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CARBONIFEROUS CORALS AND CHAETETIDS FROM EXOTIC LIMESTONE BLOCK OF THE CRIMEA

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Abstract. A chaetetid sponge and coral fauna from a Carboniferous exotic limestone block in the Lower Jurassic Esciorda olistostrome on the Bodrak River (Crimean Mountains) are described for the first time. The Bodrak exotic block is composed of massive limestone. It contains the chaetetid *Chaetetes (Boswellia)* sp., the tabulate coral *Multithecopora* sp., and poorly preserved rugose corals, including *Dibunophyllum*? sp., *Cordibia*? sp. and Gen. et sp. indet. Only the fasciculate colonies of the rugose coral *Lytvophyllum askynensis* (Kossovaya, 2009) are confidently identified. The studied association of fossils is similar to that of the Donets Basin and the Urals and confirms the Lower Bashkirian age of the Bodrak limestone block.

Introduction

In situ Carboniferous deposits in the Crimean Mountains are unknown. However pebbles, boulders and so-called exotic (rootless) blocks (olistoliths) of Carboniferous age have been known to occur in Mesozoic flysch of the Taurida Series for many years (Einor & Vdovenko 1959; Mileev et al. 1989; Vdovenko 2013).

Geological setting and research history

One of the largest and the most famous olistolith is located on the right bank of the Bodrak River (southern outskirts of Trudolyubivka village) (Fig. 1). It was discovered in 1912 by Malysheva & Neiman (1913) and was later briefly described by Toumanskaya (1925, 1931, 1951). Clarification of the structure, age and genesis of the Bodrak exotic block is of great significance for the proper understanding of the geological structure and fundamental features of the geological history of the Crimean Mountains. Therefore the Bodrak block is a unique geological site and its conservation is of a great scientific and informative value. The origin of the Bodrak limestone block as well as other blocks, have been explained by Kotlyar et al. (1999).

The olistolith described here is located on a steep wooded slope and consists of two parts directly in contact with each other. The first part has a round shape in a plan view. Its length is 30 m, width is 25 m, and height is 10-12 m. The second part stretches down the hill to the northwest and has a length of 75 m and a width of 25 m. Both blocks are composed of light gray cryptocrystalline, massive limestones with brecciated areas. The rocks are penetrated by numerous calcite veins; occasional small fluorite crystals occur. Weakly developed bedding is observed in the massive limestones in the top of olistolith (Fig. 2A). In the southern part of the exotic block, the limestone beds dip to the south (23-25°); in the west and north parts of it they dip steeply (70°) to the northwest.

At the foot of the slope in which the olistolith is located, coarse-grained clastic rocks crop out. They belong to the Eskiorda olistostrome of Taurida Series (Lower Jurassic). Direct contact of the limestone olistolith and surrounding rocks is not exposed. These limestones have a clotted peloidal fabric (Fig. 2B). The limestone contains numerous fossils (foraminifera, corals, chaetetids, brachiopods, crinoids, algae, conodonts). Toumanskaya (1925, 1951) discovered the Lower Carboniferous fauna which included solitary and colonial corals, chaetetids, and brachiopods. Afterwards Miklukho-Maklay & Porshnyakov (1954) and Einor & Vdovenko (1959) investigated the fossils and determined the

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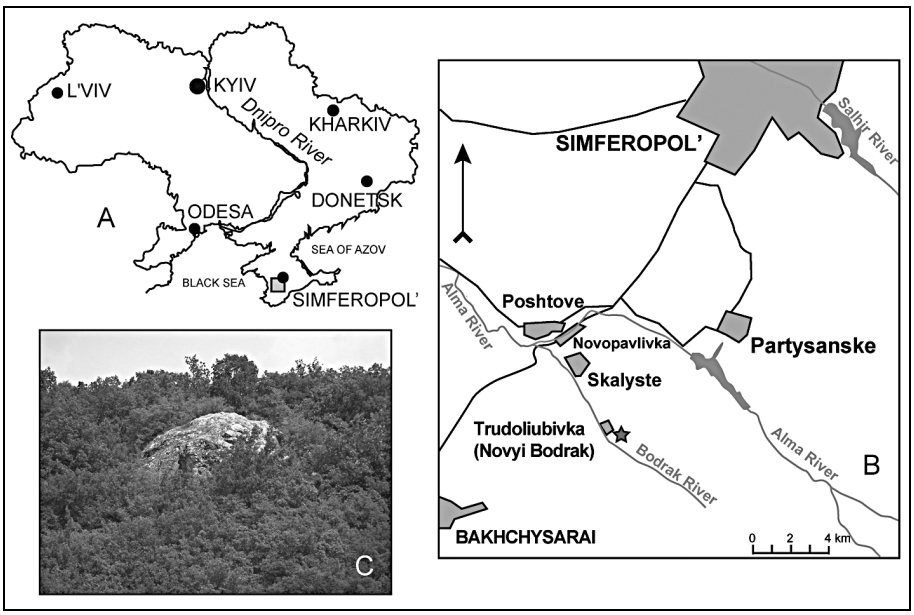

Fig. 1 - A) General map of Ukraine showing position of the study area. B) Location map of the study area (asterisk indicating location of the Carboniferous exotic block). C) General view of the Bodrak block.

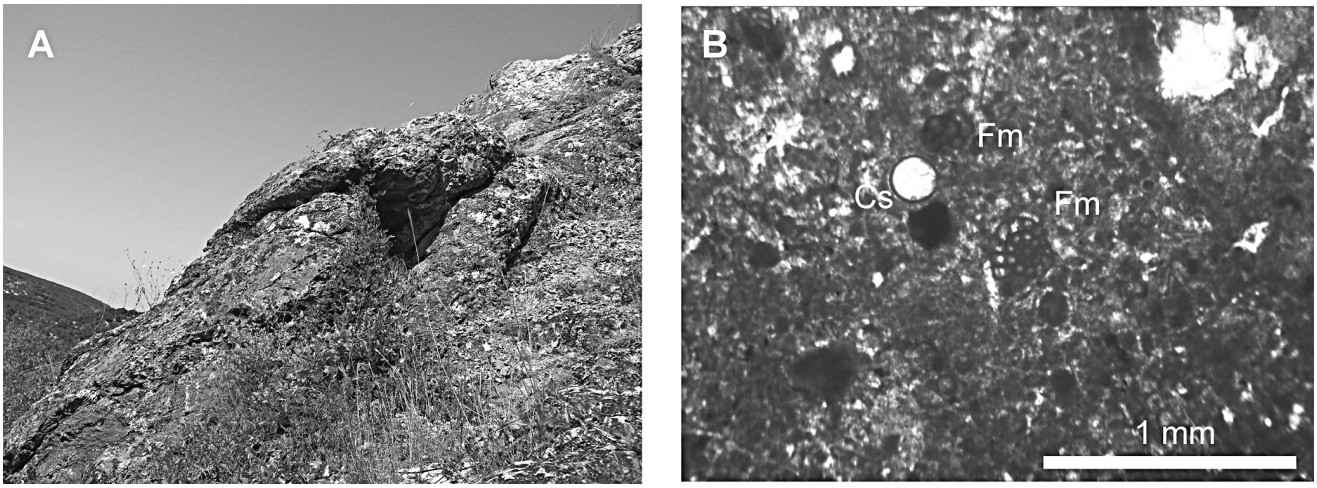

Fig. 2 - A) Massive Carboniferous limestone. B) Texture of limestone: clotted peloidal fabric (Cs - calcisphere, Fm – foraminifers).

age of the Bodrak block limestone using foraminifera fauna to range from the Upper Visean to Bashkirian. In our opinion the most precise age of the Bodrak limestone was obtained by Mileev (Mileev et al. 1989) based on the presence of the alga *Donezella*, and the conodont *Declinognathodus noduliferous* (Ellison & Graves) determined by Vorontsova (in Mileev et al. 1989: 6). This conodont species clearly indicates a Bashkirian age of the limestone.

Toumanskaya collected several coral specimens from the Bodrak block and delivered them to Fomichev for identification. His preliminary identifications (*Yuanophyllum irregulare* Fomichev, *Lithostrotion baschkiricum* Perna) were published by Toumanskaya (1951), but were never mentioned by Fomichev in his publications. Since 1951 the list of these species passed from one publication to another without any changes. Einor & Vdovenko (1959) indicated the presence of the tabulate coral *Syringopora*. It should be mentioned that no images of the corals, the chaetetids or the other fossils from the Bodrak Block have been published. Thus, the present paper includes the first illustrated descriptions of the Rugosa, Tabulata and Chaetetida collected from the Bodrak Block.

Material

Since 2005, the authors have been collecting corals and chaetetids from the Bodrak block. Two beds rich in poorly preserved colonial and solitary rugose corals as well as tabulate corals were found in its southern part. Many corals and chaetetids were found as scattered fragments. These fossils are mainly poorly preserved, being intensely deformed and crushed. Therefore only about two dozen samples from the whole collection are useful for identification. Rugose corals and chaetetids were studied by Ogar, tabulate corals by Klevtsovskyi. The collection is housed in Museum of Paleontology of Taras Shevchenko University of Kyiv (Acronym TSNUK 2P264/CR).

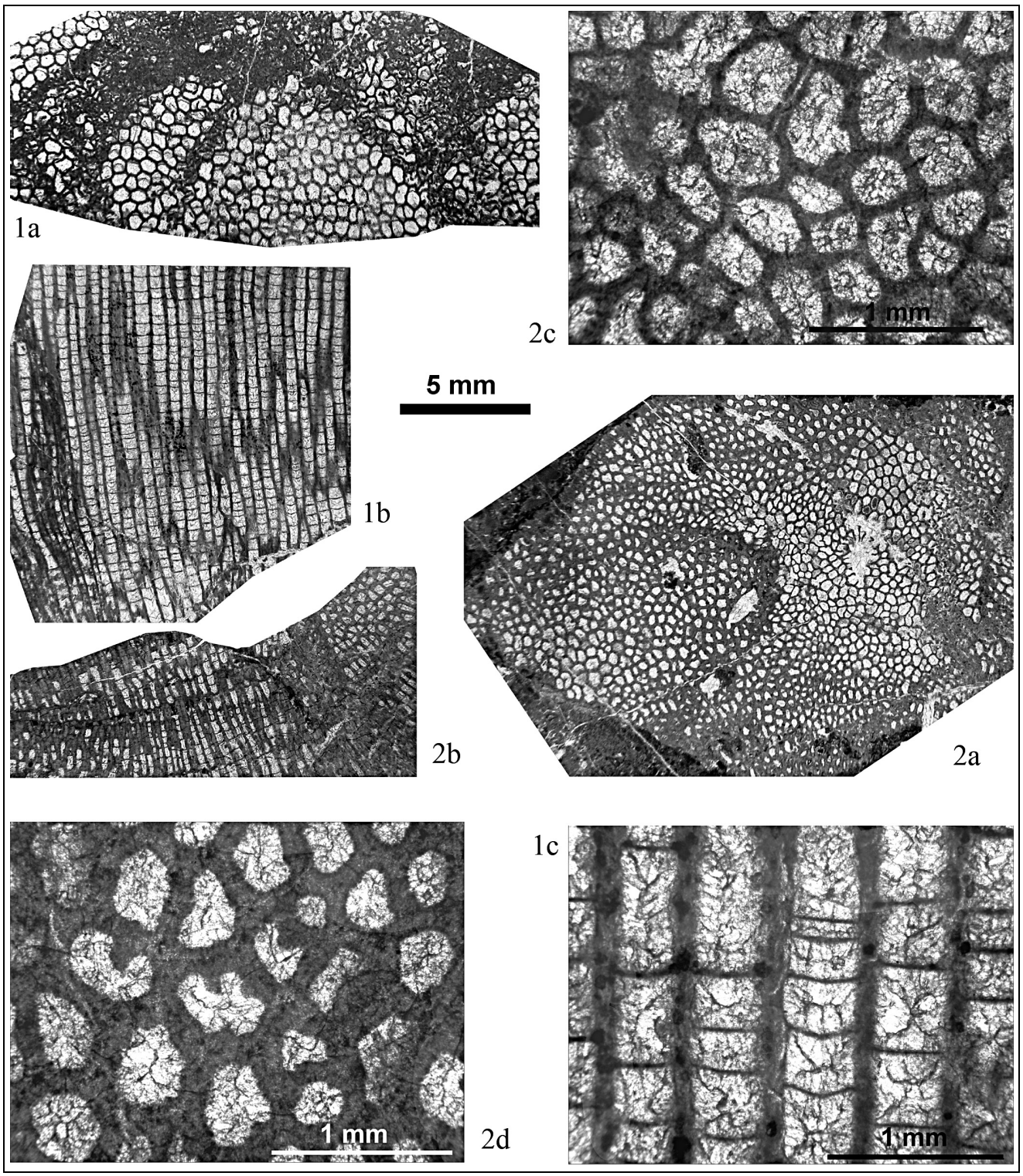

PLATE 1

Chaetetes (Boswellia) sp.
Fig. 1) Specimen TSNUK 3P264/CR1; a- transverse section of the colony; b- longitudinal section; c- detail of the longitudinal section illustrating slightly concave tabulae. Fig. 2) Specimen 3P264/CR4; a- transverse section; b- longitudinal section; c, d- detail of the transverse sections showing different areas of the colony with relatively thin (c) and thicken walls (d).

Systematic Palaeontology

Phylum **Porifera** Grant, 1836

Class **Sclerospongiae** Hartman & Goreau, 1970

Order **Chaetetida** Okulitch, 1936

Family Chaetetidae Milne-Edwards & Haime, 1850, emend Sokolov, 1939

Subfamily Chaetetinae Milne-Edwards & Haime, 1850

Genus *Chaetetes* Fischer von Waldheim, 1829

Subgenus *Boswellia* Sokolov, 1939

Type species: *Chaetetes (Boswellia) boswelli* Heritsch, 1932, 'Upper *Dibunophyllum* Zone (D_2)' of Ivovik, Serbia.

Diagnosis: "Chaetetids with thickened irregular walls and rounded corners to lumina that may be either irregular or subpolygonal. Increase by pseudoseptal and basal fission. Incomplete fission and separation of pseudosepta into isolated columns occurs locally. Fascicular fibrous walls. Complete tabulae, variable in distribution. Intramural spicules (originally siliceous) present in some". After Grey (1980: 806).

Remarks. Grey (1980) established the presence of the intramural spicules in the species *Chaetetes (Boswellia) mortoni* Grey, 1980. Consequently, diagnosis of the subgenus *Chaetetes (Boswellia)* formulated by Grey differs from traditional diagnosis by Sokolov (1939).

Chaetetes (Boswellia) sp.

Pl. 1

Material: Four fragments of colonies (TSNUK 2P264/CR1-4); eight thin sections.

Description. Hemispherical colonies typical for the genus *Chaetetes*. They have areas composed of calices, sharply differentiated by size and shape. Size of areas about 1 cm. Some areas consist of sub-polygonal (sub-hexagonal) calices with relatively thin walls (0.06 - 0.1 mm). Maximum thickening of walls observed in corners of calices (0.15-0.19 mm). Calices of other areas have thick walls and rounded lumina almost losing their polygonal shape. Lumina diameters range from 0.2 to 0.5 mm, usually 0.4-0.45 mm. Pseudosepta frequently appear in thick-walled calices, one to three per transverse section. Tabulae slightly curved downwards, 3-4 unevenly spaced tabulae per vertical millimeter with a minimum distance of 0.12 mm, (maximum - 0.9 mm) between them. Spicules not visible.

Remarks. An important feature of the described specimens is the significant difference in wall thickness of the calicles, which distinguishes them from similar species. This wall thickness is characteristic of subgenus *Boswellia*. A similar subspecies, *Chaetetes (Boswellia) boswelli minor* Sokolov, 1950b from the Namurian of the Lugansk region (Ukraine), differs in its largest calice diameter is 0.55-0.6 mm. The Uralian species *Chaetetes (Boswellia) baschkiricus* Katchanov, 1973, from the Lower Bashkirian, has larger calices (0.45-0.65 mm). *Chaetetes (Boswellia) abnormis* Katchanov, 1973, is similar to the previous species in diameter (0.5 mm), but differs by having frequent pseudosepta and calices with a meandrine form. Similar calicles are also typical for *Chaetetes (Boswellia) contractus* Spiro, 1961, from the Mikhailovsky horizon (Visean) of Tula region (Russia).

Phylum **Coelenterata** Frey & Leuckart, 1847

Class **Anthozoa** Ehrenberg, 1834

Subclass **Tabulata** Milne-Edwards & Haime, 1850

Order **Syringoporacea** Sokolov, 1947

Family Multithecoporidae Sokolov, 1950a

Genus *Multithecopora* Yoh, 1927

Type species: *Multithecopora penchiensis,* Yoh 1927

Diagnosis: See Tchudinova (1986: 169).

Remarks. The most typical characters of the genus *Multithecopora* are: very thick concentrated walls, distant connecting tubes, strongly contracted visceral chamber, irregularly distributed and distally concave tabulae.

Multithecopora sp.

Pl. 2

Material: One small colony (TSNUK 2P264/CR5) and five poorly preserved fragments of other colonies (TSNUK 2P264/CR6-10). Fifteen thin sections.

Description. Small probably phaceloid to bushy colonies, composed of cylindrical, slightly bent corallites, irregularly spaced every 0.3-2.5 mm, most commonly 0.5-1.5 mm. Corallites round or suboval in transverse sections, 1.4-2.2 mm in diameter, most commonly 1.5-1.8 mm. Corallite walls 0.4-0.7 mm thick, but generally 0.45-0.65 mm. Epitheca faint, smooth, fibrous, approximately 0.03-0.04 mm thick. Corallite walls consist of multiple alternations of fibrous and lamellar layers (Pl. 2, fig. 2d).

In less densely-packed colonies, the total number of layers decreases whereas diameter and wall thickness remain approximately constant. Rare conspicuous septal spines arise from external (fibrous) layer. Occurrences of septal projections make sclerenchyma slightly undulate. Lumen of visceral chamber is round, oval, rarely irregular, approximately 0.4-0.6 mm thick, i.e. about 1/3-1/4 corallite diameter. Tabulae are rare, complete, concave (Pl. 2, fig.2c), generally grouped in small assemblages but absent in most corallites. Connecting tubes not observed. Increase lateral (Pl. 2, fig.2b).

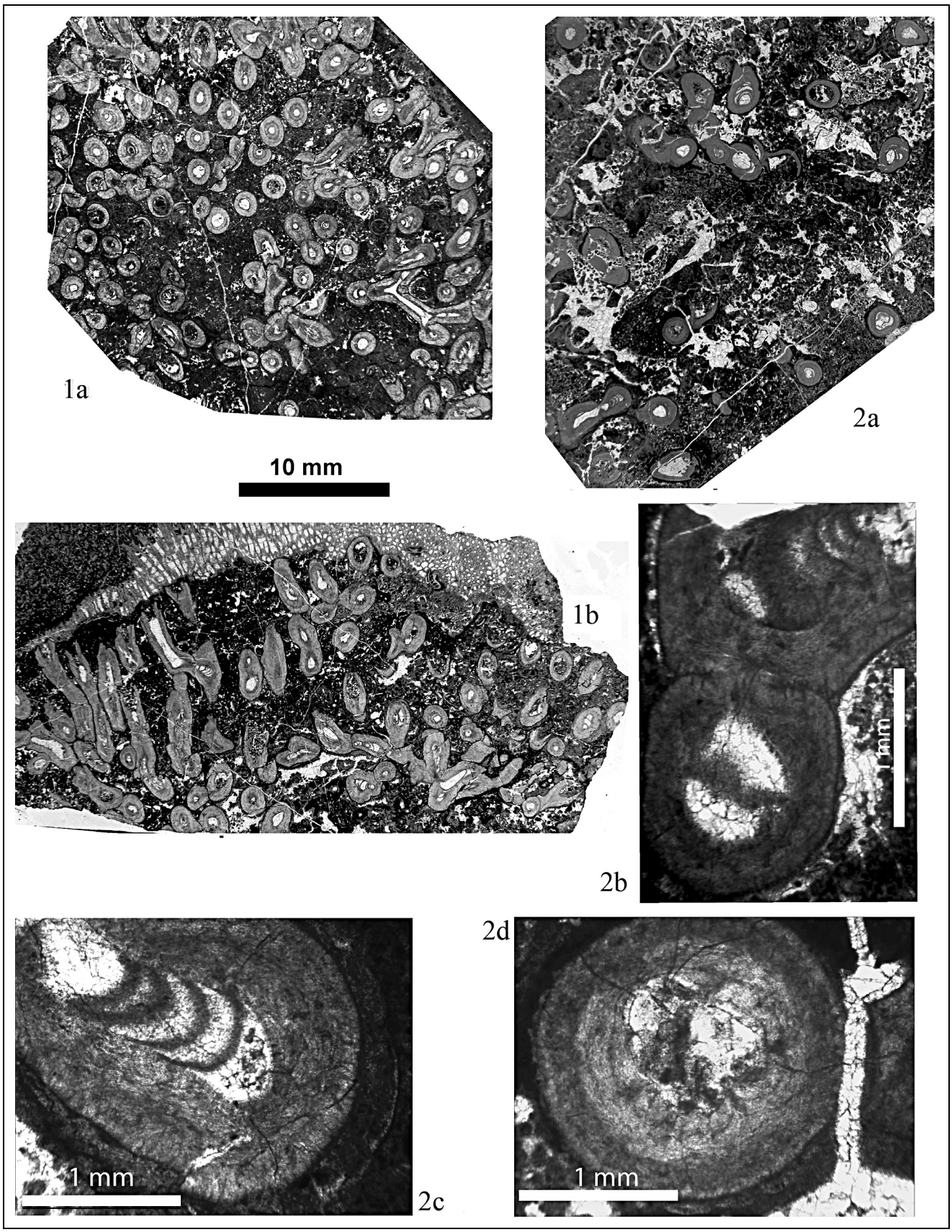

PLATE 2

Multithecopora sp.

Fig. 1) Specimen TSNUK 3P264/CR5; a- transverse sections of colony; b- longitudinal section. Fig. 2) Specimen TSNUK 3P264/CR6; a- sections through fragmented corallites; b-d- details of transverse sections illustrating hystero-neanic stage of lateral increase (b); concave tabulae (c); microstructure of the wall and presence of septal spines (d).

Remarks. Corallite walls of *Multithecopora* specimens commonly consist of three layers. *Multithecopora* sp. differs from them as it has five layers. This species is similar to *Multithecopora* sp. D., from Carboniferous deposits of the Iberian Peninsula (Coronado & Rodríguez 2014) but differs mainly form the Ukrainian specimens by its slightly smaller diameter and a thinner wall.

Subclass **Rugosa** Milne-Edwards & Haime, 1850

Order **Stauriida** Verrill, 1865

Family Aulophyllidae Dybowski, 1873

Subfamily Dibunophyllinae Wang, 1950

Genus *Dibunophyllum* Thomson & Nicholson, 1876

Type species: *Dibunophyllum muirheadi* Thomson & Nicholson, 1876, p, 462; Upper Visean of the British Isles.

Diagnosis: See Fedorowski (2004: 104).

Dibunophyllum? sp.

Pl. 3, figs 1, 2

Material: Two fragments of coral (TSNUK 2P264/CR11, 12), five thin sections and four acetate peels.

Description. Conjectural solitary corals of medium size with thin external wall. Major septa long, few of them reaching the axial structure. Minor septa not developed or restricted to the outermost part of the dissepimentarium. Cardinal and counter septa long, fusing in a central spindle-shaped axial structure in sections with larger diameters (Pl. 3, fig. 1b; 2). Cardinal-lateral septa slightly shortened. Corallite diameter on septal number ratio: 5 mm - 21-22; 7.5-8 mm - 27; 10 mm - 30. Septa thin in the dissepimentarium and somewhat thickened in the tabularium. Dissepitheca present. Dissepimentarium narrow, about 1.5 mm-wide at corallite diameter of 10 mm. At this diameter, it consists of three rows of dissepiments, rectangular near external wall and herringbone in inner zone (Pl. 3, fig. 1c). Spindle-shaped axial structure connected to the axial end of some major septa in section larger than 6 mm in diameter. Tabulae convex, downturn near the dissepimentarium and flat in the central part.

Remarks. We consider described specimens as immature growth stages of *Dibunophyllum.* This assignment is suggested by both the axial structure based on the cardinal septum (Pl. 3, fig.1b), and by the symmetry in the arrangement of the major septa. *Dibunophyllum*? sp. is most similar to *Dibunophyllum yui* Chi, 1931 from the Middle Carboniferous of China (Chi 1931: p. 39, pl. 4, fig. 7). However, a comparison is difficult because the holotype of the Chinese species is represented only by a mature growth stage. Numerous species of '*Dibunophyllum*' from the Pennsylvanian of Kansas (Cocke 1970) are probably only homeomorphically similar to *Dibunophyllum*. They differ from our specimens significantly in development of minor septa.

Genus *Cordibia* Fedorowski & Ogar, 2013

Type species. *Cordibia pumila* Fedorowski & Ogar, 2013; Lower Bashkirian (Limstones E_1^{up} and E_1^{1}, Lower *Reticuloceras-Bashcortoceras* Zone) of the Donets Basin, Ukraine.

Diagnosis: See Fedorowski & Ogar (2013: 302).

Cordibia? sp.

Pl. 3, figs 3-5

Material: Four deformed fragments of coral (TSNUK 2P264/CR13-16), poorly preserved, five thin sections.

Description. Clusters of deformed corallite fragments. Habitus of corallum unidentified. Surface of corallites marked by thin growth striae. Corallites diameters 8-10 mm. At diameter of about 8 mm number of septa about 22-24× 2. Major septa long, several commonly connected with axial lamella. Minor septa about one-third length of major septa, penetrate tabularium. Septa thin in dissepimentarium, slightly thickened in tabularium. Dissepitheca developed. Axial structure consists of long median plate approximately twice its width (about 1 mm), 4-5 septal lamellae and 4-5 axial tabellae. Microstructure of septa and median plate probably trabecular (Pl. 3, fig. 5). In transverse section the dissepimentarium consists of 3-4 rows of rectangular or irregular dissepiments (Pl. 3, fig. 3a, 3c). Tabulae incomplete, subhorizontal in periphery and adaxially elevated axial tabellae (Pl. 3, fig. 5).

Remarks. The present specimens are most similar to the type species, *Cordibia pumila* Fedorowski & Ogar, 2013, but the poor preservation of Crimean specimens and lack of sufficient evidence of protocolonial growth make their identification questionable.

Familiae incertae

Gen. et sp. indet.

Pl. 3, fig 6

Material: One corallite fragment (TSNUK 2P264-CR17), one transverse thin section.

Description. Cylindrical fragment with corallite diameter of 6 mm. Major septa about half the corallite radius. Habitus of corallum uncertain. Minor septa half as long as the major septa, penetrate the tabularium, occasionally interrupted in dissepimentarium. Axial structure simple, spindle-shaped, consists of thin median lamella, thickened by stereoplasma, dimensions 0.75

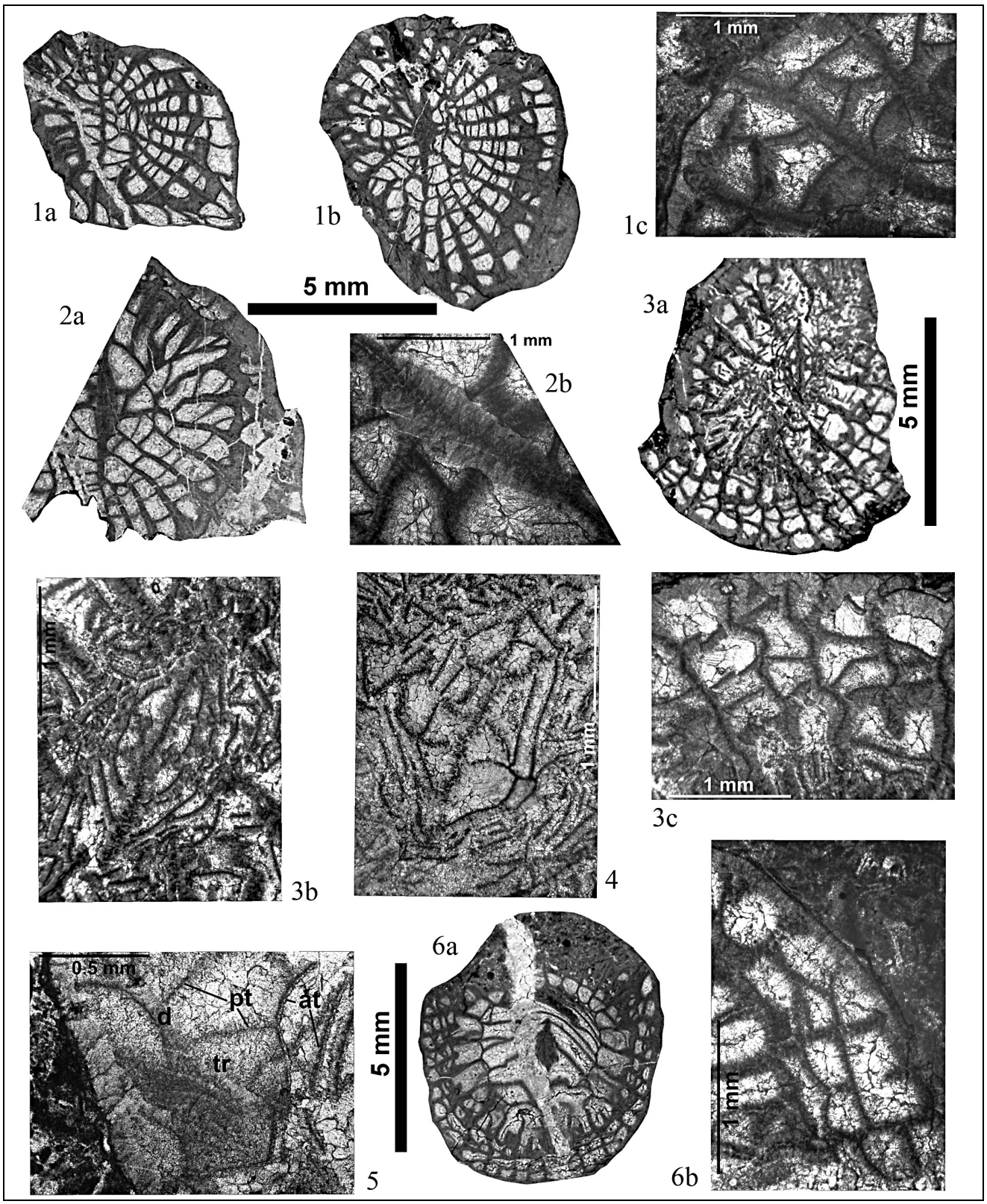

PLATE 3

Dibunophyllum? sp.

Fig. 1) Specimen TSNUK 3P264/CR; a, b- Transverse sections (cardinal septum towards the bottom); c- detail of the transverse section showing the dissepimentarium structure. Fig. 2) Specimen TSNUK 3P264/CR1; a- transverse section of the corallite fragment (cardinal septum towards the bottom); b- detail of the axial structure.

Cordibia? sp.

Fig. 3) Specimen TSNUK 3P264/CR13; a- transverse section; b- axial structure; c- detail of the dissepimentarium structure. Fig. 4) TSNUK 3P264/CR14; axial structure. Fig 5) Specimen TSNUK 3P264/CR15; longitudinal section (d- dissepiment, at- axial tabella, pt- peripheral tabellae, tr- remains of septal trabeculae). Gen. et sp. nov. Fig. 6) Specimen TSNUK 3P264/CR17; a- transverse section; b- detail of the transverse section illustrating interruption of the minor septa.

- 1.5 mm. Dissepimentarium narrow, about ¼ of the corallite radius, consists of 3 rows of mostly rectangular septa; lonsdaleoid dissepiments interrupt minor septa (Pl. 3, fig. 6b). Tabularium in two series, separated from dissepimentarium by thickened inner wall. Axial tabellae adaxially arched; peripheral tabellae downturn towards the dissipimentarium. Inner margins of major septa are connected to the intersections of tabulae and form inner tabularium.

Remarks. The Crimean specimen is the most similar to new genus A, new species B of Fedorowski (2009: p. 242, fig. 6A and written communication) from the Lower Bashkirian (Lower *Reticuloceras* Zone, Limestone E_1^{IV}) of the Donets Basin.

A similar species was described from the Bashkirian of the Urals as *'Lithostrotion' ineptum* by Gorsky (1978: p. 145-146, pl. 20, figs. 5, 5a). The main difference is the thick lenticular axial structure of the Crimean specimen. Uralian species are characterized by the presence of a thin discontinuous median lamella.

Family Petalaxidae Fomichev, 1953

Genus *Lytvophyllum* Dobrolyubova in Soshkina et al., 1941

Type species. *Thysanophyllum tschernovi* Soshkina, 1925; Lower Permian, Artinskian Stage; Urals, Lytva River.

Diagnosis: See Fedorowski et al. (2007: 153).

Remarks. Fedorowski et al. (2007: 152-158) has summarized the composition of the genus, relationships with similar genera, and the stratigraphic and geographic distribution of related species.

Lytvophyllum askynensis (Kossovaya, 2009)

Pl. 4

1975 *Lytvophyllum antiquum* (Gorsky) 1975 - Gosky: in Gorsky et al., p. 87, pl. 27, fig. 2.

1971 *Lytvophyllum dobrolyubovae* Vassilyuk - Katchanov, p. 69-72, pl. 2, fig 1, 2.

1973 *Lytvophyllum dobrolyubovae* Vassiluk - Katchanov, p. 86, pl. 20, figs. 6, 7.

Part 1978 *Lytvophyllum antiquum* Gorsky, p. 153-157, text. fig. 30; pl. XXI, figs. 3,4, 6-8; pl. XXII, fig. 6.

1979 *Lytvophyllum antiquum* Gorsky - Degtyarev, p. 51, pl. LII, figs. 1-2.

2009 ?*Pseudolytvophyllum askynensis* Kossovaya, p. 74-76, pl. I, figs. 1-7.

Holotype: Specimen 17-1 (fasciculate colony), Central Scientific Research Geological Museum (Saint-Petersburg, Russia); section Askyn, Gornaya Bashkiria, Akavassian Substage, Bashkirian Stage.

Diagnosis: See Kossovaya (2009: 74).

Material: Four fragments of colonies (TSNUK 2P264/CR18-21) with poorly preserved internal structure (deformed and crushed to various degrees), and a large number of broken fragments of corallites. Four transverse and one longitudinal thin sections.

Description. External wall is thin (0.08 mm), fibrous and bears growth striae. Corallite diameter 3.6 to 7 mm. Number of septa 14-20. Major septa up to 2/3 corallite radius in length. Septa occasionally interrupted by large lonsdaleoid dissepiments. Major septa thin in dissepimentarium, slightly thickened in tabularium. Minor septa very short, sub-triangular. Major and minor septa fused of their triangular basis near external wall. Median lamella derived from counter protoseptum, occasionally slightly thickened. Dissepimentarium consists of one row of thickened dissepiments. Tabularium composed of complete sub-horizontal tabulae about 1 mm apart. Lateral offset observed in one section.

Remarks. The Crimean specimens are morphologically very similar to *Lytvophyllum antiquum* Gorsky described from the Lower Bashkirian of Urals by Gorsky et al. (1975), Gorsky (1978) and Degtyarev (1979). This species name first appeared in the Atlas (Gorsky et al. 1975) with an erroneous indication of the number of the holotype; moreover, instead of the holotype a different specimen was illustrated. Later, the name *L. antiquum* was applied to an illustrated holotype not belonging to the genus *Lytvophyllum* (Fedorowski et al. 2007: 153; Kossovaya 2009: 71). Therefore, the name *antiquum* cannot be accepted as valid. We agree that this species should be assigned to ?*Pseudolytvophyllum askynensis* Kossovaya, 2009 (family uncertain). However, in our opinion it belongs to the genus *Lytvophyllum* Dobrolyubova, 1941 (in Soshkina et al. 1941), family Petalaxidae Fomichev, 1953. Relationships between genera *Pseudolytvophyllum* Yu & Wang, 1983 (in Yu et al. 1983) *and Lytvophyllum* Dobrolyubova, 1941 are described by Fedorowski et al. (2007: 151, 156).

According to Fedorowski et al. (2007) only a part of the coral fauna described by Vassilyuk (1960) from the Lower Bashkirian of the Donets Basin belongs to *Lytvophyllum.* The holotype of *Lytvophyllum dobrolyubovae* Vassilyuk (Vassilyuk 1960: pl. 26, figs.1, 1a) has more highly developed lonsdaleoid dissepiments interrupting septa in comparison with *Lytvophyllum askynensis*.

Specimens described by Katchanov (1971, 1973) as *Lytvophyllum dobrolyubovae* from the Bashkirian of the Urals do not differ significantly from *Lytvophyllum askynensis*.

It should be noted that *Lytvophyllum askynensis* is probably homeomorphic with the similar species *Lithostrotion (Siphonodendron) ignekensis* Armstrong (Armstrong 1972: p. A19, A20; pl. 5, figs. 1-5) from the Chester of Arctic Alaska. However, recent studies of *Schoenophyllum* Simpson, 1900 show not only homeomorphic similarities, but also genetic relationships of this genus with the family Petalaxidae Fomichev, 1953 (Rodríguez & Bamber 2010).

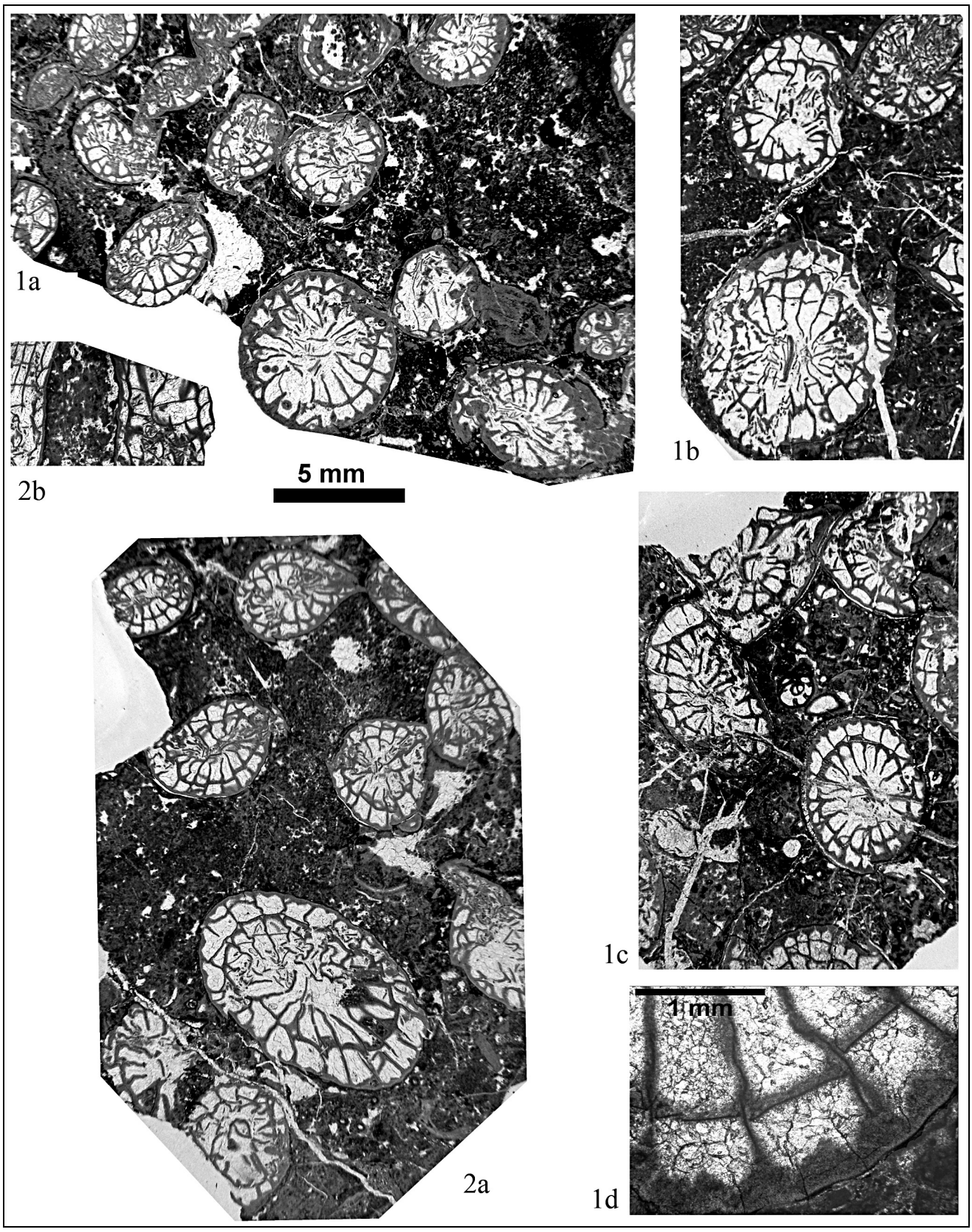

PLATE 4

Lytvophyllum askynensis (Kossovaya, 2009).
Fig. 1) Specimen TSNUK 3P264/CR18; a-c - transverse sections of the colony; d– detail of the corallite structure. Fig. 2) Specimen TSNUK 3P264/19; a- transverse sections of the colony; b- longitudinal section.

Stratigraphic and geographic range. Lower Bashkirian (Akavassian Substage) of Urals and lower Bashkirian of Crimea.

Conclusions

1. As mentioned above the studied material is very poorly preserved. Only one species is identified confidently; the other corals and the chaetetid are placed in open nomenclature. Nevertheless, this is the first description of corals and a chaetetid from the Carboniferous of Crimea, which have been known since the beginning of the last century.

2. The presence of *Lytvophyllum askynensis*, as well as *Cordibia*?, *Dibunophyllum*? and Gen. et sp. nov. allows comparison of the age of the Bodrak limestone with the Feninian regional substage of the Donets Basin and Akavassian Substage of the Southern Urals. This fact confirms the Lower Bashkirian age of the exotic block limestone, previously established using conodonts.

3. We assume the presence of the shallow basin with carbonate sedimentation, located in the northern part of the Paleotethys and connected to the Paleouralian Ocean during the Early Bashkirian near the present Crimea Mountain.

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