GEOLOGICA CARPATHICA, 47, 5, BRATISLAVA, OCTOBER 1996
301–310

CYCLOTELLA IRIS BRUN & HÉRIBAUD — A GROUP FROM THE UPPER MIOCENE SEDIMENTS OF THE SOFIA BASIN, BULGARIA

Project No. 329

NADJA G. OGNJANOVA-RUMENOVA

Department of Palaeontology and Stratigraphy, Institute of Geology, Bulgarian Academy of Sciences, Acad. G. Bonchev str. Bldg. 24, 1113 Sofia, Bulgaria

(Manuscript received April 20, 1995; accepted in revised form December 14, 1995)

Abstract: *Cyclotella iris* Brun & Hérib. and its varieties have been studied by LM and SEM. They were represented in Neogene continental deposits of the Sofia Basin, South Bulgaria with rich abundance. New data about the fine structure of the *Cyclotella iris* var. *integra* Perag. & Hérib. were obtained and this made it possible to add the morphological characteristics of the *Cyclotella iris* group. In the informal subdivision of the genus *Cyclotella* this species and its varieties would fall within separate subgroup.

Key words: diatom biostratigraphy, *Bacillariophyta*, *Cyclotella*, *Cyclotella iris*, taxonomy, morphology.

Introduction

The development of the different genera of class *Centrophyceae, Bacillariophyta*, in the continental deposits have been used for the diatom biostratigraphic subdivision (Ognjanova & Popova 1982; Temniskova et al. 1994). The appearance and the development of genus *Cyclotella* Kütz. are objects in a series of phylogenetic studies (VanLandingham 1985; Krebs et al. 1987; Fourtanier & Gasse 1988; Loginova 1990; Khursevich 1994; Krebs 1994). *Cyclotella* can be considered as the youngest genus of the family *Stephanodiscaceae* Glezer & Makarova 1986. Species of the genus are commonly planktonic, most of them live in freshwater habitats, but some also live in brackish and marine waters. Some extinct species, known only from nonmarine sediments show the archaic characteristics of the genus *Cyclotella*. Species of this genus have been determined in continental Upper Miocene deposits from the whole of Southern Europe: Spain (Servant-Vildary 1986); France (Héribaud 1893; Ehrlich 1966; Serieyssol 1981, 1984); Greece (Gersonde & Velitzelos 1978; Economou-Amilli 1987, 1991); Armenia (Poretzky 1953; Golovenkina 1967).

Nonmarine Neogene sediments of the Sofia Basin, South Bulgaria, have been investigated. 365 species, varieties and forms of diatoms were found (Ognjanova-Rumenova 1994). The representatives of class *Centrophyceae* are dominant in the established diatom assemblages, but their taxonomic composition is not so varied (11 genera, 37 species, 15 varieties and 6 forms). The genus *Cyclotella* has been represented by 15 species, varieties and forms. Very interesting is the discovery of all varieties of *Cyclotella iris* Brun & Hérib. Similar infraspecific variations of this species had been determined only for the Upper Miocene sediments in the Massif Central (Héribaud 1893; Serieyssol 1981, 1984). Serieyssol (1984) revised the type material of Héribaud and Brun and pointed out the great variability of *Cyclotella iris* Brun & Hérib. She determined two new varieties and presented a taxonomic subspecies key. Unfortunately, all described fragments of *Cyclotella iris* var. *integra* Perag. & Hérib. showed evidence of dissolution and this variety was not included in the key. In the sediments of the Sofia Basin this variety is represented with rich adundance and this made it possible to provide a SEM investigation and to add the morphological characteristics of the *Cyclotella iris* group (Fig. 4).

Material and Methods

Material was collected from the Neogene Sofia Basin. The lithostratigraphic Units were introduced by Kamenov & Kojumdjieva (1983). In the Neogene sediments, variegated terrigenous formation (probably of Maeotian age) and the Sofia group formed from three formations were distinguished: Gniljane (Pontian age), Novi-Iskar (Pontian, sometimes partly Dacian age) and Lozenec (Dacian-Romanian age). The investigated materials were from boreholes C-14, village of Katina; C-1113, village of Dobroslavci (Fig. 1).

The samples were cleaned according to Schrader (1973) and Hasle & Fryxell (1970). The Scanning Electron Microscopical (SEM) investigations were provided on Jeol JSM 35CF and Jeol JSM T300. The terminology is recomended by Ross & Sims (1972), Anonymous (1975), Ross et al. (1979). The abundance of the diatom taxa in the samples was defined relatively by Schrader's scale (Schrader 1973).

Results and Discussion

Classification problems

The first *Cyclotellae* subdivision was made by Lowe (1975), McFarland & Collins (1978), Serieyssol (1981, 1984). The groups and the pointed morphological criteria were added by Servant-Vildary (1986) and Loginova (1990). The morphological features, which they determined are: *1* — presence

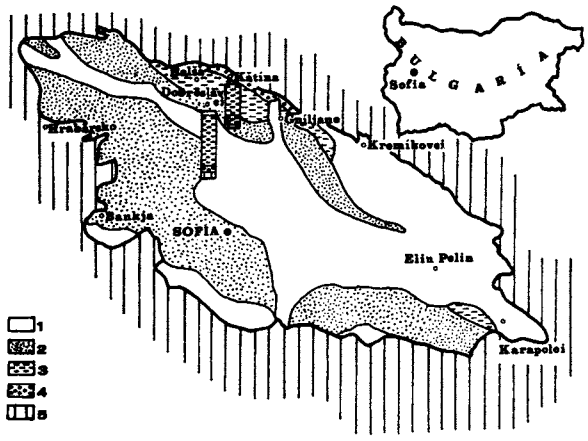


Fig. 1. Schematic map of the Sofia Basin. **1** — Quaternary; **2** — Lozenec Formation; **3** — Novi-Iskar Formation; **4** — Gniljane Formation; **5** — Pre-Neogenic rocks.

and spacing of the marginal fultoportulae; *2* — presence and spacing of fultoportulae on the valve face; *3* — presence and number of rimoportulae; *4* — presence of spines; *5* — other special features such as granulae and structure of striae. Both Serieyssol (1984) and Servant-Vildary (1986) have attached importance on the structure of alveolae. On the basis of these morphological criteria Serieyssol (1984) distinguished 7 groups in genus *Cyclotella* Kütz. and Loginova (1990) — 12.

Krammer & Lange-Bertalot (1991) were strongly against the taxonomic subdivision on the basis only of SEM-criteria. They united all the recent freshwater representatives in 3 groups. The species subdivision based on the elements, visible by light microscope (LM). Economou-Amilli (1991) described new polymorphic species *Cyclotella* from the Upper Miocene sediments, North Greece — *C. elymaea*. She found that the fultoportulae on the valve face is not a constant morphological feature. This fact made problematic the taxonomic significance of all the ultrastructural criteria, which were used for the genus *Cyclotella* subdivision and proved the necessity of new fossil investigations.

According to Serieyssol (1984) *Cyclotella iris* and its varieties fall into separate a *Cyclotella* group on the basis of: 1 — complex alveolar structure; 2 — rimoportula; 3 — marginal fultuportulae.

Paleontological description of taxa

Cyclotella iris Brun & Héribaud 1893

Plate I: Figs. 1-2; 10-13

1893 *Cyclotella iris* Brun & Hérib. in Héribaud, p. 224, pl. VI, Figs. 1-4.
1900 *Cyclotella iris* Brun & Hérib. in Schmidt, pl. 222, Figs. 37, 38, 41.
1980 *Cyclotella iris* Brun & Hérib. in Khursevich, Loginova, pl. V, Figs. 12-14.
1984 *Cyclotella iris* Brun & Hérib. in Serieyssol, p. 201, Figs. 1-3, 19, 20, 25-36.

Nomenclature: The holotype is the specimen designated by Héribaud (1893), p. 224, pl. VI, s. 1-4, Flore Miocene d'Auxillac-Faufouilloux, Auxillac zone moyen, Auxillac tres beau.

Dimensions: Diameter of the discs: 9.5-38.2 μm; Striae: 8-18 per 10 μm (often 15 per 10 μm); Diameter of the central area: 5.8-11 μm.

Morphology: The valves are circular. Their diameters vary in size. The valve face consists of an undulate central area with raised and depressed hemispherical parts, and a striated marginal zone extending inwards one-half to one-thirds of the valve radius. The striae are undulate and of unequal length. Their width increases only slightly towards the margin. Often, they show a slight bipolarity in their pattern. The striae consist of 3 to 5 rows of areolae. The central area is irregularly elliptical, decorated with numerous randomly distributed bumps (Pl. I: Figs. 10, 11). The valve interior, a complex alveolar structure, as defined by Serieyssol (1984) is visible in the SEM. The rimoportula is located on a costa between two alveolar openings. Marginal fultoportulae are found on every first or second costa. Each marginal fultoportula has three satellite pores internally and is marked externally by a small circular pore. The external openings of the marginal fultoportulae are in the middle of the hyaline field between the striae, or between the rows of fine stria areolae. Central fultoportulae have never been observed.

Remarks: According to Serieyssol (1984) the diameter of the valve face ranges from 30 to 50 μm, but there are specimens from the Sofia Basin — smaller than these, established in the Massif Central.

Localities: Borehole C-14, village of Katina, Novi-Iskar Formation (stage Pontian), depth: 135.00 m, 175.00-180.00 m, 195.00 m. Borehole C-1113, village of Dobroslavci, Novi-Iskar Formation (stage Pontian), depth: 240.00 m, 245.00-253.00 m, 275.00-280.00 m (Figs. 1, 2).

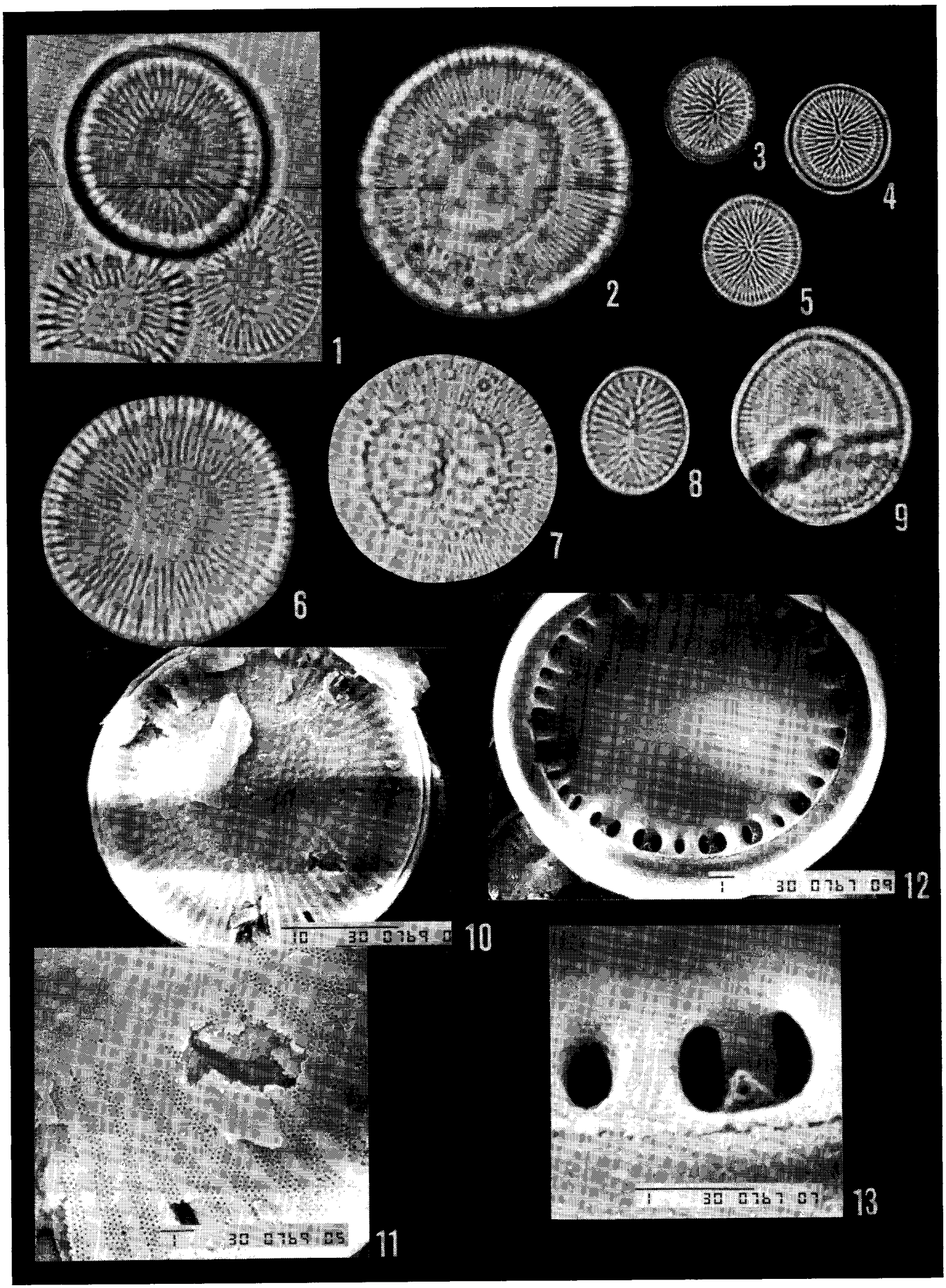
Known stratigraphic range: Upper Miocene, France (Héribaud 1893; Serieyssol 1984); Pleistocene, Byelorussia (Khursevich & Loginova 1980) — to modern lakes, where it is especially abundant in clear and acid water (Krammer & Lange-Bertalot 1991).

Cyclotella iris var. *charetoni* (Héribaud) Serieyssol 1982

Plate I: Fig. 6; Plate III: Figs. 1-4

1902 *Cyclotella charetoni* Héribaud, p. 22, pl. VIII, Fig. 30 (cit. Serieyssol, 1981).
1982 *Cyclotella iris* Brun & Hérib. in Loginova, pl. I, Figs. 20-22.
1984 *Cyclotella iris* var. *charetoni* (Hérib.) Ser. in Serieyssol, p. 202, Figs. 11, 12, 15, 49-52.

Plate I: Fig. 1. *Cyclotella iris* Brun & Hérib., C-14, v. Katina (180.00 m), LM ×2000. **Fig. 2.** *Cyclotella iris* Brun & Hérib., C-1128, v. Dobroslavci (305.30 m), LM ×5000. **Figs. 3-4.** *Cyclotella iris* var. *integra* Perag. & Hérib., C-1113, v. Dobroslavci (235.30 m), LM ×2000. **Fig. 5.** *Cyclotella iris* var. *integra* Perag. & Hérib., C-1113, v. Dobroslavci (245.00 m), LM ×2000. **Fig. 6.** *Cyclotella iris* var. *charetoni* Ser., C-14, v. Katina (180.00 m), LM ×5000. **Fig. 7.** *Cyclotella iris* var. *combierensis* Ser., C-14, v. Katina (195.00 m), LM ×5000. **Fig. 8.** *Cyclotella iris* var. *cocconeiformis* Brun & Herib., C-1113, v. Dobroslavci (235.00 m), LM ×5000. **Fig. 9.** *Cyclotella iris* var. *ovalis* Brun & Hérib., C-1, v. Goljanovci (6.00 m), LM ×5000. **Fig. 10.** *Cyclotella iris* Brun & Herib., C-14, v. Katina (180.00 m) — valve exterior, SEM ×3500. **Fig. 11.** *Cyclotella iris* Brun & Hérib., C-14, v. Katina — striae pattern, SEM ×10,000. **Fig. 12.** *Cyclotella iris* Brun & Hérib., C-14, v. Katina (180.00 m) — valve interior (complex alveolar structure), SEM ×7500. **Fig. 13.** *Cyclotella iris* Brun & Hérib., C-14, v. Katina (180.00 m) — ultrastructure of the marginal fultoportula, SEM ×35,000.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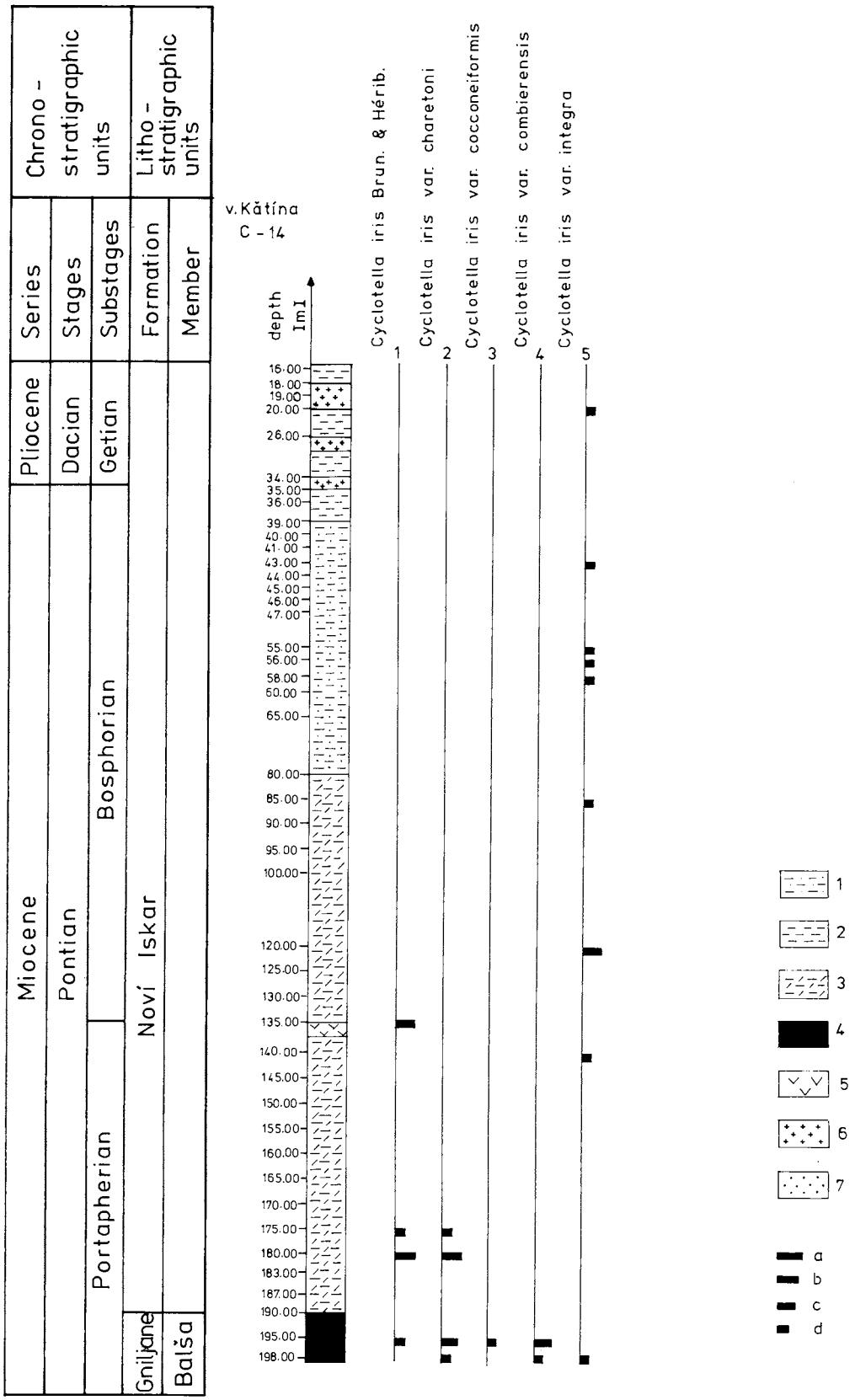


Fig. 2. *Cyclotella iris* group succession in the sediments of the investigated borehole C-14, v. Katina. **1** — clayey sands; **2** — clays; **3** — diatomaceous clays; **4** — lignite; **5** — seam, contained *Dreissena* aff. *superfoetata* Brus; **6** — seam contained *Viviparus bulgaricus* Brus; **7** — sandy clays with gravels. **a** — abundant species; **b** — common species; **c** — frequent species; **d** — rare species.

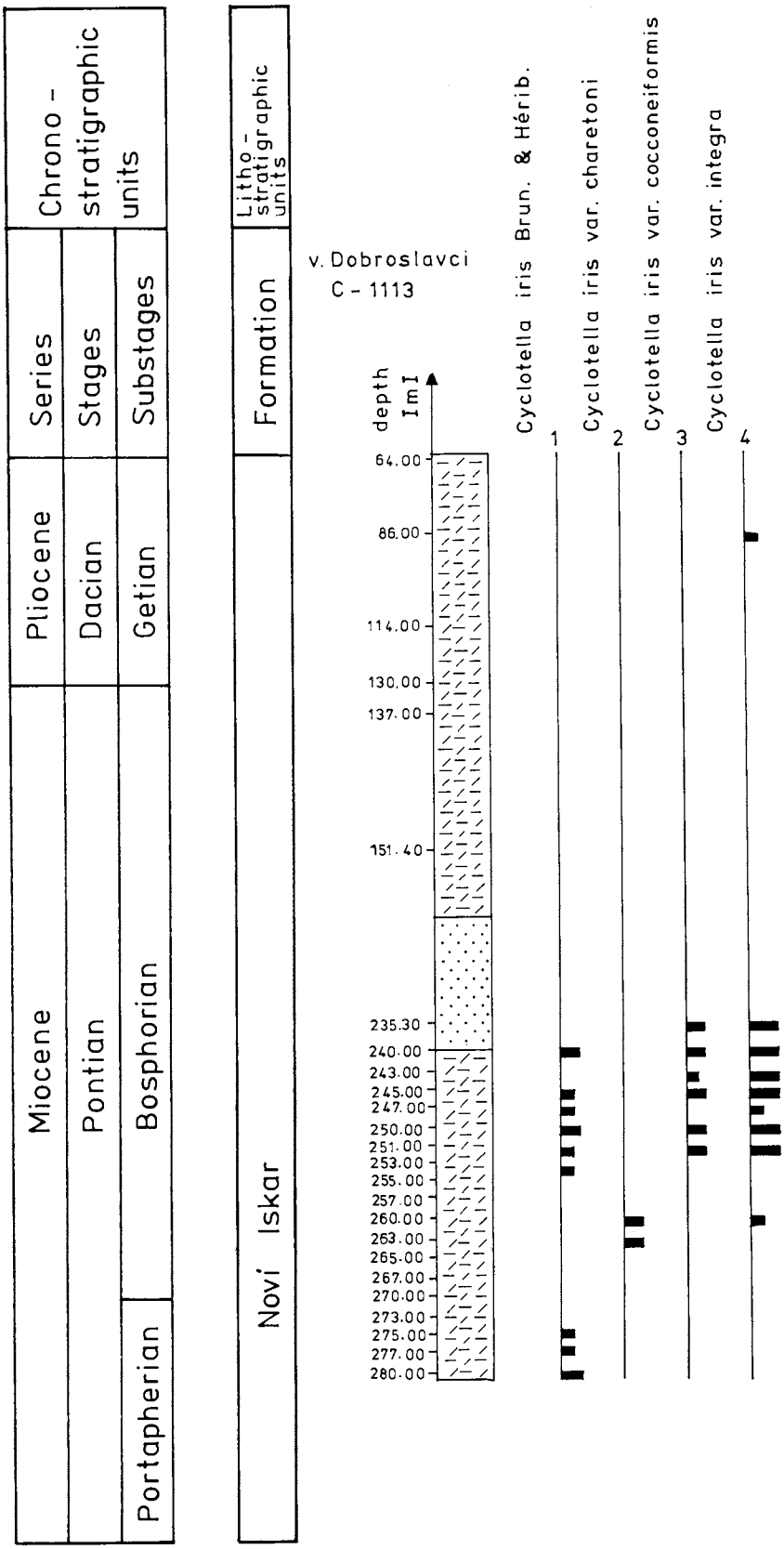
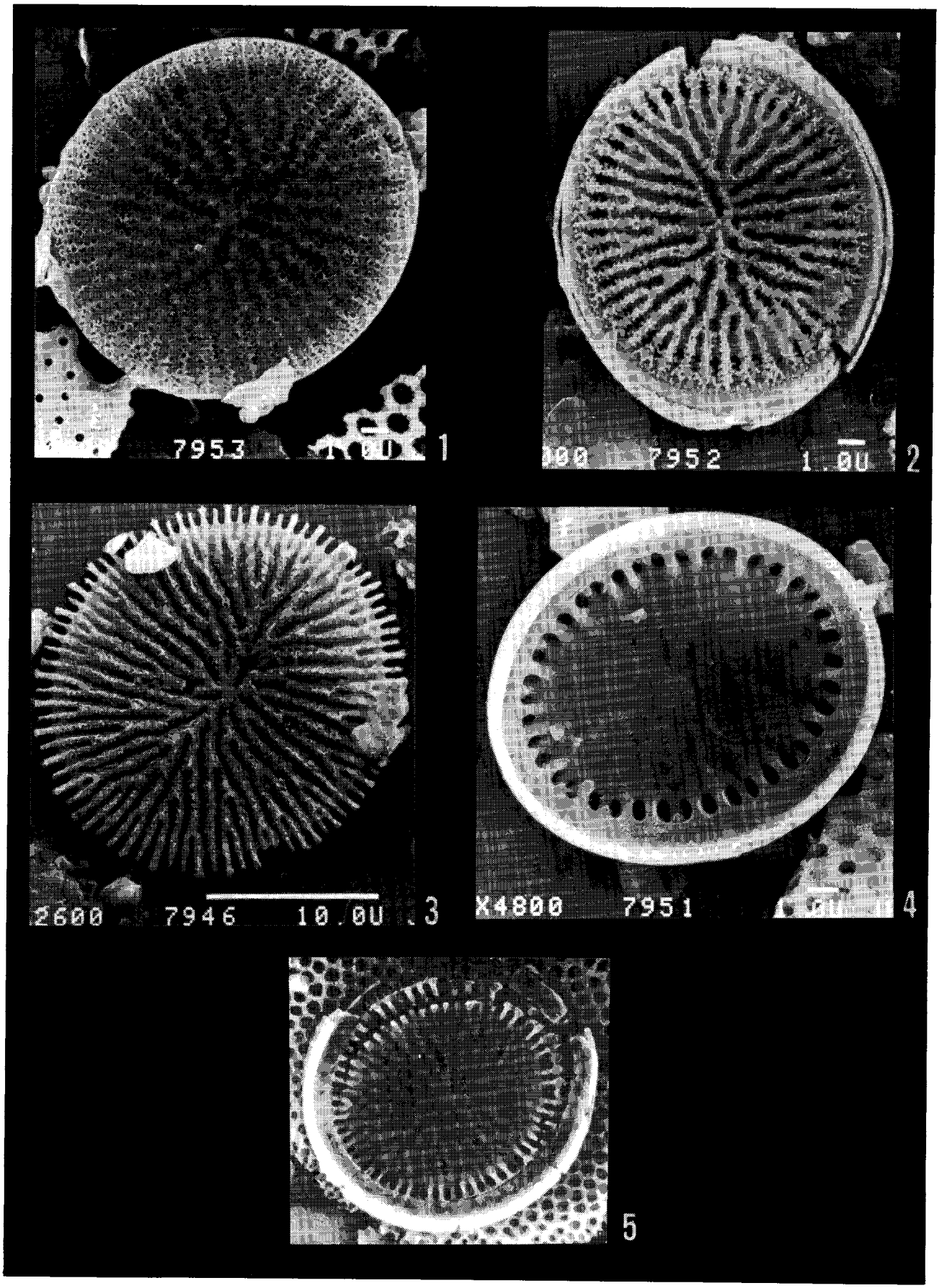


Fig. 3. *Cyclotella iris* group succession in the sediments of the investigated borehole C-1113, v. Dobroslavci. For the lithology see Fig. 2.

PLATE II



Characteristics / Cyclotella iris varieties	var. iris	var. cocconeiformis	var. ovalis	var. integra	var. charetoni	var. combierensis
Shape						
circular	+	+	+	+	+	+
oval						
Striae length						
equal	+	+	+	+	+	+
unequal						
Striae pattern						
radial-subradial	+	+	+	+		+
bipolar						
sectors radial-subradial					+	
Central area						
Well defined						
A. smoother	+		+		+	+
B. structureless		+		+		
Absence of central area						

Fig. 4. Additions to the morphologic characteristics of *Cyclotella iris* group, first determined by Serieyssol (1984).

Nomenclature: The holotype is determined by Héribaud, 1902, p. 22, pl. VIII, Fig. 30, Depot de la Bade, France. (cit. Serieyssol 1984).

Dimensions: Diameter of the discs: 14.7-25.6 μm; Striae: 12-15 per 10 μm.

Morphology: *Cyclotella iris* var. *charetoni* (Hérib.) Ser. was distinguished from *C. iris* Brun & Hérib. by the nondichotomous striae. The striae form sectors of radial and subradial rows. The central area is well defined, almost structureless.

In the valve interior no central fultoportulae are found by SEM. The marginal fultoportulae are on every 3rd to 7th costae of the complex alveolar structure. There is a rimoportula, which is located on a costa between two alveolar openings.

Remarks: There were established again smaller sized specimens for Sofia Basin.

Localities: Borehole C-14, v. Katina, Novi-Iskar Formation (stage Pontian), depth 175.00-180.00 m; 195.00-198.00 m. Borehole C-1113, v. Dobroslavci, Novi Iskar Formation (stage Pontian), depth 260.00-263.00 m (Figs. 2, 3).

Known stratigraphic range: Upper Miocene, France (Serieyssol 1984); Pleistocene, Byelorussia (Loginova 1982); to modern lakes in Ethiopia, where the variety is abundant in alkaline, carbonate, bicarbonate and sode lakes of high conductivity (Serieyssol 1984).

Cyclotella iris var. *cocconeiformis* Brun & Héribaud 1893

Plate I: Fig. 8; Plate III: Fig. 5

1893 *Cyclotella iris* var. *cocconeiformis* Brun & Hérib. in Héribaud, p. 225, pl. VI, Fig. 4.
1966 *Cyclotella iris* var. *cocconeiformis* Brun & Hérib. in Ehrlich, pl. V, Fig. 19.
1966 *Cyclotella iris* var. *ovalis* Brun & Hérib. in Ehrlich, pl. IV, Fig. 18.
1984 *Cyclotella iris* var. *cocconeiformis* Brun & Hérib. in Serieyssol, p. 201, Figs. 4, 5, 10, 18, 21, 43-48.

Nomenclature: The holotype is designated by Héribaud (1893), p. 225, pl. VI, Fig. 4 — Flore Miocene d'Auxillac-Faufouilloux, Auxillac zone moyen, Auxillac trés beau.

Dimensions: Diameter of disc: 9.6 μm; Striae: 15 per 10 μm; Diameter of the central area: 3.2 μm.

Morphology: The form of the valve face is oval-elliptical. It has small dimensions — the long axis has a maximum length of 23 μm (Serieyssol 1984). The striae have a bipolar pattern with striae of equal length except in the pole area where shorter striae are found. The central area is a well defined oval covered with random bumps. The central area may or may not have the raised and depressed hemispherical areas. On small individuals of this variety the rimoportula occurs in the same position as the marginal fultoportula. The difference of the two processes is in the form of the external openings (circular and slit shaped) and the location of the satellite pores.

Remarks: The specimens, established in the Sofia Basin have bumps along the interstrial strip (Plate III: Fig. 5).

Localities: Borehole C-14, v. Katina, Novi-Iskar Formation (stage Pontian), depth 170.00 m. Borehole C-1113, v. Dobroslavci, Novi-Iskar Formation (stage Pontian), depth 235.30-245.00 m; 250.00-251.50 m (Figs. 2, 3).

Known stratigraphic range: Upper Miocene, France (Héribaud 1893; Ehrlich 1966; Serieyssol 1984).

Cyclotella iris var. *combierensis* Serieyssol 1984

Plate I: Fig. 7

1966 *Cyclotella iris* Brun & Hérib. in Ehrlich, pl. V, Figs. 14-17.
1984 *Cyclotella iris* var. *combierensis* Serieyssol, p. 203, Figs. 22, 23, 58-60.

Nomenclature: The holotype is designated by Serieyssol (1984) p. 203, Figs. 22, 23, 58-60, slide No. 1, sample ZX-24, Combier, Ardeche, France.

Dimensions: Diameter of the discs: 13.4-19.8 μm; Striae: 15-18 per 10 μm.

Morphology: Frustules are cirular in valve view. The valve face is slightly convex. The central area is well defined with numerous randomly distributed bumps and pore-like depressions. The striae are radial, with equal length and increase in width towards the margin.

Remarks: The specimens, determined from the Sofia Basin again have a smaller diameter of the valve face (after Serieyssol 1984 — the diameter varies between 25-45 μm), but this variety could be distinguished by having a circular shape and randomly distributed rough bumps.

Localities: Borehole C-14, v. Katina, Novi-Iskar Formation (stage Pontian), depth 195.00-198.0 m (Fig. 2).

Known stratigraphic range: Upper Miocene, France (Ehrlich 1966; Serieyssol 1984).

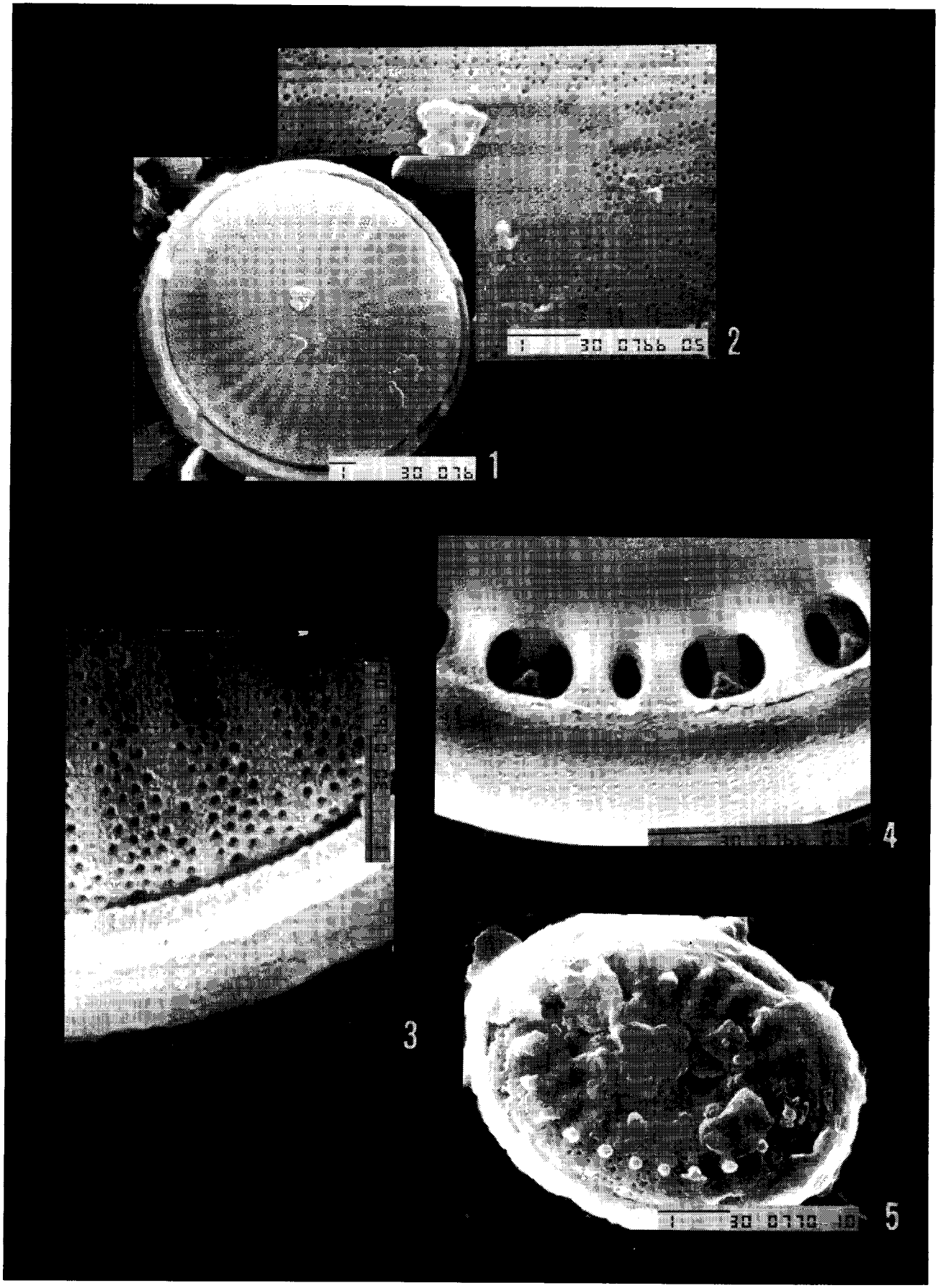
Cyclotella iris var. *integra* Peragallo & Héribaud 1902 (cit. Serieyssol 1984, p. 202)

Plate I: Figs. 3-5; Plate II: Figs. 1-5

1902 *Cyclotella iris* var. *integra* Perag. & Hérib. in Héribaud, p. 17, pl. VIII, Fig. 31 (cit. Serieyssol 1984).
1900 *Cyclotella iris* Brun & Hérib. in Schmidt, pl. 222, Fig. 40.
1984 *Cyclotella iris* var. *integra* Perag. & Hérib. in Serieyssol, p. 202, Figs. 13, 14, 16, 53-57.

Plate II: Figs. 1-2. *Cyclotella iris* var. *integra* Perag. & Hérib., C-1113, v. Dobroslavci (235.30 m) — valve exterior, SEM ×4000. **Fig. 3.** *Cyclotella iris* var. *integra* Perag. & Hérib., C-1113, v. Dobroslavci (235.30 m), SEM ×2600. **Fig. 4.** *Cyclotella iris* var. *integra* Perag. & Hérib., C-1113, v. Dobroslavci (235.30 m) — valve interior: complex alveolar structure; a — the single rimoportule; b — marginal fultoportula, SEM ×4800. **Fig. 5.** *Cyclotella iris* var. *integra* Perag. & Hérib., C-14, v. Katina (120.00 m) — valve interior, SEM ×2500.

PLATE III



Nomenclature: The holotype is determined by Héribaud (1902), p. 17, pl. VIII, Fig. 31, Flore Miocene d'Auxillax-Faufouilloux. (cit. Serieyssol 1984).

Dimensions: Diameter of the discs: 14.3-39.8 µm; Striae: 10-15 per 10 µm.

Morphology: The valves are clearly elliptical to almost circular in outline. The striae are of unequal length and branch bipolar out towards the margin. Numerous small granules occur along the interstrial strips. There is a complete absence of the central area.

A complex alveolar structure in the valve interior is visible in the SEM. The marginal fultoportulae are found on every second to third costa. Each fultoportula has three satellite pores internally and is marked externally by a small pore (Plate II: Fig. 4b). The rimoportula is located on a costa between two alveolar openings (Plate II: Fig. 4a). Central fultoportulae have never been observed.

Remarks: The specimens, determined from the Sofia Basin, do not have the undulate central part of the valve face and the diameters of the discs are smaller than those in the Massif Central.

Localities: Borehole C-14, v. Katina, Novi-Iskar Formation, (stages Pontian, partly Dacian), depth 20.00 m, 43.00 m, 55.00-58.00 m, 85.00 m, 120.00 m, 140.00 m, 198.00 m. Borehole C-1113, v. Dobroslavci, Novi-Iskar Formation (stages Pontian, partly Dacian), depth 86.00 m, 235.30-251.50 m, 260.00 m (Figs. 2, 3).

Known stratigraphic range: Upper Miocene, France (Serieyssol 1984).

Cyclotella iris var. *ovalis* Brun & Héribaud 1893

Plate I: Fig. 9

1893 *Cyclotella iris* var. ovalis Brun & Hérib. in Héribaud, p. 225, pl. VI, Fig. 2.
1900 *Cyclotella iris* Brun & Hérib. in Schmidt, pl. 222, Fig. 39.
1949 *Cyclotella iris* Brun & Hérib. in Manguin, pl. II, Fig. 24.
1968 *Cyclotella iris* Brun & Hérib. in Molder, Tynni, pl. I, Fig. 6a.
1984 *Cyclotella iris* var. *ovalis* Brun & Hérib. in Serieyssol, p. 202, Figs. 6-9, 20, 24, 37-42.

Nomenclature: Holotype is designated by Héribaud (1893): p. 225, pl. VI, Fig. 2, Flore Miocene d'Auxillac-Faufouilloux Auxillac zone moyen, Auxillac trés beau.

Dimensions: Diameter of the disc: 17.3 µm; Striae: 18 per 10 µm.

Morphology: The valves are slightly oval. The striae are of unequal length and bipolar patterns. The central area has indistinct outline and is irregularly elliptic. This variety is distinguished from the *Cyclotella iris* in the valve form and from *C. iris* var. *cocconeiformis* in the striae pattern. *C. iris* var. *ovalis* has striae of unequal length while *C. iris* var. *cocconeiformis* has striae of equal length except in the pole regions.

Localities: Only this variety has been determined from other (nondescribed in the Fig. 1) borehole — C-1, v. Goljanovci. These sediments belong to the Novi-Iskar Formation (stage Pontian), depth 6.00 m.

Known stratigraphic range: Upper Miocene, France (Héribaud 1893; Serieyssol 1984); Pliocene-Pleistocene, Central Africa (Manguin 1949); Pleistocene, Finland (Mölder & Tynni 1968) to modern lakes, where it is reported in oligotrophic cold water, pH—7.4 and high carbonate content (Serieyssol 1984).

Acknowledgements: I am grateful for the valuable discussion with Dr. Temniskova (Sofia University), Dr. H. Hakansson (University of Lund) and Dr. Serieyssol (American college in Paris). I wish to thank to Dr. V. Georgiev and Mr. K. Rekalov (Geological Institute, Bulgarian Academy of Sciences) for the assistance and helping in SEM investigation.

Plate III: Fig. 1. *Cyclotella iris* var. *charetoni* Ser., C-14, v. Katina (180.00 m) — valve exterior, SEM ×7500. **Fig. 2.** *Cyclotella iris* var. *charetoni* Ser., C-14, v. Katina (180.00 m) — central area, SEM ×20,000. **Fig. 3.** *Cyclotella iris* var. *charetoni* Ser., C-14, v. Katina (180.00 m) — striae pattern, SEM ×35,000. **Fig. 4.** *Cyclotella iris* var. *charetoni* Ser., C-14, v. Katina (180.00 m) — detail of the valve interior (marginal fultoportula with three satellite pores), SEM ×20 000. **Fig. 5.** *Cyclotella iris* var. *cocconeiformis* Brun. & Hérib., C-14, v. Katina (180.00 m) — valve exterior, SEM ×20,000.

References

Anonymous, 1975: Proposal for a standardization of diatom terminology and diagnoses. *Nova Hedwigia*, Beiheft, 53, 323-354.

Economou-Amilli A., 1987: New fossil taxa of *Cyclotella* Kützing (Bacillariophyceae) from the Neogene basin of Mytilinii, Samos Island, Greece. *Archiv für Hydrobiologie, Suppl.*, 73, 2 (*Algological studies*, 47), 139-156.

Economou-Amilli A., 1991: *Cyclotella elymaea*, a new fossil species from the Neogene basin of Kozani- Aeani-Servia, Northern Greece. *Diatom Research*, 6, 2, 223-233.

Ehrlich A., 1966: Contribution a l'etude des gisements volcanolacustres a diatomees de la region de Rochessauve et de Saint Bauzile (Ardeche). *Bull. Soc. Géol. France*, 7, 8, 311-321.

Fourtanier E. & Gasse F., 1988: Premiers jalons d'une biostratigraphie et evolution des diatomees f'Afrique depuis II. *C. R. Acad. Sci. Paris, Ser. II*, 306, 1401-1408.

Gersonde R. & Velitzelos E., 1978: Diatomeenpalaookologii in Neogen-Becken von Vegora N-W Mazedonien (Vorlaufige Mittelung). *Ann. Géol. Pays Hellén.*, 29, 373-382.

Golovenkina N., 1967: Interesting and rare diatoms from Neogene continental deposits from the Sisian region, Armenia. In: *Novitates Systemicae plantarium non vascularium*, 22, 38-46 (in Russian).

Hasle G. & Fryxell G., 1970: Diatoms: Cleaning and mounting for light and electron microscopy. *Transactions of the American Microscopical Society*, 89, 4, 469-474.

Héribaud J., 1893: Les Diatomees d'Auvergne. Clermont-Ferrand, 1-255.

Kamenov B. & Kojumdjieva E., 1983: Stratigraphy of the Neogene in Sofia basin. *Paleontology, Stratigraphy and Lithology*, 18, 69-85 (in Bulgarian).

Khursevich G., 1994: Evolution and Phylogeny of some diatom genera of the class Centrophyceae. In: P. Kociolek (Ed.): *Memoirs of the California Academy of Sciences*, 17, 257-267.

Khursevich G. & Loginova L., 1980: The fossil diatom flora of Byelorussia. Minsk, 1-122 (in Russian).

Krammer K. & Lange-Bertalot H., 1991: Susswasserflora von Mitteleuropa: Bacillariophyceae. Bd 2/3 Teil: Centrales, Fragilariaceae, Eunotiaceae. Stuttgart, 1-576.

Krebs W., 1994: The biochronology of freshwater planktonic diatom communities in Western North America. In: P. Kociolek (Ed.): *Memoirs of the California Acaemy of Sciences*, 17, 485-499.

Krebs W., BradburyJ. & Theriot E., 1987: Neogene and Quaternary lacustrine diatom biochronology, Western USA. *Palaios*, 2, 505-513.

Loginova L., 1982: The Likhvin diatom flora from the central part of the East-European plain, its palaeogeographical and stratigraphic significance. *Acta Geol. Hung.*, 25, 1-2, 149-160.

Loginova L., 1990: Evolution and Phylogeny of the diatom genus *Cyclotella*. In: H. Simola (Ed.): *Proceedings of the 10th International Diatom Symposium*, 47-53.

Lowe R., 1975: Comparative ultrastructure of the valve of some *Cy-*

clotella species (Bacillariophyceae). *Journal of Phycology*, 11, 415-424.

McFarland B. & Collins G., 1978: A key to the species of the diatom genus *Cyclotella* (Kütz.) Breb. based only on new morphological data. In: *Abstracts of the 26th Annual Meeting of the Nort American Benthological Society*, May 10-12, 1978,

Manguin E., 1949: Contribution a la connaissance des diatomees fossiles des depots lacustres de l'Aukaratra. *Annales Geologiques du Service des Mines*, 18, 85-115.

Mölder K. & Tynni R., 1968: Uber Finnlands rezente und subfossile Diatomeen II. *Bull. Geol. Soc. Finl.*, 40, 151-170.

Ognjanova-Rumenova N., 1994: Taxonomical composition of fossil diatoms from Neogene nonmarine sediments, Sofia basin. *Annuaire del'Universite de Sofia, Fac. Biologie, Livre 2 — Botanique*, 85, 55-58.

Ognjanova-Rumenova N. & Popova E., 1992: Diatom bostratigraphy and comparative core correlation within the Sofia basin, Bulgaria. In: J. Kovar-Eder (Ed.): *Palaeovegetational development in Europe and regions relevant to its palaeofloristic evolution*. 197-203.

Poretzky W., 1953: Fossil diatoms from Numus and Arzni, Erevan region, Armenian SSR. In: Proshkina-Lavrenko A. (Ed.): *Diatom Symposium, Nauka*, Leningrad, 55-107 (in Russian).

Ross R. & Sims P., 1972: The fine structure of the frustule in centric diatoms: A suggesred terminology. *British Phycological Journal*, 7, 139-163.

Ross R., Cox E., Karayeva N., Mann D., Paddock T., Simonsen R. & Sims P., 1979: An amended terminology for the siliceous component of the iatom cell. *Nova Hedwigia*, Beiheft, 64, 513-533.

Schrader H-J., 1973: Proposal for a standardized method of cleaning diatom bearing deep-sea and land- exposes marine sediments. *Nova Hedwigia*, Beiheft, 45, 403-409.

Serieyssol K.,1981: *Cyclotella* species of late Miocene age from St. Bauzile, France. In: R.Ross (Ed.): *Proceedings of the 6th Symposium on Recent and Fossil Diatoms*. 27-42.

Serieyssol K., 1984: *Cyclotella iris* Brun & Héribaud. In: D. Mann (Ed.): *Proceedings of the 7th International Diatom Symposium*. 197-212.

Servant-Vildary S., 1986: *Cyclotella* sp. fossiles de depots d'eau douce d'age miocene en Espagne. In: M. Richard (Ed.): *Proceedings of the 8th International Diatom Symposium*. 495-511.

Schmidt A., 1874-1959: Atlas der Diatomaceenkunde, Leipzig.

Temniskova-Topalova D., Valeva M. & Ognjanova-Rumenova N., 1994: Nonmarine biostratigraphy of some genera of the class Centrophyceae from Southern Bulgaria. In: P. Kociolek (Ed.): *Memoirs of the California Academy of Sciences*, 17, 301-310.

VanLandingham S., 1985: Potential Neogene Diagnostic diatoms from the western Snake River Basin, Idaho and Oregon. *Micropaleontology*, 31, 167-174.