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Izmirella cretacea nov. gen., nov. sp., a complex alga from the Lower Cretaceous, NE of Bornova-Izmir/Turkey

Baba Senowbari-Daryan[1] and Ismail Isintek[2]

[1] GeoZentrum Nordbayern, University of Erlangen-Nürnberg, Loewenichstr. 28, D-91054 Erlangen, Germany; (basendar@uni-erlangen.de)

[2] Department of Geological Engineering, Engineering Faculty, Dokuz Eylul University, 35100 Bornova, Izmir, Turkey; (ismail.isintek@deu.edu.tr)

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ABSTRACT

Izmirella cretacea *nov. gen., nov. sp., a complex alga, forming microbioherms is described from Barremian – Aptian platform carbonates of the "Bornova block", an allodapic unit derived from the northern margin of the Menderes Massif, included in Maastrichian – Danian flysh deposits, called the "Bornova melange". The verticillate thallus of this alga consists of strongly imbricated bowl- to funnel-shaped whorls having tightly stacked laterals with two layers. The first is composed of radially and fan-like running segments, appearing as large cells in section parallel to the growth direction. The second is composed of multibranched tubes, running perpendicular to the segments of the first layer. Besides its organizational traits, this has original calcite mineralogy and an aggregative behaviour leading to the formation of laminated build-ups closely resembling stromatolitic bioconstructions or even stromatoporoids.*

Keywords: Algae, *Izmirella*, Cretaceous, Izmir, Turkey

1. INTRODUCTION

In the Izmir region (Western Turkey) near Bornova, Mesozoic rocks are represented by the "wildflysch" zone of the Taurids consisting of a Maastrichtian-Danian sandy-shaly matrix with Late Triassic to Late Cretaceous carbonate megablocks. Previous work on the Mesozoic carbonates has been carried out by AKDENIZ et al. (1986), ERDOĞAN (1990) and ISINTEK et al. (2000). AKDENIZ et al. (1986) noted a thick carbonate sequence of Late Cretaceous age, tectonically overlying the Late Cretaceous clastics. ERDOĞAN (1990) reported that the Late Triassic to Late Cretaceous limestone masses in question were allochthonous blocks in the so-called "Bornova Melange" of Maastrichtian-Danian age. According to ERDOĞAN (1990) the carbonate block lying between the village of Naldöken and Çiçekli consists of Jurassic to Upper Cretaceous deposits, including an Albian bauxite lens north of Naldöken (Fig. 1). Recently the presence of a second bauxite bearing horizon in the Barremian part of the upper limestone unit has been documented NE of Naldöken (Fig. 2).

The *Izmirella*-bearing limestones are exposed in the so-called "Bornova-block" located between Naldöken and Çiçekli (1:25.000, Izmir – L18 – b1 sheet; Figs. 1, 2). The studied Cretaceous deposits, north of Naldöken, are represented by a thick sequence of lagoonal, subtidal to supratidal limestones, Barremian–Lower Aptian in age and including a bauxite horizon. The type section of the *Izmirella*-bearing limestones is located 250 m east of the Hendilagili Ridge, 2.7 km to the northeast of Naldöken (Figs. 1b, 2), and consists of a grey, thick bedded limestone sequence about 30 m thick (Fig. 3). The basal part of the section (about 10 m thick) consists of thick-bedded peloidal micrite and/or peloidal sparry facies, including laminated fenestral structures, intercalated with terrestrial lime clays and palaeosols.

The middle part of the section is made up of well bedded or nodular micritic and/or sparitic limestones, sometimes laminated, with pebbly or clayey micrite associated with early erosional surfaces. The clayey micritic limestones include rare foraminifera, gastropods, ostracods, faecal pellets, *Salpingo-*

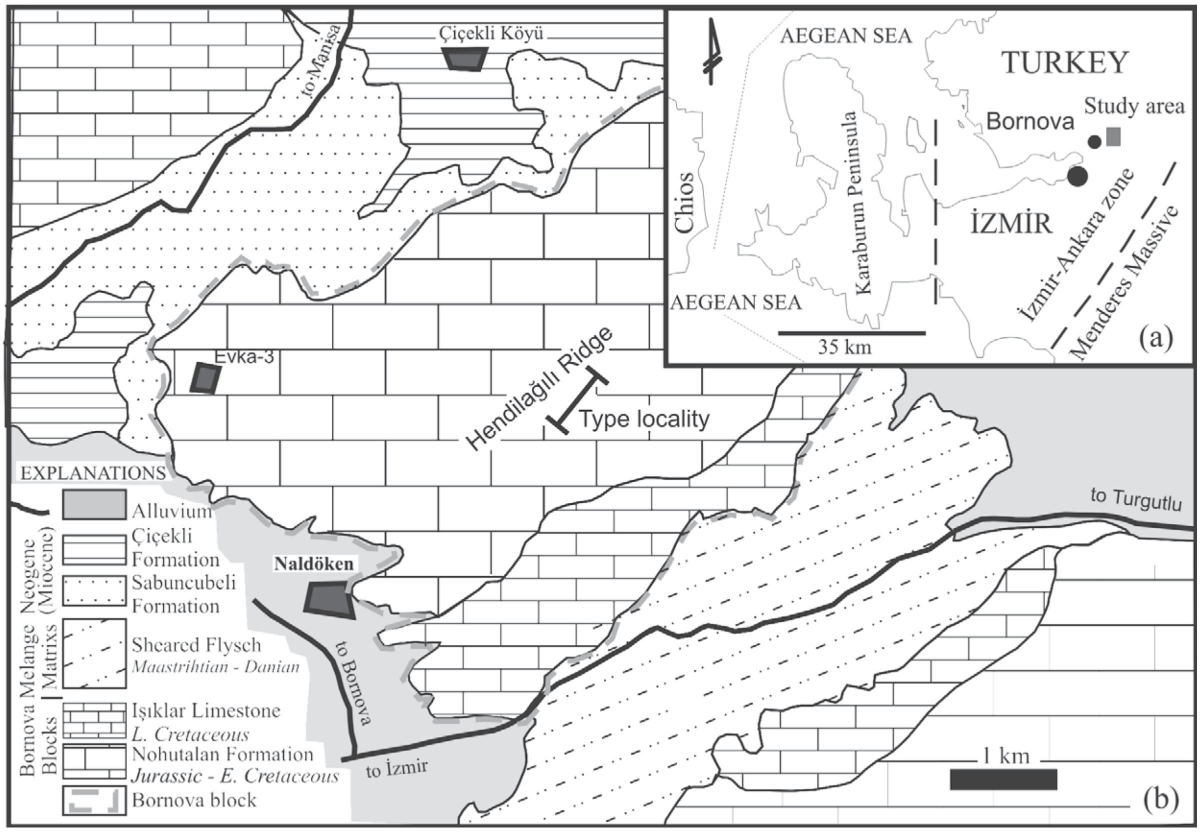


Figure 1: Location map of the study area in Western Turkey; (a) geological map of the Bornova area; (b) the position of the *Izmirella* nov. gen. bearing site (simplified after ERDOĞAN, 1990).

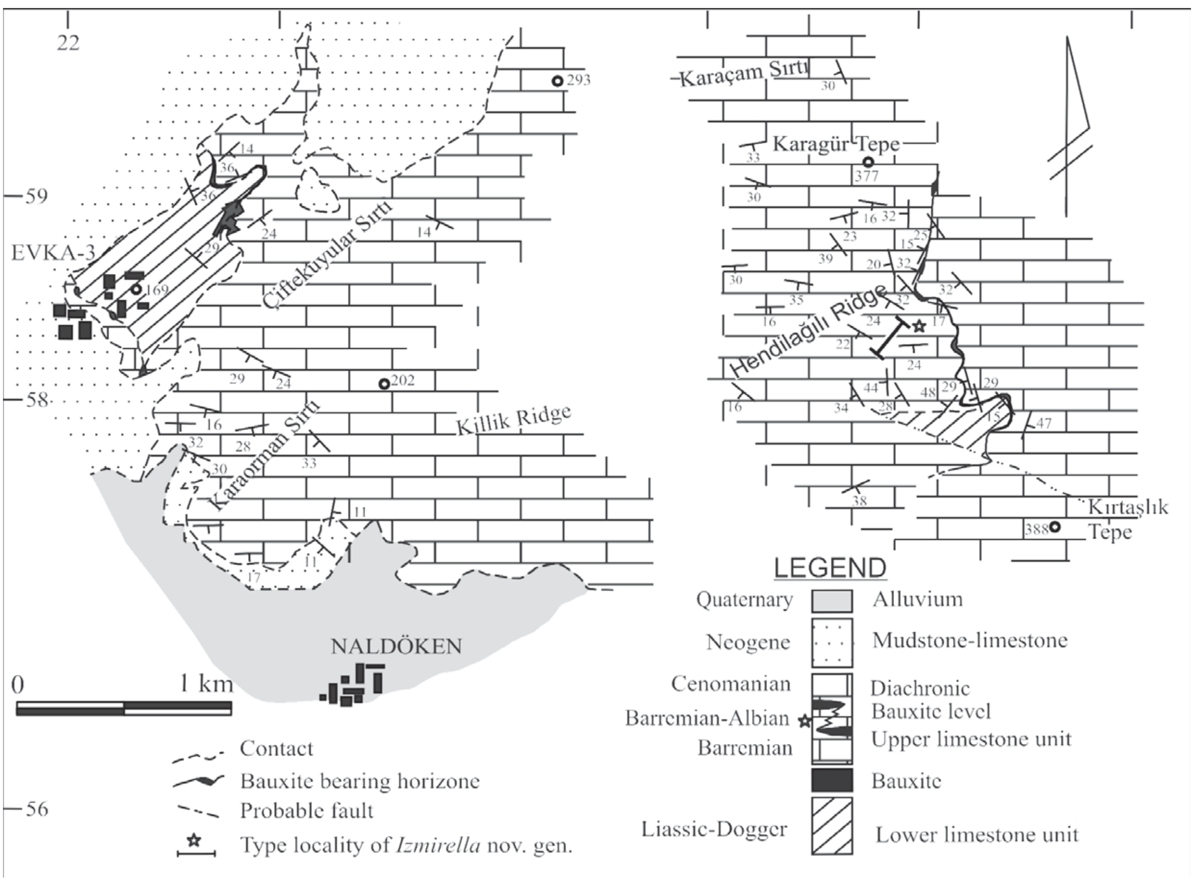


Figure 2: Detailed geological map of the Mesozoic carbonates of the "Bornova block" in the area of the type locality of *Izmirella* nov. gen.

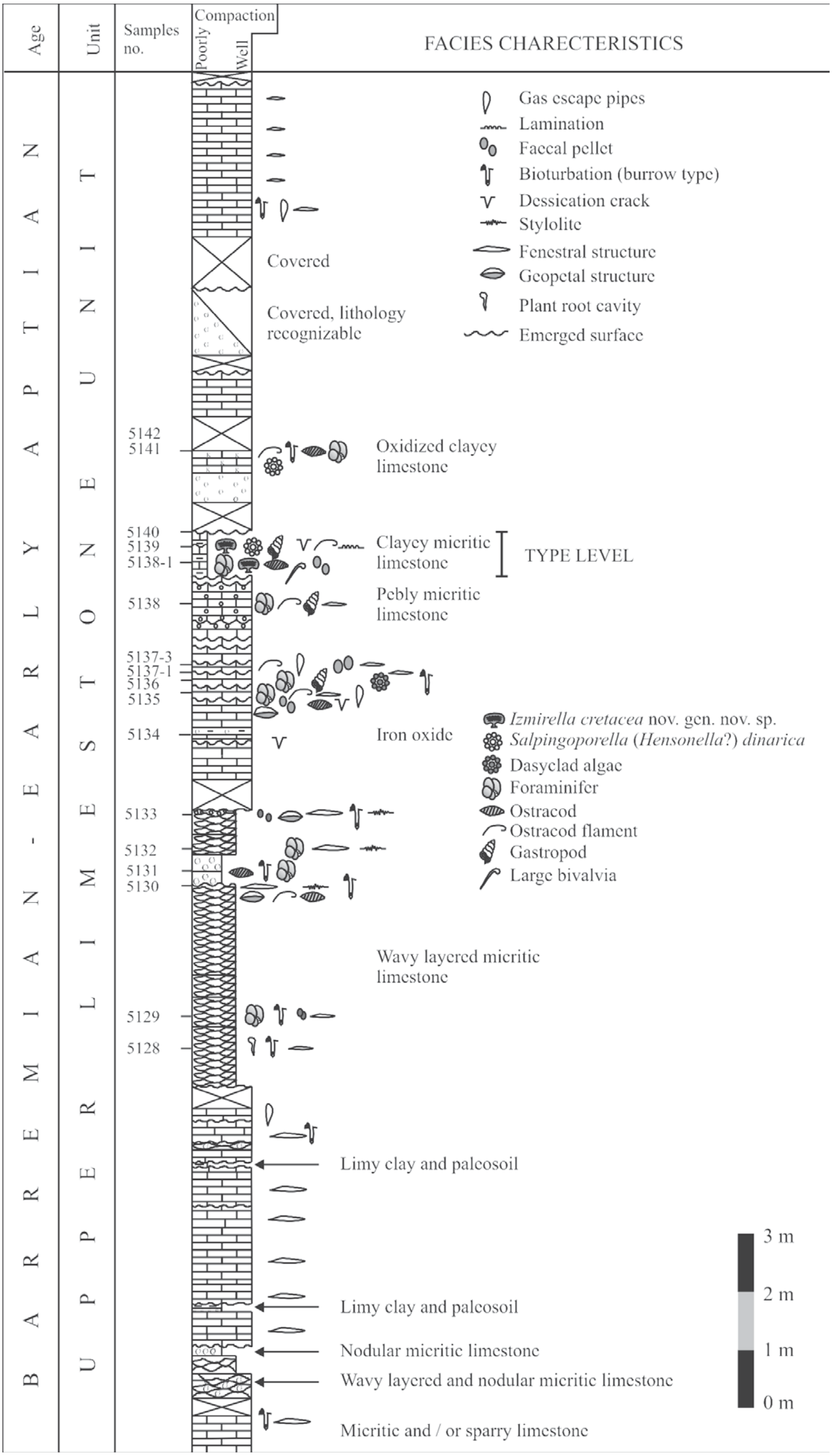


Figure 3: Type section of the *Izmirella cretacea* nov. gen., nov. sp. bearing limestone, in the upper limestone unit of the "Bornova block".

porella (*Hensonella*?) *dinarica* RADOIČIĆ, large (2–25 cm) fragments of *Izmirella* microbioherms. *Salpingoporella* (*Hensonella*?) *dinarica* RADOIČIĆ is a paleobiogeographic marker of the Mediterranean Southern Tethyan margin (PEYBERNES & CONRAD, 1979), and has been reported from beds ranging from the Valanginian(?) (SCHINDLER & CONRAD, 1994) or from the Tithonian?–Berriasian (GRANIER, 2002) to Late Aptian (VELIĆ & SOKAČ, 1983). Its acme is in the Barremian–Lower Aptian (LUPERTO SINNI & MASSE, 1993).

The upper part of the type section with *Izmirella cretacea* nov. gen., nov. sp. is characterized by bioturbated, thick bedded or laminated micritic and/or intra-pelsparitic limestone with laminated fenestral structures, and thick bedded nodular micritic limestone.

2. SYSTEMATIC PALAEONTOLOGY

Alga incertae sedis
Genus *Izmirella* nov. gen.

Derivatio nominis: After the city of Izmir, close to which the alga was found.

Diagnosis: Thallus segmented, composed of strongly imbricated bowl- to funnel-shape whorls, each with tightly stacked, septate laterals. Laterals, appearing as an oval or rectangular cell layer in sections, are divided radially several times towards the periphery of the whorls. A multibranched cell layer originates from the upper surface of the laterals, forming a second layer of whorls. A third layer consisting of "chaotic" tubes is located between the individual layers of the thallus. Calcification was originally calcitic. The organism grew with successive rows of closely packed individuals forming domal, laminated thalli resembling stromatolites or even stromatoporoids.

Type species: *Izmirella cretacea* nov. sp.

Izmirella cretacea nov. sp.
(Figs. 4–10; Pls. 1–7)

Derivatio nominis: After the occurrence of the alga in the Cretaceous deposits.

Holotype: Longitudinal section illustrated in Pl. 4, Fig. 1.

Isotypes: All specimens illustrated in Pls. 1–7.

Locus typicus: 2.7 km northeast of Naldöken, 250 m east of Hendilagili Ridge, Karaburun/Turkey (see Figs. 1–2).

Stratum typicum: Lower Cretaceous (Barremian–Aptian)

Diagnosis: Because of the monospecific character of the alga, the species diagnosis corresponds to the diagnosis of the genus.

Material: Four microbioherms contain numerous hemispherical laminae. From one microbioherm containing the holotype (Pl. 4, Fig. 1) three large thin sections (10×15 cm) and from the second microbioherm two large thin sections were made.

Depository: The holotype (5 thin sections and 4 rock pieces) and illustrated paratypes are kept in the Forschungsinstitut und Naturmuseum Senckenberg/Frankfurt a. M., Germany, Inventary-Nr: microbioherm of holotype (rockpieces: SM.B. 20863/a–c, thin sections illustrated in Pls. 1–4: SM.B. 20863a/1, 20863b/1, 20863c/1, 20863d/1, 20863e/1), and one paratype SM.B. 20864 illustrated in Pl. 5.

Description of microbioherms

Izmirella cretacea nov. gen., nov. sp. forms bioconstructed bodies up to 22 cm high which resemble stromatolites or stromatoporoid sponges with distinct laminations (Pl. 1, Figs. 1–4; Pl. 2, Figs. 1–2; Pl. 3, Fig. 1). The individual laminae (layers) of the outside of the bioherms correspond internally to the individual rows, which are formed by numerous thalli of *Izmirella cretacea* arranged one beside the other (Pl. 2, Figs. 1–2). In thin sections, individual laminae are separated by dark horizons, usually thinner than the layers of *Izmirella* rows (Pl. 2, Figs. 1–2). These dark horizons are composed of small and multibranched tubes of "chaotic" arrangement (Pl. 5, Figs. 5, 8) resembling *Girvanella*. These tubes will be described in detail under the description of *Izmirella*.

The microbioherm containing the holotype is tabular, up to 7 cm thick with a height of 14 cm and a lateral extent of 21 cm (before cutting). Another microbioherm (Pl. 1, Figs. 1–4), showing the height (Figs. 1–2), thickness (Fig. 3) and lateral extension (Figs. 1–2), is also tabular, reaching 5.5 cm thickness, 22 cm height and 22 cm width.

The microbioherm containing the holotype exhibits the well-developed lamination on one side only but the paratype, illustrated in Pl. 1 shows well developed lamination on both sides. The base of this microbioherm is bulbous and shows several circular shaped initial parts of individual thalli of *Izmirella*, having a diameter of approximately 2 mm. Each basal bulb consists of the individual thalli of *Izmirella* cut in cross section (see Pl. 2, Fig. 1 upper part of the photograph).

The outer surfaces of all four available microbioherms are lamellar. The height of individual laminae is almost constant (about 3 mm, rarely varying between 2 mm and 5 mm). The laminae in the basal part of two microbioherms extend laterally, parallel to the substrate but in the younger part they are almost sub-spherical. In the third microbioherm the laminae at the top also extend parallel to the substrate (Pl. 1, Figs. 1–2). This specimen seems to be broken at both sides. The top of all microbioherms are vaulted.

Description of *Izmirella cretacea* nov. gen., nov. sp.

Three large thin sections (10x15 cm, two parallel and one transverse to the growth direction) were cut into the microbioherm containing the holotype. Two large thin sections were made from the second microbioherm.

The longitudinal sections show (as recognizable from the outside), the layers (laminae) reaching a height of about 3 mm (Pl. 1, Figs. 1–4; Pl. 2, Figs. 1–2; Pl. 3, Fig. 1). Each laminae is composed of numerous thalli of *Izmirella*, arranged in rows one beside the other (Pl. 2, Figs. 1–2; Pl. 3, Fig. 2). Adjacent thalli are in contact (especially at their lower and middle parts), but they never amalgamate laterally. Individual thalli reach a diameter of 2.5–4.5 mm (Pl. 3, Figs. 2–4; Pl. 4, Figs. 1, 4, 6; Pl. 5, Fig. 1, 3; Pl. 6, Figs. 1, 4). Most thalli have the same length corresponding to the height of laminae.

Each thallus is composed of numerous soup-plate- or bowl- to V-shaped elements or segments (Pl. 2, Figs. 1–2; Pl. 3, Figs. 2–4; Pl. 4, Figs. 1–2, 4–5; Pl. 5, Figs. 1, 3; Pl. 6, Fig. 1, 4), termed whorls in this paper. The whorls are fitted one above the other. At the basal part of the thalli, the individual whorls are usually soup-plate-like, at the middle they become more bowl-like, at the upper part the whorls are mostly V-shaped in section with a wide collar (Pl. 3, Fig. 3; Pl. 4, Figs. 1, 4–5), U-shaped (Pl. 3, Fig. 4), or even cup-shaped (Pl. 6, Figs. 1, 4, 8). In some specimens the bowl-shaped whorls of the middle part are less steep and resemble the soup-plate shaped whorls of the basal part, which they partly overlap (Pl. 5, Fig. 3). The inside of the youngest whorl is filled with either secondary calcite cement (Pl. 2, Figs. 1–2; Pl. 3, Fig. 2; Pl. 7, Fig. 7) or a micritic film which covers the inside of the whorl (Pl. 3, Fig. 4). Micrite also filled part of the inside of the whorl (Pl. 4, Fig. 2; Pl. 6, Figs. 4, 8). The micritic fillings do not show any geopetal fabric and are interpreted to be of organic origin. Spherical elements of about 50 µm in diameter were observed within this micritic mass (Pl. 6, Fig. 12). Interpretation of these spherical elements as reproductive organs (gametangia) is very speculative.

In longitudinal sections (parallel to the axis of the thallus) the individual whorls exhibit two layers of "cell-like" structures (Pl. 4, Figs. 2–3, 5–6; Pl. 5, Figs. 1–4, 6; Fig. 4). The basal layer is composed of "large cells" corresponding with what we assume to be "laterals" (analogous to the thallus organization of dasyclad algae) cut in cross sections, arranged radially and running from the centre to the periphery of the whorls, similar to Recent *Acetabularia* (Pl. 3, Figs. 5–6; Pl. 4, Figs. 2–3, 5–7; Pl. 5, Figs. 1–4, 7; Pl. 6, Figs. 2–3, 5, 10–11, 13; Pl. 7, Figs. 1–2.). In cross section, the outline of the laterals ("large cells") is oval to quadratic in shape, normally 80x40 µm directly around the axial column, termed here as the "axial stem" (Pl. 4, Figs. 2–3, 6; Pl. 5, Figs. 1, 3, 6; Pl. 6, Figs. 2, 5; Fig. 4 marked with number 1). As observed in tangential sections, the laterals are divided several times toward the periphery of the whorls, by a zig-zag (wavy), thin wall (Pl. 3, Figs. 5–6; Pl. 4, Fig. 7; Pl. 5, Figs. 1–3, 7; Pl. 6, Figs. 10–11, 13; Pl. 7, Figs. 1–2; Figs. 5–6). At least five divisions and six orders of laterals were commonly observed (Fig. 7). As shown in Fig. 7, the levels where the laterals divide are not exactly at the same horizons. The divided pattern of the "laterals" of *Izmirella* resembles some porostromate calcareous algae, like *Hedstroemia, Selonopora* or Palaeozoic genera including *Botomaella* or *Halysis* (compare RIDING & VORONOVA, 1985, fig. 6; MUNNECKE et al., 2001, fig. 9; FLÜGEL, 2004, pl. 98, fig. 2). Such dichotomy of the "laterals" was also observed in the dasycladalean genus *Campbelliella* (see DE CASTRO, 1993, pl. 13).

The second layer, which appears darker in transmitted light, is developed above the first and is composed of tubes originating from the upper surface of the laterals (Pl. 4, Figs. 3, 6; Pl. 5, Figs. 2, 4; Pl. 7, Fig. 1). If the section passes through the upper surface of the laterals, they appear as a plate of pores, reflecting the cross sections of the tubes (Pl. 3, Figs. 5–6; Pl. 7, Fig. 1; Figs. 4, 6). We term this layer with its corresponding tubes as "tubes of the second layer", interpreted as having

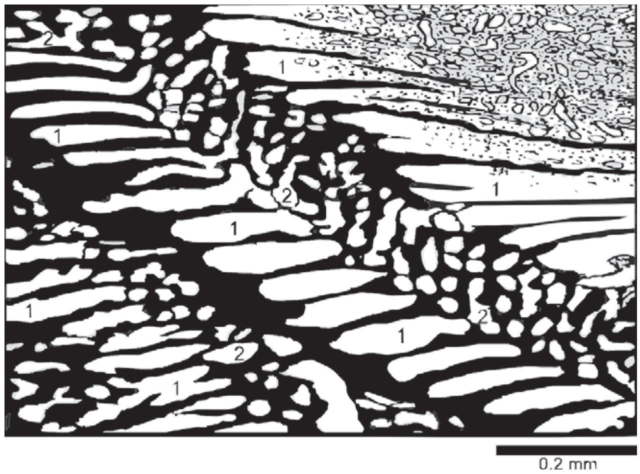


Figure 4: Section through three layers of laterals appearing white in thin sections (1) and three layers of tubes of second layers appearing dark in thin sections (2). The upper right corner of the photograph corresponds to the upper surface of laterals, from which the tubes of second layer (2) originate. The centre of the thallus is located in the NE, outside of the drawing. Redrawn from Pl. 5, Fig. 2.

originated by multi-branching from different portions of the "laterals" (Pl. 4, Figs. 3, 6; Pl. 5, Figs. 1–4; Pl. 6, Fig. 6). The transverse outline of these "tubes" is usually polygonal, or somewhat circular, with a diameter of approximately 10 µm (Pl. 5, Figs. 2, 4, 6,). The resulting pattern consists of a layer of tubes between two layers of laterals (Pl. 4, Figs. 2, 3, 6; Pl. 5, Figs. 1–4, 6; Pl. 6, Fig. 3; Pl. 7, Figs. 1, 7–8), which represent off shoots? of *Izmirella* and may be erroneously interpreted as representing another alga.

As mentioned above, the darker horizons between the individual laminae (Pl. 2, Figs. 1–2; Pl. 3, Fig. 1) are composed of a "chaotic" cell layer, similar to *Girvanella* (Pl. 4, Fig. 7; Pl. 5, Figs. 5, 8). As observed in several specimens, the edge of the last whorl becomes trumpet-like from which the "chaotic"

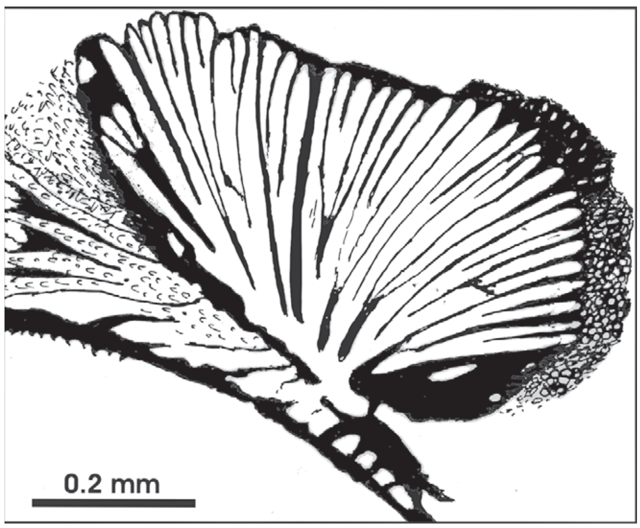


Figure 5: Section exhibiting the radiating branching pattern of the laterals from the axial stem. From seven laterals at the base (from the "axial stem"), about 40 laterals originate in the periphery of the whorl.

PLATE 1

1–4: Microbioherm (paratype) formed by *Izmirella cretacea* nov. gen., nov. sp. Scale: 1 cm.

1 View of the "front-side" of a paratype showing the well-developed wavy laminae oriented parallel to the substrate (for magnification of laminae see fig. 4).

2 View of the other side ("back-side") of the same specimen illustrated in fig. 1.

3 Side-view of the same specimen illustrated in fig. 1 or fig. 2.

4 Magnified part from Fig. 1 (quadrangle marked with white line) shows details of the lamination.

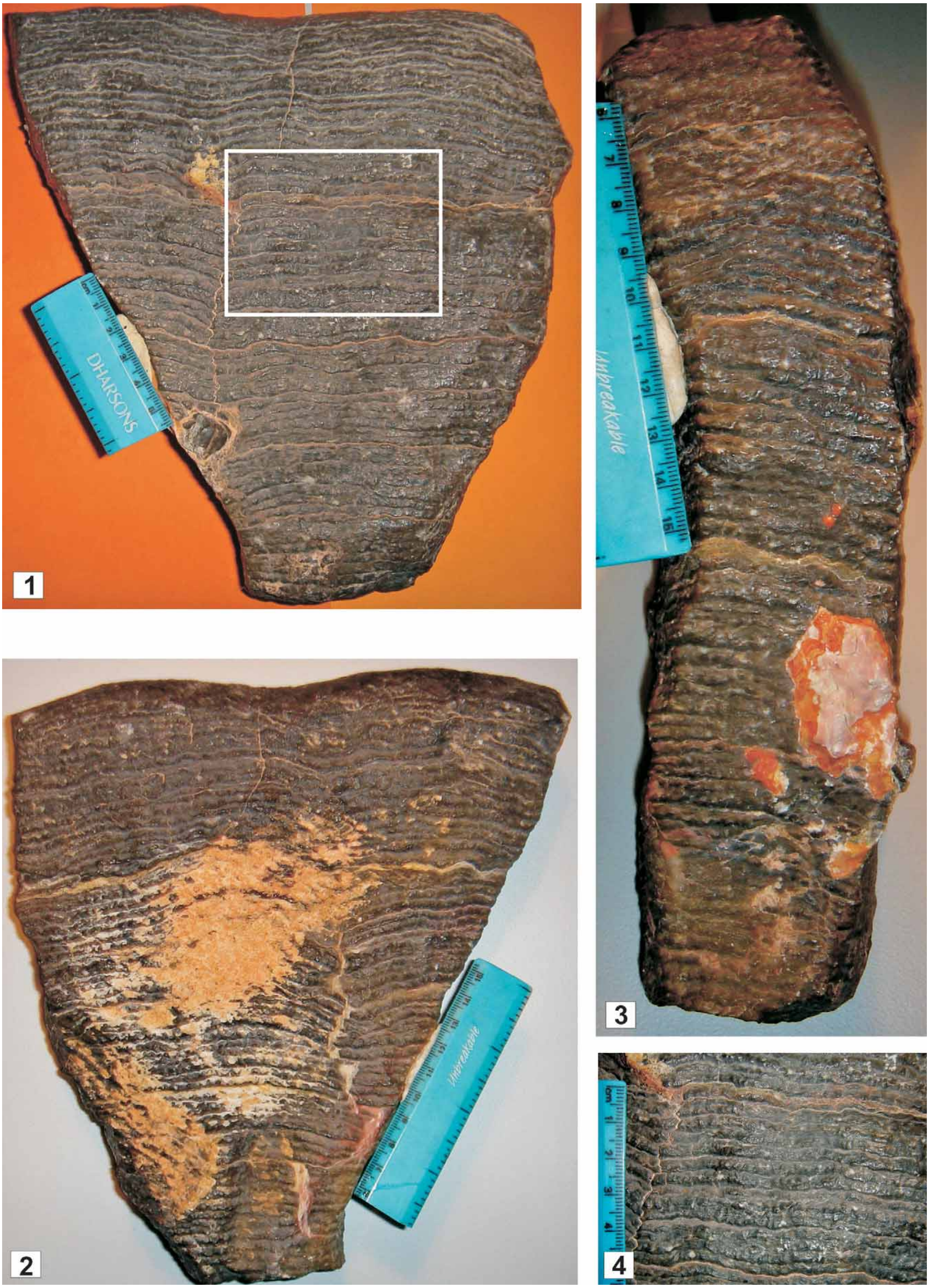
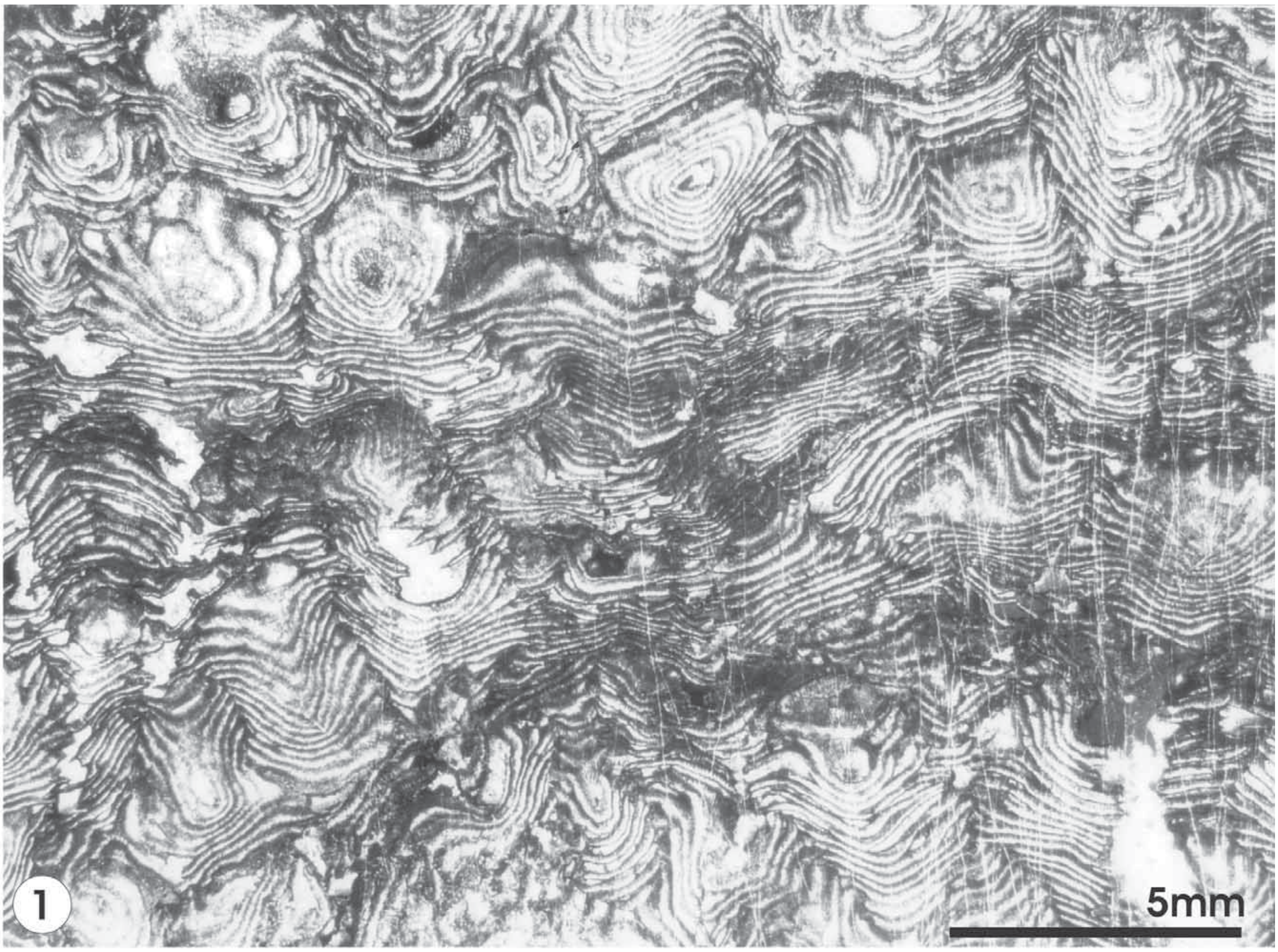

1
DHARSONS
2
Unbreakable
3
Unbreakable
4

PLATE 2

1–2: *Izmirella cretacea* nov. gen., nov. sp.

1 Magnification from thin section 1q (transverse to oblique section) showing three layers (correspond to the laminae, separated by dark area containing "chaotic tubes") in which the individual thalli are arranged in rows one beside the other. In the lower part of the photograph the thalli are cut in longitudinal section exhibiting the individual soup-plate-, bowl- or funnel-shaped whorls arranged one above the other. At the upper part of the photograph the thalli are cut obliquely or transversely, exhibiting the circular outline of the whorls in cross section.

2 Magnification from thin section 1/l showing the rows (layers or laminae), in which the individual thalli are arranged one beside the other. The dark areas between the layers of adjacent thalli contain small "chaotic tubes". The youngest whorl of the thallus is usually filled with calcite cement.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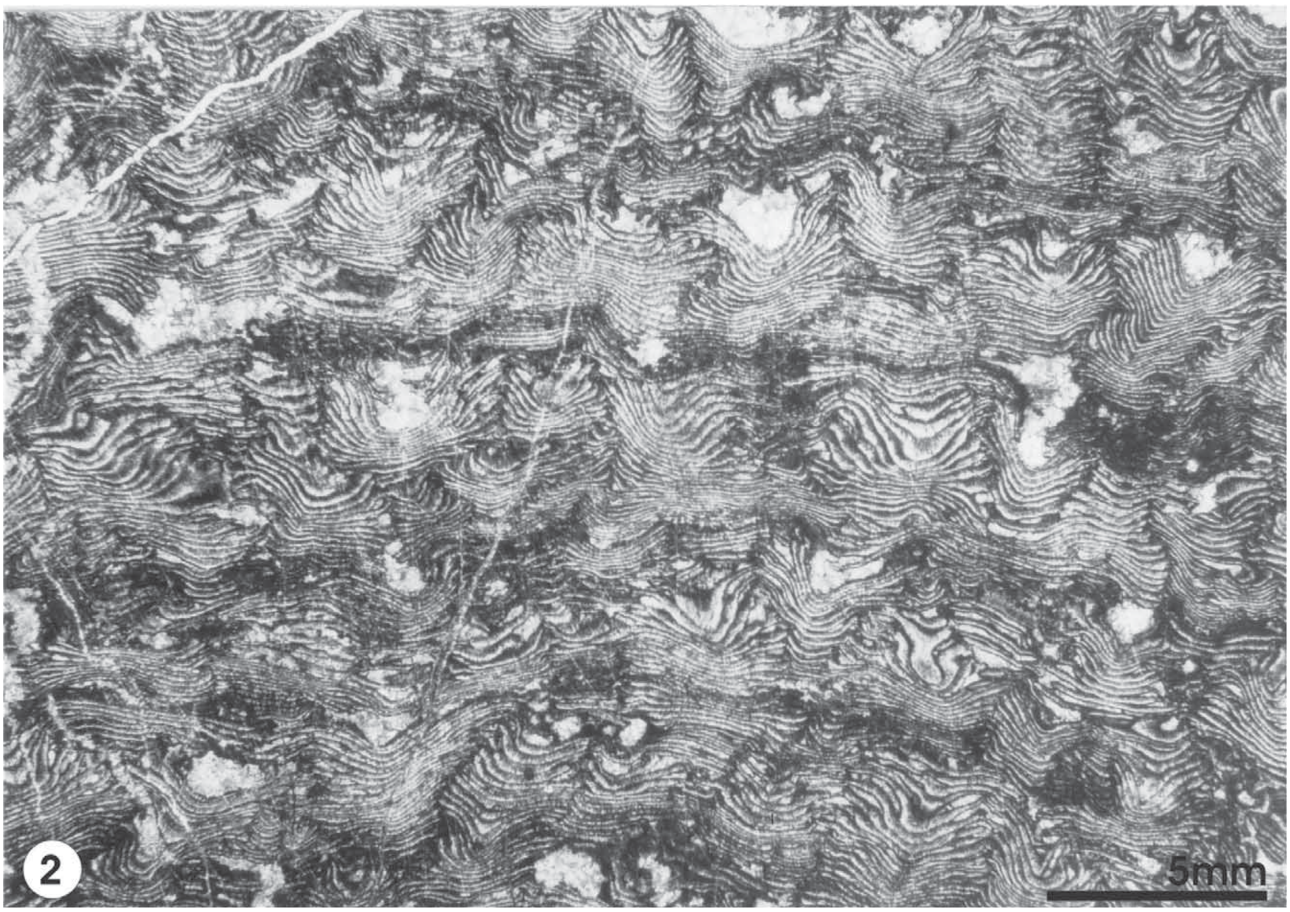
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5mm

PLATE 3

1–7: *Izmirella cretacea* nov. gen., nov. sp. Scale in Fig. 1 is 2 cm, in all others 1 mm.

1 Longitudinal section (parallel to the growth direction) of a microbioherm containing the holotype (see Pl. 4, Fig. 1) exhibits the individual layers (laminae) composed of numerous thalli of *Izmirella* arranged in rows one beside the other in horizontal direction (thin section 1/l).

2 Magnification from fig. 1 showing several thalli with bowl- or funnel-shaped whorls. The interior of the last whorl is usually filled with calcite cement. Thin section1/1.

3 Magnification from fig. 1. View of a thallus showing the plate-like and relatively broad whorls at the lower part (right in photograph) and V-shaped whorls at the upper part (left in photograph) of a thallus. Thin section 1/1.

4 Section through the younger part of a thallus that exhibits the cup-shaped last whorl. From the upper part of the youngest whorl there appears to arise a new whorl or a new thallus(?). The interior of the last whorl is covered by micrite of organic origin; the remainder is filled with calcite cement (for details see Fig. 10).

5 Longitudinal section through a thallus showing the "laterals" of the first order (small arrows), branching to the "laterals" of the second and higher orders. The large triangular arrows indicate the radially arranged "laterals" of the fourth order. The medium-sized triangular arrows indicate the polygonal outline of the "tubes of the second layer" running perpendicular to the "laterals" of first and second order. The small triangular arrow indicates the axial stem connecting the individual whorls. The large arrows at the left of the photograph indicate the branching pattern of the "tubes of the second layer" from the upper part of the "laterals". Note the wavy (zig-zag-like) wall between the "laterals" of first and second orders (compare fig. 7). Thin section 1/1.

6 Similar to fig. 5. Longitudinal section through four whorls exhibiting alternating "laterals" and the polygonal outline of the "tubes of the second layer" which are cut in transverse section and run perpendicular to the "laterals". Note the wavy (zig-zag-like) wall between the "laterals". Thin section l/q.

7 Section exhibiting the edge of the last whorl of a broad, trumpet-like form, from which the tubes of the second layer originate (for details see Fig. 8).

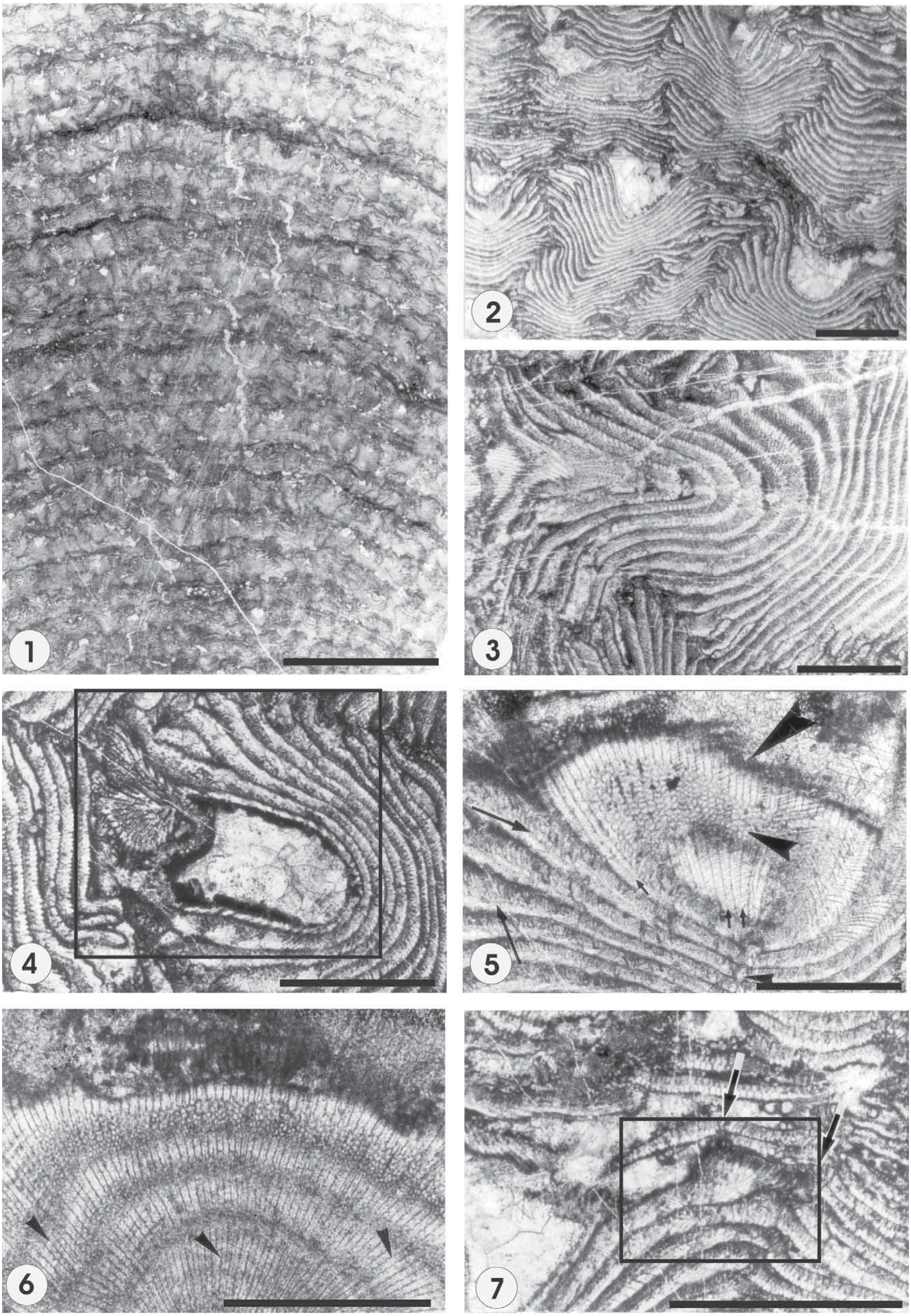
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PLATE 4

1–7: *Izmirella cretacea* nov. gen., nov. sp.

All figures are from the same microbioherm as the holotype (thin section 1/l, Pl. 3, Fig. 1).

Scale in all figures 1 mm.

1 Holotype. Axial longitudinal section showing numerous soup-plate to bowl- to funnel-shaped whorls. The narrow axial stem is cut in the upper and lower parts of the whorl. Thin section 1/1.

2 Section through a thallus exhibiting several whorls with the axial stem cut in the centre of the last four whorls. Tubes of the second order, originating from the edges of the last whorl, extend bridge-like between the edges of the last whorl. The interior of the last whorl is covered by micritic layer (black) of organic origin. "Up" is toward the left.

3 Magnification of several whorls showing the "laterals" (appearing as large cells) passing to the small, branched tubes ("tubes of second layer") which have arisen from the laterals of first order (arrow). "Up" is toward the left.

4 Magnification of a thallus showing the bowl-like whorls at the lower part (right in photograph) and funnel- or V-shaped at the upper part (left in photograph) of a thallus. The small arrow indicates the radially arranged and fan-like multibranched tubes of the first order of "laterals" (longitudinal section). "Up" is toward the left.

5 The "laterals" of the first and second order are recognizable in the last funnel-shaped whorl. The axial stem is cut in the centre of the preceding three whorls. "Up" is toward the left.

6 Similar to fig. 5. The large arrows indicate the branching pattern of the "tubes of the second layer" and the triangular arrow points to the branching of a "tube of the second layer".

7 Transverse to oblique section through several whorls. The arrows indicate to the fan-like radially branched first, second and third order "laterals".

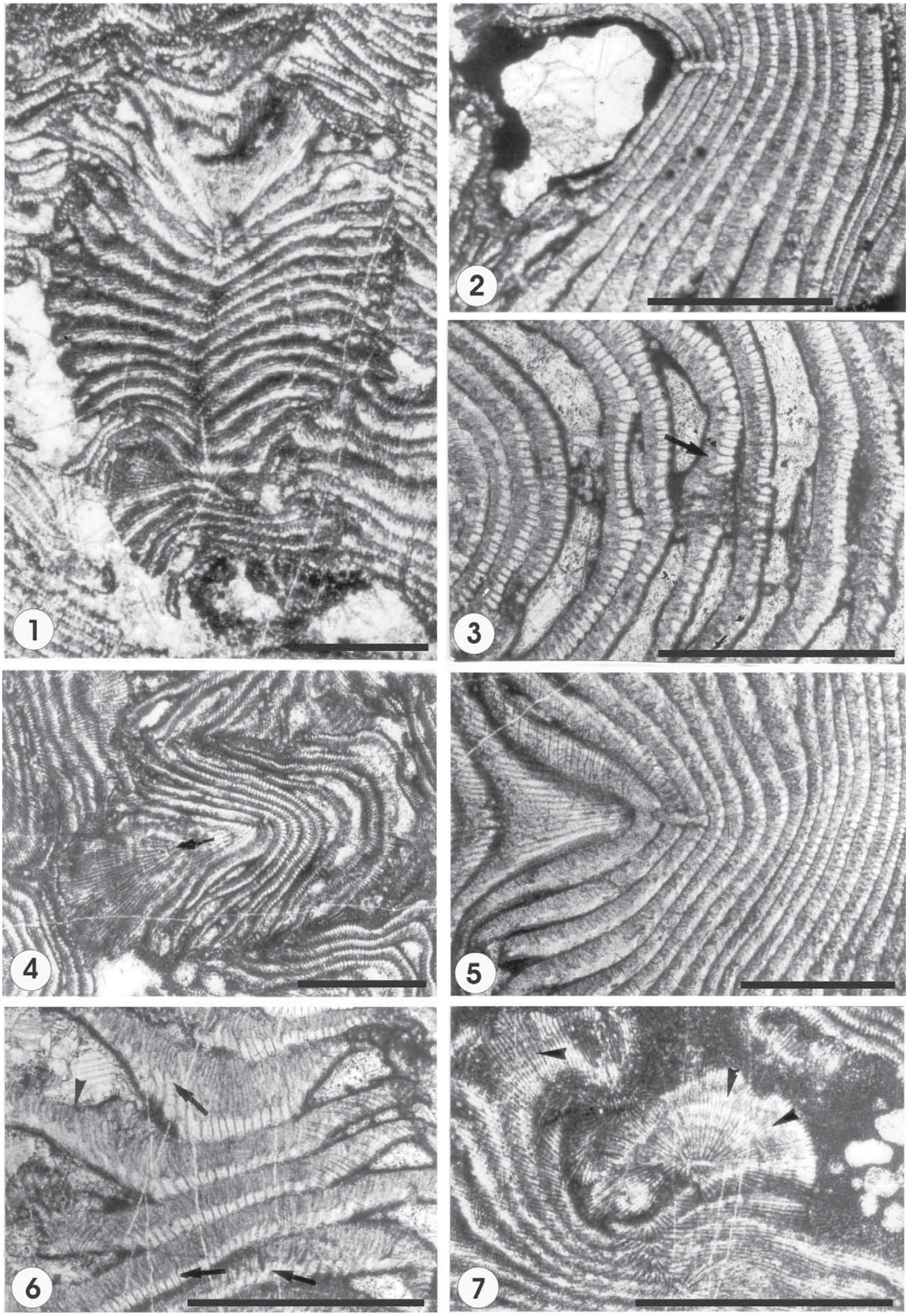
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PLATE 5

1–8: *Izmirella cretacea* nov. gen. nov. sp. from the third microbioherm.

Scale in figs. 1 and 3 is 0.5 mm, in fig. 6 is 0.1 mm, in all others 0.2 mm.

1 Section through several whorls of a thallus exhibiting the laterals and the tube layers of second order. The laterals appear as rectangular cells in the middle part, becoming oval and tube-like to the periphery of the whorls. The fan-like branching of the laterals is recognizable in the last whorl (for details see figs. 2, 4).

2 Magnification from fig. 1 shows the details of three whorls with laterals (light area) and the tubes of a second layer (dark area). The fan-like branching of the laterals of the last whorl is clearly recognizable. The dark area with some pores at the last whorl (upper right) shows the boundary between the laterals and tubes of the second layer. Arrows indicate the origin of the tubes of the second layer from the laterals (for details see Fig. 4).

3 Section through the upper part of a thallus exhibiting individual whorls running down and covering the old whorls. The axial stem is cut at the upper part, continuing to the fan-like branched laterals.

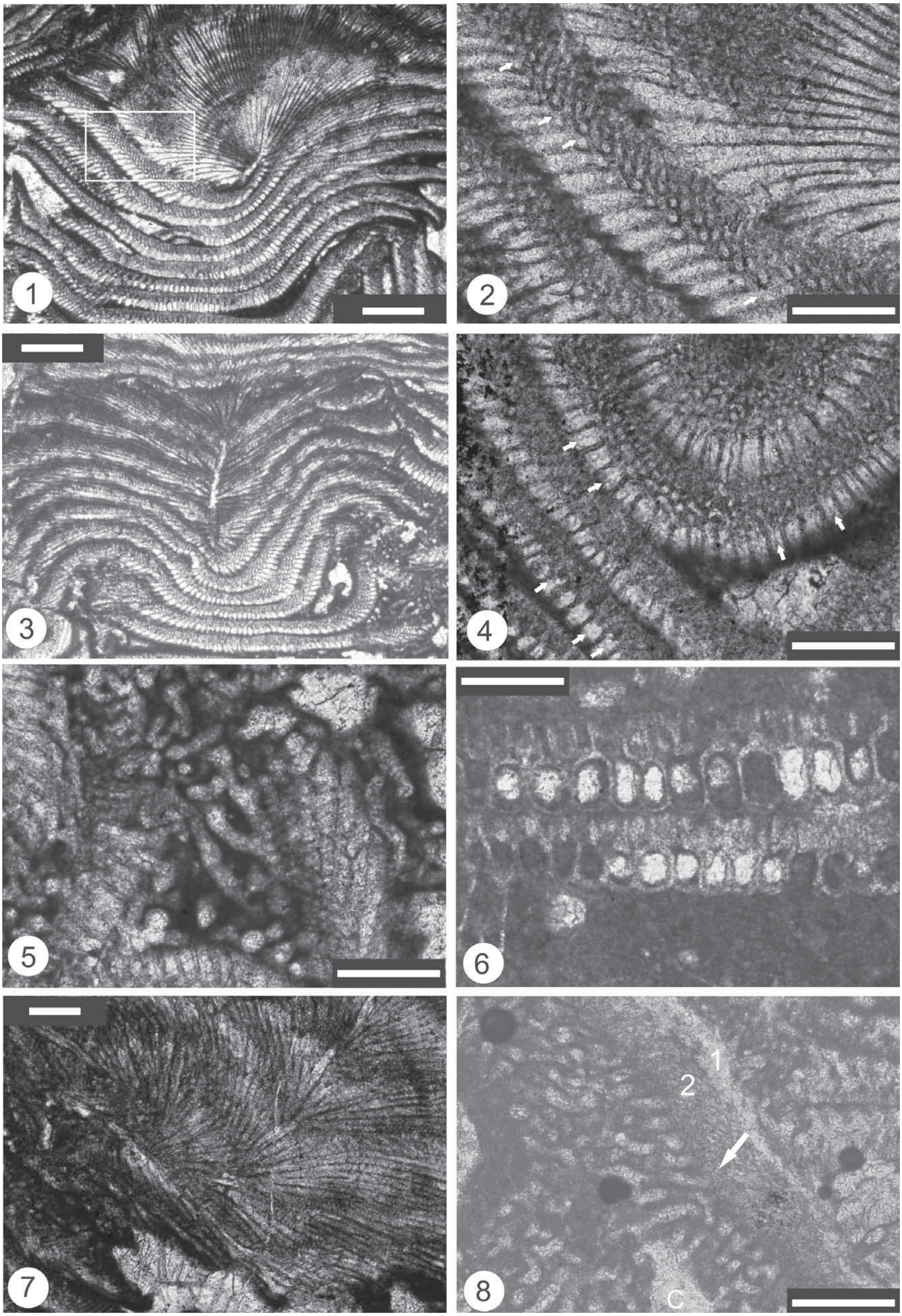
4 Similar section to fig. 2 showing the same characteristics. Arrows indicate the detailed origin of the tubes of the second layer.

5 Cluster of "chaotic" cells originating from the laterals (white area with large "cells").

6 Two "cell" layers of laterals (large "cells") and tubes of the second layer (small "cells") in an isolated fragment of a thallus.

7 Fan-like branching of the laterals as shown in fig. 7.

8 Formation of "chaotic" tubes from the second layer (2) of the whorl. White "line" (1) indicates the laterals. Arrow indicates the origin of the "chaotic" tubes. C = the cavity within the "chaotic" tubes.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7
8
1
2
C

PLATE 6

1–13: *Izmirella cretacea* nov. gen. nov. sp. from the third microbioherm.

1 Section through two thalli each with numerous whorls. The interior of the last whorl in the thallus on the left is filled with calcite cement. The axial stem is cut in the lower part of the thallus on the right. For details see fig. 2.

2 Magnification of the area in fig. 1, marked with white rectangle, showing numerous whorls with the laterals appearing as rectangular cells (lower part) adjacent to the axial stem. The axial stem passes through the whorls and branches at the upper most part (see fig. 3).

3 Magnification of the upper most part of the axial stem in fig. 2 showing the branching pattern. The laterals appear gray (partly as a cell layer); the tubes of the second layer are darker. Small arrows indicate the branched tubes of the second layer.

4 Section through a thallus with a cup-shaped final whorl. The edge of the last whorl (quadrangle, see fig. 7) expands (trumpet-like), with the later rejuvenation above. The interior of the last whorl is filled partly with micrite (gray) of organic origin. Numerous small spherical elements (gametangia?, barely recognizable, see fig. 12) are embedded within the micritic filling.

5 Section from the upper part of a thallus showing the laterals and the branching pattern of the axial stem at the upper end of the thallus (for details see fig. 6).

6 Magnification of fig. 5 showing the details of the axial stem.

7 Magnification from fig. 4 (quadrangle) showing the trumpet-like broadening of the upper end of the last whorl.

8 Section through the upper part of a thallus showing the interior of the last whorl filled partly by micrite (gray) of organic origin and partly by cement (white). Numerous spherical elements (gametangia?) are embedded within the micritic filling. Cluster of tubes (appearing as cells) connect (like a bridge) the outer edges of the last whorl (for details see fig. 9 and 12).

9 Magnification of part of fig. 8, (large rectangle) of cells originating from one end of the whorl connecting both edges of the last whorl.

10 Cross section through two thalli showing the last whorls appearing concentric (bulbous) with numerous laterals. Arrow indicates the details of the last whorl in fig. 11.

11 Magnification from fig. 10 (arrow) showing the rejuvenation (?) of a whorl from a lateral and the branching pattern of the laterals.

12 Magnification from fig. 8 (small rectangle) shows the tubes (right in photograph) and numerous spherical elements (gamentangia?) within the micrite infilling.

13 Magnification of the upper part of the specimen illustrated in Pl. 5, Fig. 3 showing the origin of the whorls and laterals from the axial stem (white area) and the tubes of the second layer that originated from the laterals (dark area).

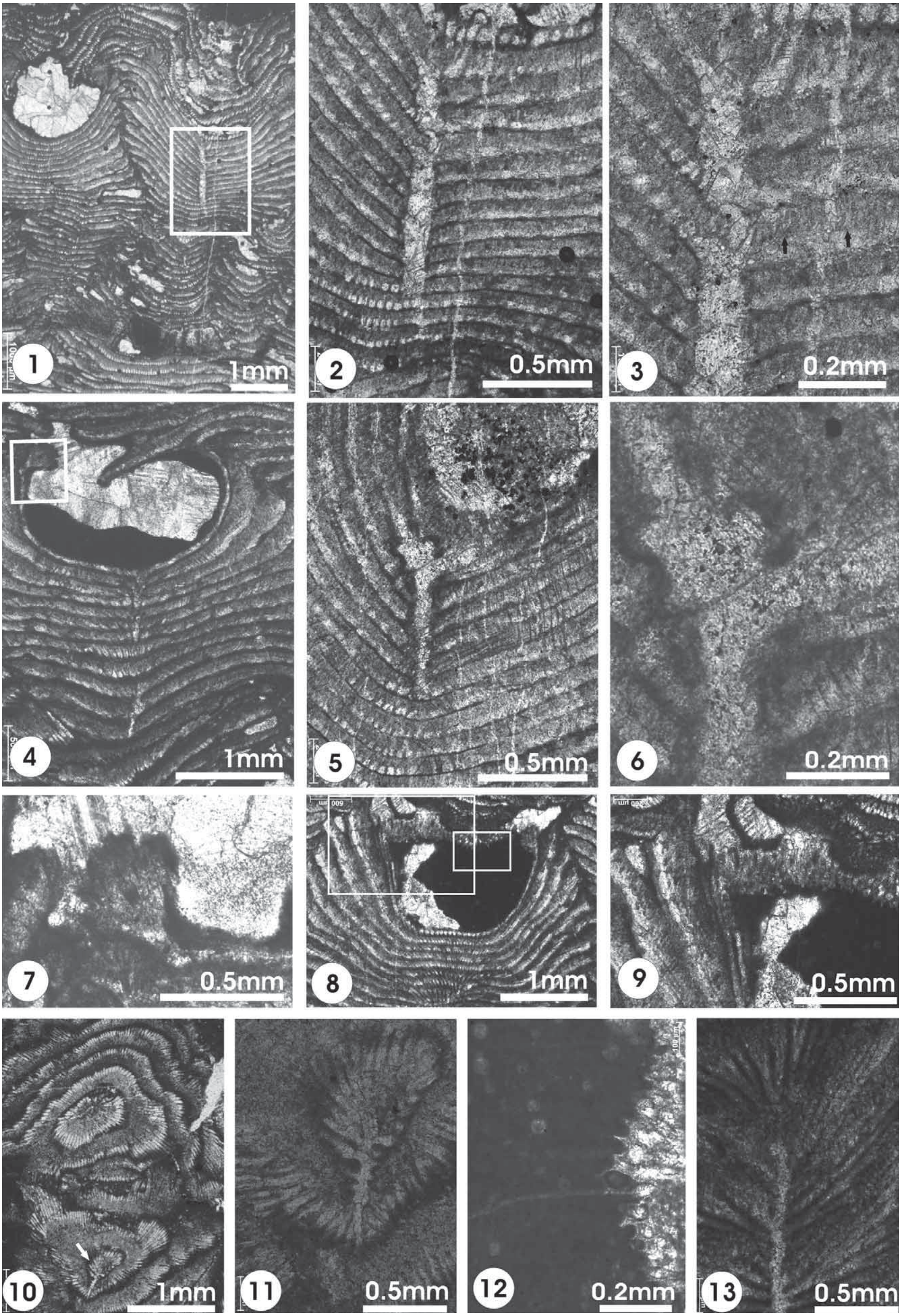
1
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PLATE 7

1–8: SEM-photomicrographs from different parts of *Izmirella cretacea* nov. gen., nov. sp.

1 Section through three layers of laterals and tubes in a second layer. White arrows indicate the tube-like laterals. Tubes of the second layer originate from the "pores", in the upper surface of laterals. For magnification of the area marked with rectangle marked see fig. 2. "Up" is toward the left.

2 Magnification from fig. 1 (rectangle) showing the inside of laterals filled with large calcite crystals (arrows) and the wall of the laterals characterized by microgranular micritic crystals. For magnification of the area marked with a rectangle see fig, 3. "Up" is toward the left.

3 Magnification from fig. 2 showing the laterals, characterized by large crystals, and the wall characterized by microgranular structure of the crystals. "Up" is toward the left.

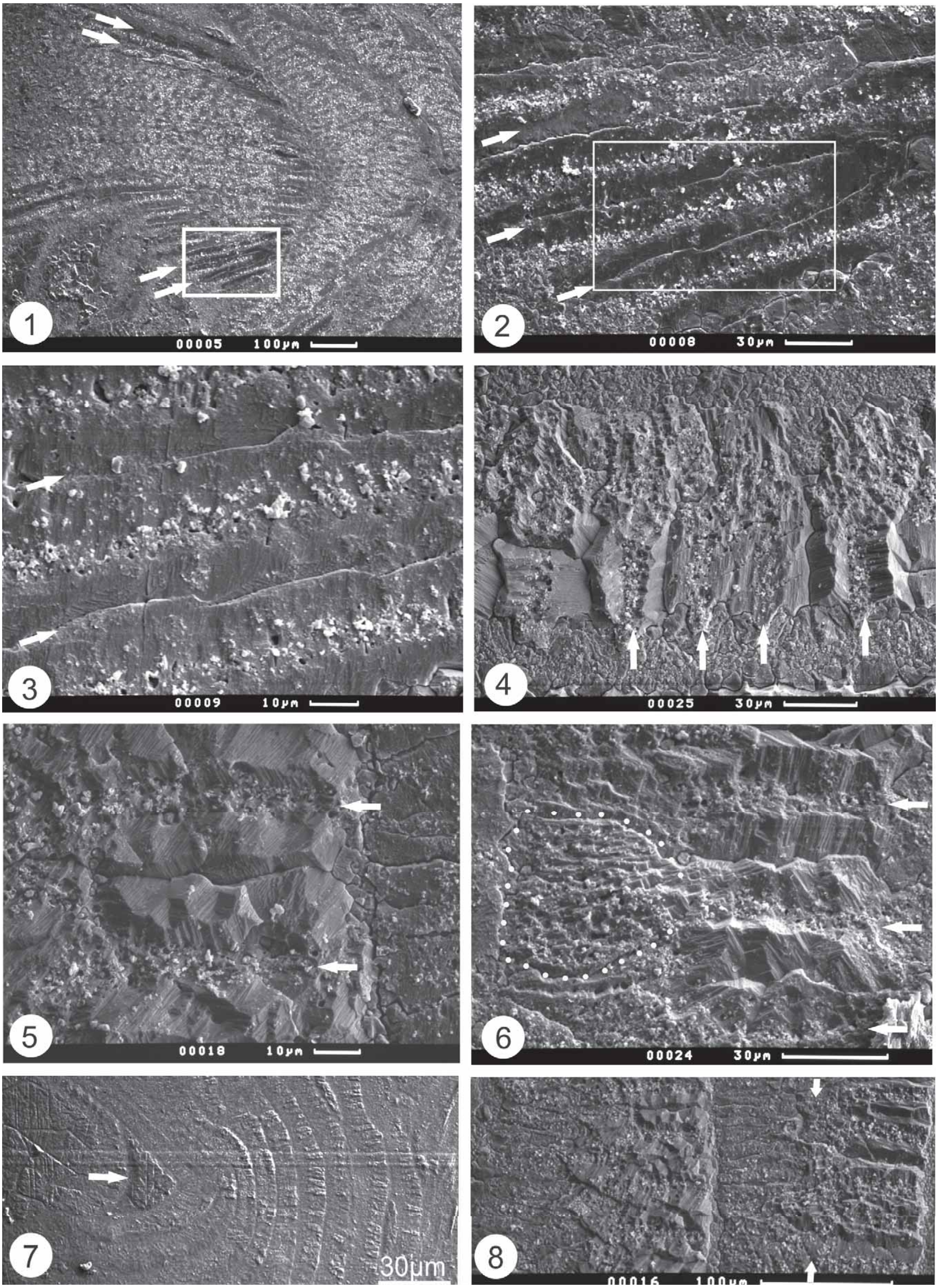
4 Magnification from fig. 7 showing the laterals with large crystals. Arrows indicate the wall of laterals branching to the tubes of the second layer. "Up" is toward the left.

5 Similar to fig. 3. "Up" is toward the left.

6 The interior of laterals is characterized by large crystals and the walls (arrows) by microgranular structure. The area within the dots points to the tubes of the second layer that originated from one lateral. "Up" is toward the left.

7 SEM-view of alternating laterals (large crystals) and tubes of the second layer (small crystals). Arrow indicates the last whorl filled with calcite cement. "Up" is toward the left.

8 Alternation of laterals and tubes of second layer. Arrows indicate their boundaries. "Up" is toward the left.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00005 100µm
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6
00024 30µm
7
30µm
8
00016 100µm

Girvanella-like tube layer originates (Pl. 3, Fig. 4; Pl. 5, Figs. 5, 8; Pl. 6, Figs. 4, 7; Fig. 8). The edges of the last whorl in some specimens are connected by a layer of tubes, forming a lid (appearing as a bridge between the edges) covering the top of the whorl (Pl. 3, Fig. 4; Pl. 4, Fig. 2; Pl. 6, Figs. 8–9; Figs. 9–10). Apparently the repetitive settlement of the alga results from these tube layers originating from the edges or lids of the last whorl. In most cases one or several calcite-filled cavities were observed within the clusters of the "chaotic" *Girvanella*-like tubes (Pl. 5, Fig. 8). Interpretation of these cavities as conceptacles is very speculative.

The most peculiar part of this alga is the axial stem connecting the whorls of the thallus (Pl. 4, Figs. 1–2, 5; Pl. 5, Fig. 3; Pl. 6, Figs. 1–6, 10–11, 13). The axial stem is very narrow (less than 1 mm; usually 0.40–0.80 mm). Numerous sections show that the axial stem is a part of this alga and can not be interpreted as a boring or as an interaction between the alga and another organism (symbiosis or commensalism; like a worm, etc.). The following criteria support this interpretation: **a**) the axial stem is always in the centre of the whorls and the whorls are arranged symmetrically around it; **b**) the cements of the axial stem continue into the whorls and there is no recognizable boundary between them (Pl. 6, Figs. 3–6, 11–13); **c**) the laterals of the last whorl originated from the branching of the axial stem and the axial stem does not possess its own wall (Pl. 6, Figs. 2–3, 4–5, 10–13); **d**) the axial stem never steps out over the last whorl.

The **holotype** (Pl. 4, Fig. 1) exhibits numerous bowl- to V-shaped whorls in longitudinal section, showing only some of the characteristics of *Izmirella cretacea* summarized from the paratypes. The holotype is composed of at least 20 whorls. The axial stem is cut through several whorls. A reconstruction of a half-whorl of *Izmirella cretacea* nov. gen., nov. sp. is given in Fig. 6.

Rejuvenation of the thalli usually takes place at the boundary between two laminae (Pl. 2, Figs. 1–2; Pl. 3, Figs. 2, 4, Pl. 4, Fig.4). This boundary is marked by a dark horizon where individual whorls, at the base of the thalli, are usually developed as a soup-plate pile arranged densely one above the other.

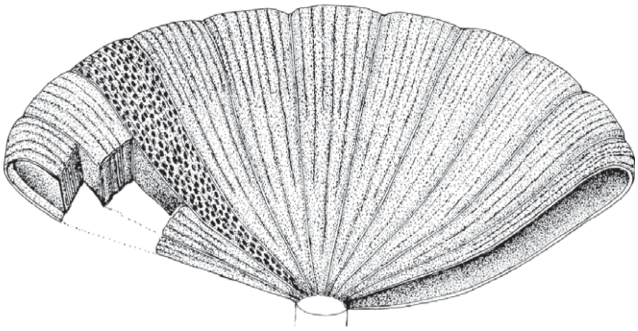

Figure 6: Reconstruction of a half whorl of *Izmirella cretacea* nov. gen., nov. sp. showing the radially arranged "laterals" that are subdivided internally and peripherally to laterals of the second and higher orders (compare also Fig. 7). From the pores of the upper surface (shown in third lateral from left) open into the cross-sections of "tubes of the second layer" which are oriented perpendicular to the laterals of first and higher orders. Schematic, not to scale.

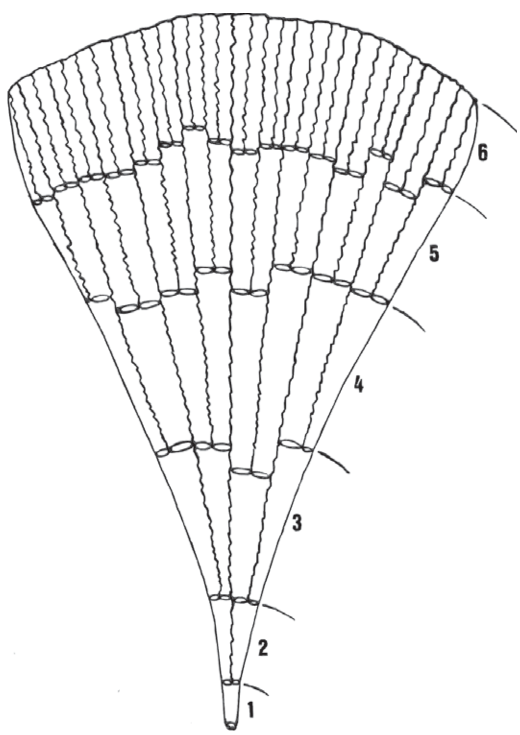

Figure 7: The branching pattern of the laterals of the first, second and further orders (6 orders, see numbers) of the whorls. The branching doesn't occur at exactly the same level. The wall between the tubes is zig-zag-like (wavy). Schematic, not to scale.

3. DISCUSSION

Izmirella cretacea nov. gen., nov. sp. is a representative of fossil plants, most probably algae. However, because of the totally different characteristics, its systematic classification within the known groups of algae is uncertain.

In longitudinal sections, (parallel sections to the growth direction), through the thalli of *Izmirella*-buildups, the individual laterals appears as cell rows, resembling some red algae (Rhodophycea) with "large cells", e. g. representatives of the genus *Lithoporella* (FOSLIE) or *Titanoderma* NÄGELI (compare WRAY, 1977, fig. 58; RASSER, 1994; PILLER & RASSER, 1999). *Izmirella* may be ascribed to such algae if its thallus is fractured (Pl. 5, Fig. 6). In thin-sections of *Izmirella*, the "large-cell"-like structures (similar to *Lithoporella*), are in reality the radially arranged (similar to representatives of Modern Acetabulariaceae) "laterals" cut in cross section. Cells with different sizes and arrangement may occur in some red algae, e. g. in crustose coralline red algae *Phymatolithon calcareum* and *Lithothamnium coralloides* (ADEY & MCKIBBIN, 1970) or in recent genus *Tenarea* (WRAY, 1977, fig. 54). Laterals in *Izmirella* are, however, segments that are arranged as in the cups of Recent dasycladales *Acetabularia* – radially around the axial stem, which is not known from red algae.

The radially arranged "laterals" and the axial stem connecting the successive whorls is a common feature of the Dasycladales, family Acetabulariaceae (see BERGER & KAEVER, 1992). In this group, individuals are usually isolated; the gregarious potential and the ability to build small bioherms, as in *Izmirella* are very rare in the fossil record. *Neo-*

Figure 8: Redrawn from Pl. 3, Fig. 7 (quadrangle) showing the edge of a trumpet-like broadened lateral, from which the tubes of the second layer originate.

teutloporella BASSOULETT et. al. is the only representative (BASSOULETT et. al., 1978) of gregarious (numerous thalli growing one beside the other) dasycladales occuring in the Oxfordian–Tithonian according to GRANIER & DELOFFRE (1993) or Oxfordian–Berriasian according to SCHLAGINTWEIT & EBLI (1999). For instance in the Upper Jurassic reef facies of Sicily, this alga is very abundant in nodular microbioherms up to 30 cm in diameter (SENOWBARI-DARYAN et al., 1994).

The following features might support the affiliation of *Izmirella* to the Dasycladales:

a) Each thallus possesses an axial stem which passes through the individual whorls (Pl. 4, Figs. 1–2, 5; Pl. 5, Fig. 3; Pl. 6, Figs. 1–6, 13). The axial stem with a diameter of 40–80 μm, however, is extremely narrow to bear the weight of laterals with a diameter of about 3 mm, but the Recent *Acetabularia* also possesses a narrow stalk. It may be assumed that the arrangement of the thalli in rows and their growth strategy in *Izmirella*, i. e. one beside the other, could help to support the individual thalli in growth position.

b) The arrangement of the "laterals" is comparable with the rays (laterals) from caps of Recent *Acetabularia*, *Polyphysa* or *Chalmasia*, radiating around the axial stem (see BERGER & KAEVER 1992, figs. 3.56, 3.81, 3.91),

c) The segments, i.e. whorls, are arranged vertically around the axial stem, one above the other.

d) The microbioherms are composed of individual stacked thalli of *Izmirella*.

Notwithstanding these apparent similarities, the verticillate organisation of the whorls around the axial stem and the septate nature of the laterals, do not conform to the features of the Dasycladales (BERGER & KAEVER, 1992). The following features of *Izmirella* argue against its assignment to Dasycladales:

a) Calcite mineralogy of skeleton: The primary skeletal mineralogy of the Dasycladales is aragonite; primary calcite in Dasycladales is extremely rare. Minor amounts of calcite do occur in some Dasycladales e. g. in *Bornetella* (FLAJS, 1977), and the membranes around the laterals of *Clypeina jurassica* (FAVRE) are composed of Mg-calite (CONRAD & VAROL, 1990). Similarly, the sporangia within the axial stem in *Diplopora iranica* (SENOWBARI-DARYAN & HAMEDANI, 2000) were primary Mg-calcite, but a primary Mg-calcite mineralogy for the thallus of Dasycladales is not known. The systematic position of some dasyclad type organisms, e. g. Palaeozoic *Psedovermiporella* ELLIOT, as Dasycladales is uncertain (FLÜGEL, 2004). Therefore, the primary calcite mineralogy of *Izmirella* does not support its classification as a dasycladalean.

b) The branching pattern of the "tubes of the second layer" is similar to porostromate cyanophyceans like *Cayeuxia*, *Hedstroemia* or *Halysis* mentioned above. However, such structures, originating from the radially arranged laterals around the axial stem, are not known from the Dasycladales. Ramification of laterals to a higher order and the formation of the "chaotic tube" in *Izmirella* are not characteristic for Acetabulariaceae. Gametangia, occurring in the laterals of e. g. *Acetabularia*, have not been observed in the laterals of *Izmirella*.

c) Also the "chaotic" (*Girvanella*-like) tube layer between the individual thalli of *Izmirella* rows does not support its interpretation as a Dasycladacean.

An alternative classification to the Dasycladales might be the red algae. Actually a placement of *Izmirella* in the Peyssonneliacea could be envisaged. In this view the "stacked superimposed whorls" might be interpreted as lamellar thalli growing on some non-calcified erect filaments (= "axial stem");

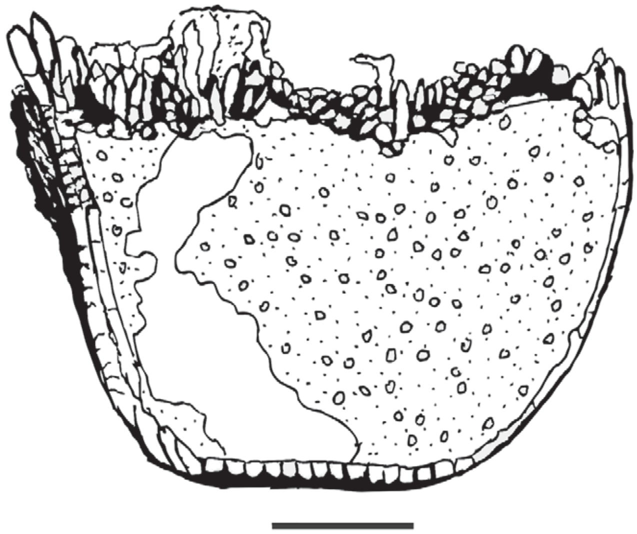

Figure 9: Section through the last cup of specimen illustrated in Pl. 6, Fig. 8 showing the large "cells" of the laterals, numerous tubes of the lid (appearing as bridge between the edges of the cup), micritic filling within the bowl (dotted area) and the small spherical elements (gametangia?) within the micritic filling. The white area within the micritic filling is sparry calcite cement.

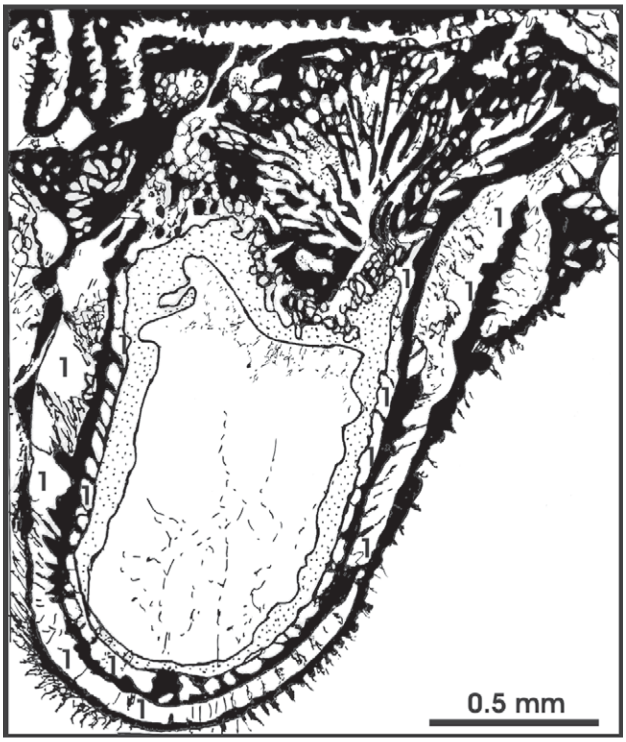

Figure 10: Section through two cups exhibiting the laterals (1) and the tubes of second layers (appearing dark between the laterals). The inside of the cup is covered with a thin micritic layer (dotted area). The white area in the centre of the cup is sparry calcite cement. Between the edges of the cup the bridge-like appearing tubes (lid) are developed, from which the "new" and multibranched laterals originated (rejuvenation). Redrawn from specimen illustrated in Pl. 3, Fig. 4.

this peculiar mode of life may be reflected by the wavy "bowl-shaped" aspect. Nevertheless, this hypothesis looks inadequate if one considers the absence of a well-defined cellular network with a hypothallus and perithallus (DENIZOT, 1968) which typifies the Peyssonneliacea.

The cell-like structure (oval or rectangular) of the laterals in sections directly around the axial stem (Pl. 4, Figs. 3, 6; Pl. 5, Figs. 1–4; Pl. 7, Figs. 2, 5, 8), also are similar to some red algae (e. g. *Lithoporella*, see WRAY, 1977, fig. 56), but they are tube-like in *Izmirella*. Different cell sizes, developed as two tube layers of *Izmirella*, is known from other red algae, e. g. in the crustose coralline red algae *Phymatolithon calcareum* and *Lithothamnium coralloides* (ADEY & MC KIBBIN, 1970). The cells are significantly elongated during winter growth. Also the mineralogy of the cells (i. e. content of Mg) in modern calcareous red algae varies from summer to winter (MILLIMAN et al., 1971; KOLESAR, 1978). Seasonal cell sizes and variation in Mg-content in calcite of the cell walls is also known from fossil solenoporacean algae (WRIGHT, 1985; WENDT, 1993). The different cell sizes, and possibly different content of Mg in the cell wall of laterals and "tubes of the second layer" in *Izmirella* could also reflect seasonal variation, but these features do not justify classifying *Izmirella* as a solenoporacean red algae.

The fan-like branching pattern of the first order of tubes and of the "chaotic" tube layer of *Izmirella* could support its attribution to the cyanophyceans. Such branching patterns of cells is common in cyanophyceans, but the axial stem of *Izmirella* and the arrangement of laterals around the axial stem are features contrary to the affiliation of *Izmirella* with this group.

Izmirella nov. gen. is surely an alga but its taxonomic position within the algae remain uncertain.

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