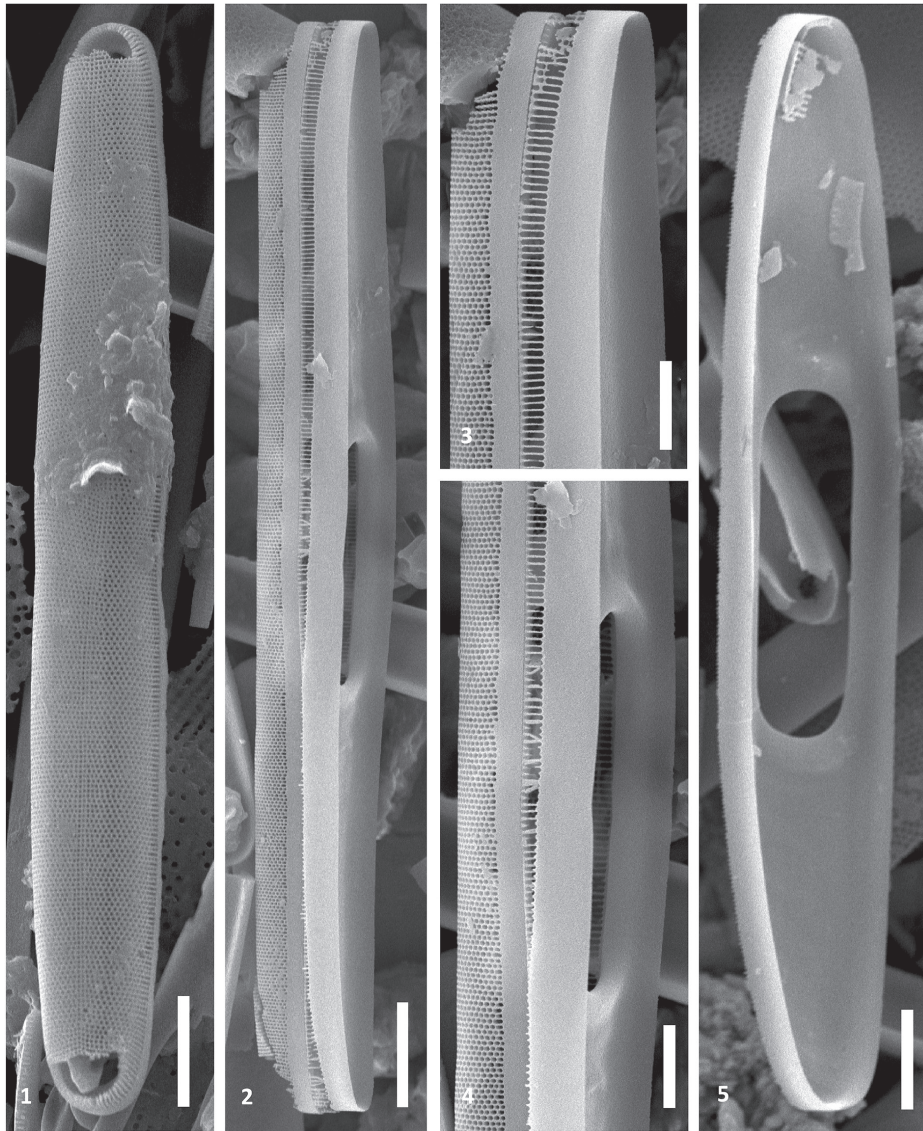


Fig. 6. *Grammatophora insignis* var. *doljensis* Grunow.

1. External view.

2–4. Tilted view of the frustule.

5. Septa.

Scale bars = 5 μm (3–4); 10 μm (1–2, 5).

metrical. Raphe branches distinctly lateral. Internally, raphe slit is very narrow. Proximally simple raphe ends straight, located on a small central nodule. Distal-raphe endings terminating in twisted helictoglossae surrounded by hyaline area. Valve surface convex, striae coarse, weakly radiate in the middle, convergent towards the apices. Striae finely lineate, five in 10 μm .

Stratigraphic and geographic distribution. The species is present in the Middle–Upper Sarmatian (Bessarabian–Khersonian) deposits in the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994), common in modern brackish-marine coastal areas.

***Podosira loczyi* Pantocsek, 1903**

(Figs. 7.1–6)

1903. *Podosira loczyi* Pantocsek, p. 82, Pl. 10, Figs. 172–173.

Description. Valvae hemispherical, no distinct valve mantle. Diameter ranging from 35 μm to 40 μm , perivalvar axis 25–30 μm . Valve surface finely areolate; areolae loculate, arranged in decussate rows, about 20 in 10 μm . Rimoportulae are scattered over the whole valve. Outside, they have simple opening; inside, they are small oval structures without stalks.

Stratigraphic and geographic distribution. The species is present in the Lower–Middle Sarmatian (Volhynian–

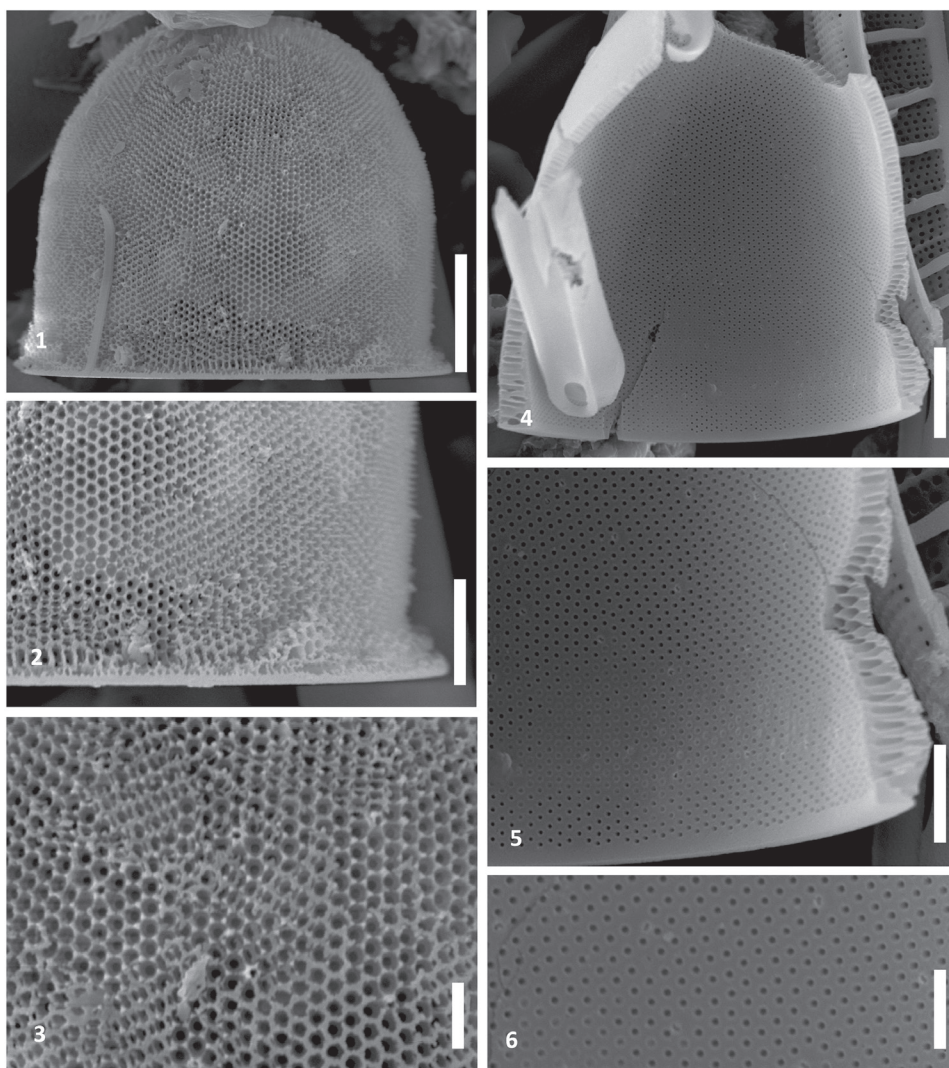


Fig. 7. *Podosira lozyi* Pantocsek.

1–3. *Podosira lozyi* Pantocsek. External valve view, decussate rows of areolae, simple opening of the rimoportule.
4–6. *Podosira lozyi* Pantocsek. Internal valve view, small oval structures of the rimoporule without stalks.
Scale bars = 2 μm (3); 5 μm (2, 5–6); 10 μm (1, 4).

Bessarabian) deposits of the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994).

***Surirella baldjickii* Norman, 1861**
(Figs. 8.1–4)

1861. *Surirella baldjickii* Norman, p. 6, Pl. 2, Fig. 2.

Description. Valvae strongly silicified, bipolar, panduriform, with broadly rounded apices; length 100–150 μm , width 44–58 μm . Margins strongly constructed in the middle. Central area broadly lanceolate. The valve surface striated, striae multiserial, containing very small round poroids (16–18 in 10 μm). Raphe system running around the whole perimeter of the valve face.

Stratigraphic and geographic distribution. The species is present in the Lower–Middle Sarmatian (Volhynian–

Bessarabian) deposits of the Varna-Balchik depression (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994).

***Surirella comis* Schmidt, 1874**
(Figs. 3.1–3)

1874. *Surirella comis* Schmidt, Pl. 4, Figs. 3–7.

Description. Valvae broadly elliptical, with almost equal ends, 95 μm long, 75 μm broad. Marginal costae short, 1.5–2 in 10 μm . Central area oval, the axial area enclosed by two longitudinal bands of short striae, which do not reach the ends of the valve.

Stratigraphic and geographic distribution. Probably warm-water species (Hendey, 1964), until now unknown from the Sarmatian deposits in the Varna-Balchik depression.

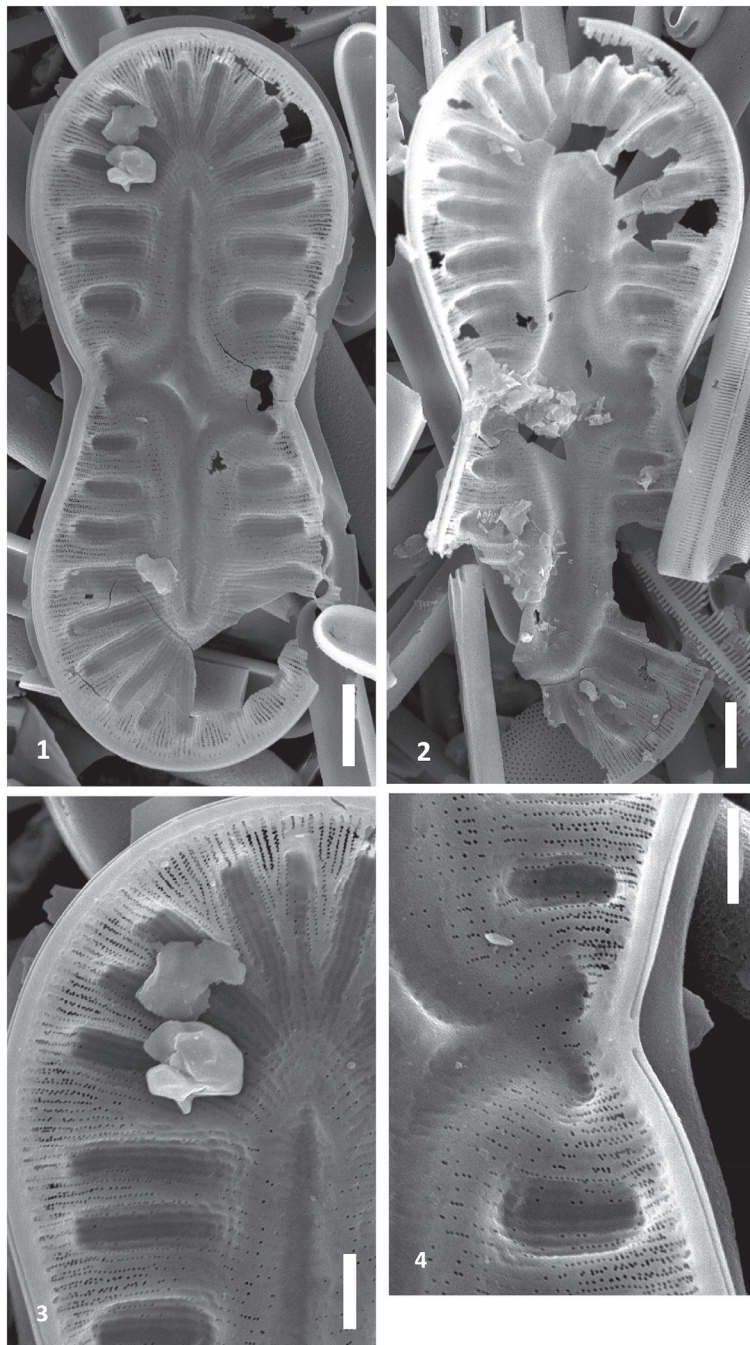


Fig. 8. *Surirella baldjickii* Norman.
 1–2. Internal view. 3–4. Details.
 Scale bars = 5 µm (3–4); 10 µm (1–2).

CONCLUDING REMARKS

In the examined material, ten characteristic diatom species of regional and local importance were selected. Comparisons with previous diatom finds (Kozyrenko, Temniskova-Topalova, 1990; Temniskova-Topalova, 1994) show that the majority of them have already been report-

ed from the Sarmatian deposits of the Varna-Balchik depression. Herein, the presence of *Surirella comis* Schmidt has been recognized for the first time from Bulgaria, as either fossil or recent form.

In the present investigation of the Balchik diatomites, housed in the Pantocsek Collection, species characteristic for the association of the *Achnathes baldjickii* var.

podolica Subzone have been indicated: *Actinocyclus podolicus* (Missuna) Kozyrenko, *Caloneis sectilis* (A.S.) Cl. var. *boryana* (Pantocsek) Cleve, *Campylodiscus limbatus* var. *astralis* Eulenstein, *Grammatophora insignis* var. *doljensis* Grunow, *Podosira loczyi* Pantocsek and *Surirella baldjickii* Norman. Its stratigraphic range is within the Sarmatian Stage (Bessarabian Substage).

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