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LOWER VISÉAN (LOWER CARBONIFEROUS) RUGOSE CORALS FROM THE DONETS BASIN (UKRAINE)

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ABSTRACT – Rugose corals are described from the lower Viséan of the Donets Basin. The new coral Dorlodotidae fam. nov. and the species *Cyathoclisia sukhensis* sp. nov. are here introduced and the presence of the genera *Amygdalophyllum* and *Ceriodotia* are established for the first time in the Donets Basin. The priority of the generic name *Protolonsdaleia* over *Eolithostrotionella* is discussed. The lower Viséan rugose coral assemblage of the Donets Basin differs from those of the upper Tournaisian and upper Viséan. Global and regional events may have led to abrupt changes in sedimentation conditions at the end of the Tournaisian time and at the beginning of the late Viséan. The colonial rugose corals *Siphonodendron*, *Dorlodotia*, *Protolonsdaleia* and *Ceriodotia* appear in the early Viséan of the Donets Basin as in many other regions of Eurasia. The similarity of the lower Viséan coral assemblage of the Donets Basin with that of the Western Paleotethys is noted but at the same time, there are significant differences with the regions of the Eastern Paleotethys. This is due to the presence of a possible paleogeographic barrier located to the eastern part of Laurussia hindering the migration of corals.

Keywords: Mississippian, Viséan, corals, paleobiogeography, Ukraine.

RESUMO – São descritos corais rugosos do Viseano inferior da Bacia Donets. São aqui propostos Dorlodotidae fam. nov. e *Cyathoclisia sukhensis* sp. nov., assim como a presença dos gêneros *Amygdalophyllum* e *Ceriodotia* são estabelecidos pela primeira vez na Bacia Donets. A prioridade do nome genérico *Protolonsdaleia* sobre *Eolithostrotionella* é discutida. A associação de corais rugosos do Viseano inferior da Bacia Donets difere daqueles do Viseano superior e do Tournaisiano. Eventos, globais e regionais, podem ter levado a mudanças abruptas em condições de sedimentação no final do Tournaisiano e no início do Viseano superior. As colônias de corais rugosos *Siphonodendron*, *Dorlodotia*, *Protolonsdaleia* e *Ceriodotia* aparecem no início do Viseano da Bacia Donets como em muitas outras regiões da Eurásia. A similaridade da associação de coral do Viseano inferior da Bacia Donets com aquela do Paleotétis Ocidental é notada, mas ao mesmo tempo, há diferenças significantes com as regiões do Paleotétis Oriental. Isto é devido à presença de uma possível barreira paleogeográfica localizada na parte oriental da Laurússia dificultando a migração dos corais.

Palavras-chave: Mississippiano, Viseano, corais, paleobiogeografia, Ucrânia.

INTRODUCTION

The latest Tournaisian Avins event (Poty, 2007) caused a global rise in the sea level and recorded the appearance and rapid spread of early representatives of the genera *Paleosmilia* Milne-Edwards & Haime, 1848, *Merlewoodia* Pickett, 1967, *Amygdalophyllum* Dun & Benson, 1920 and *Clisiophyllum* Dana, 1846 that were to become typical for the Viséan. An equally sharp decrease in the sea level in the earliest Viséan (sequence 5 in Hance *et al*., 2001) resulted in the installation of paleobiogeographic barriers, and the appearance of endemic marine taxa in various regions following the isolation of individual basins.

After that episode of endemism, the early Viséan benthic fauna colonised vast carbonate shallow-water shelves all around the Paleotethys Ocean. These carbonate shelves now crop out among others in Eurasia in the Namur-Dinant Basin (*e.g.* Poty, 2016), the Precaspian Basin (Brenckle & Milkina, 2003), the Don-Dnieper Trough (covering the modern Dnieper-Donets Basin and Donets Basin, Aizenverg *et al*., 1975; Poletaev *et al*., 1990, 2011; Ogar, 2008a; Poletaev & Vdovenko, 2013), and South China (Feng *et al*., 1998), etc.

A significant increase in morphological and evolutionary trends occurred in the early Viséan, with the notable appearance of colonial rugose corals belonging to several lineages (*Dorlodotia* Salée, 1920, *Ceriodotia* Denayer, 2011, *Siphonodendron* McCoy, 1849, *Protolonsdaleia* Lissitzin, 1925 and *Vassiljukia* Denayer & Ogar, 2016), as well as solitary rugose corals with a complex axial structure (*Axophyllum* Milne-Edwards & Haime, 1850, *Axoclisia* Semenoff-Tian-Chansky, 1974, *Amygdalophyllum* Dun & Benson, 1920 and *Clisiophyllum* Dana, 1846).

The development of shallow-water fauna, and particularly corals, was disturbed during the middle Viséan when the global sea level was again relatively low, which led to a significant differentiation of sedimentation environments in shallow seas, with the deposition of restricted carbonate (*e.g.* stromatolitic sequences), evaporitic sequences, siliciclastics (Hance *et al*., 2011) or the formation of depositional hiatuses (Poty *et al*., 2006). In the Donets Basin, this episode is recorded as black shales and siliceous marls of the Styla Suite.

GEOLOGICAL SETTINGS

The general characteristics of the lower Viséan of the Donets Basin were given previously by the authors (Denayer & Ogar, 2016; Ogar, 2017). The lower Viséan rocks are exposed in the southern part of the Donets Basin (Figure 1) where they are composed mainly of bioclastic limestones, locally dolomitised and silicified. In the regional lithostratigraphic chart of the Donets Basin it is distinguished as the Skelevatka Suite, as middle part of the Mokrovolnovakha Series (Figure 2A).

This suite underlains a thin interval (5–7 m) of black bituminous limestones, interbedded with black shales (Dokuchaev Member of the Karpivka Suite, corresponding to the Dokuchaevsky regional Horizon). The base of the horizon corresponds to the regional Va zone, which was traditionally considered as the base of the Viséan. However, after the revised definition of the Tournaisian–Viséan boundary, the base of the Viséan Stage is to be found in the Vb zone that records the first occurrence of the guide foraminifer *Eoparastafella simplex*, at the base of the Skelevatka Suite (Vdovenko *et al*., 2005). Therefore, the former Va zone has been renamed Te (=Va) zone as it is Tournaisian. Foraminafers *Dainella micula*, *Endospiroplectammina venusta*, *Eoparastaffella rotunda*, brachiopods *Levitusia humerosa* and *Delepinea magna*, rugose corals *Calmiussiphyllum calmiussi* are most common in the Dokuchaev Member.

The lower Viséan carbonates are overlain by the black shales of the Styla Suite (Ve zone) that includes intercalated bentonite beds in its lower part (Figure 2B). The Styla Suite contains only a rare and very scarce fauna, which does not allow unambiguous stratigraphic determination. The bentonite of the Ve_1 subzone yielded U-Pb zircon ages of 342.01 ± 0.10 Ma (Davydov *et al*., 2010), and thus equivalent to the Tulsky Horizon of the Russian succession and to the Holkerian and Livian regional substages of the British and Belgian successions.

Sharp changes in lithology and coral associations at the base and at the top of the Skelevatka Suite indirectly indicate possible short-term interruptions in sedimentation, which is confirmed by the development of a karstic surface at its contact with black siliceous marls of the Styla Suite (Figure 2B). The latter possibly correspond to the sequence boundary of the third-order sequences 6 and 7 of Hance *et al.* (2001).

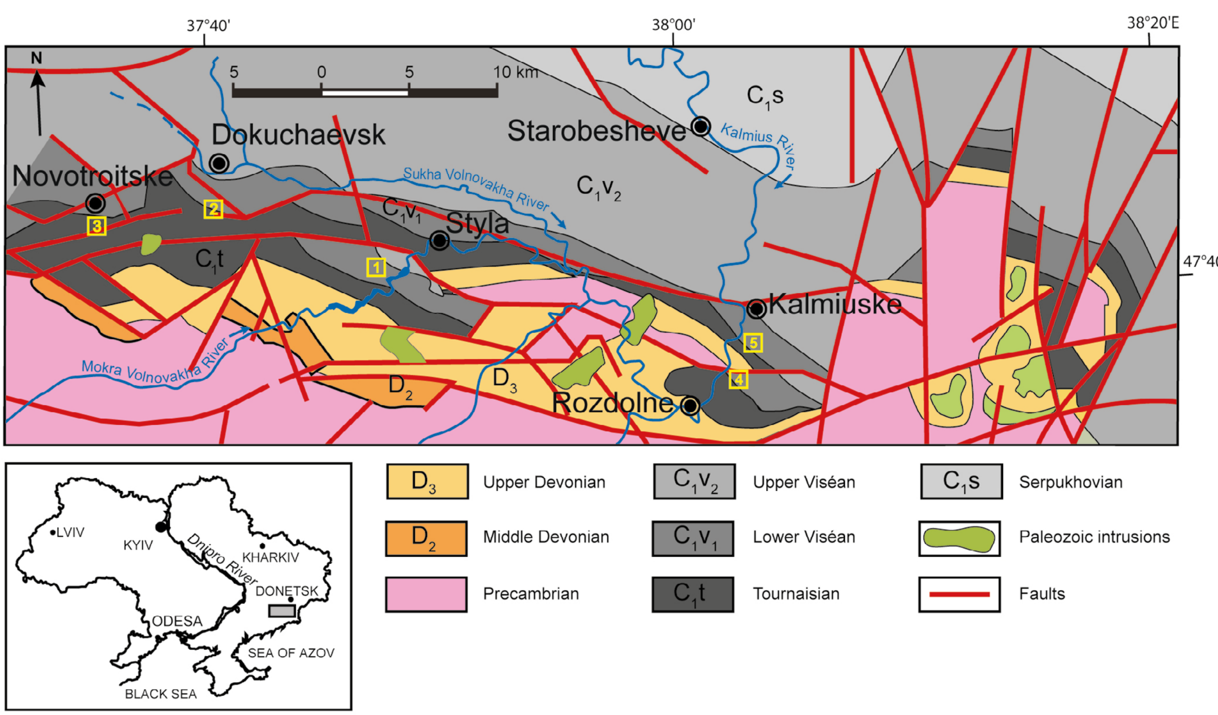

Figure 1. Geological map of the southern part of the Donets Basin (modified and supplemented after Aizenverg *et al*., 1975) with location of the rugose coral localities: **1**, left bank of the Mokra Volnovakha River near Styla village; **2**, Central Quarry near Dokuchaevsk town; **3**, Eastern Quarry near Novotroitske town; **4**, Southern Quarry near Rozdolne town; **5**, right bank of the Kalmius River near Kalmiuske town.

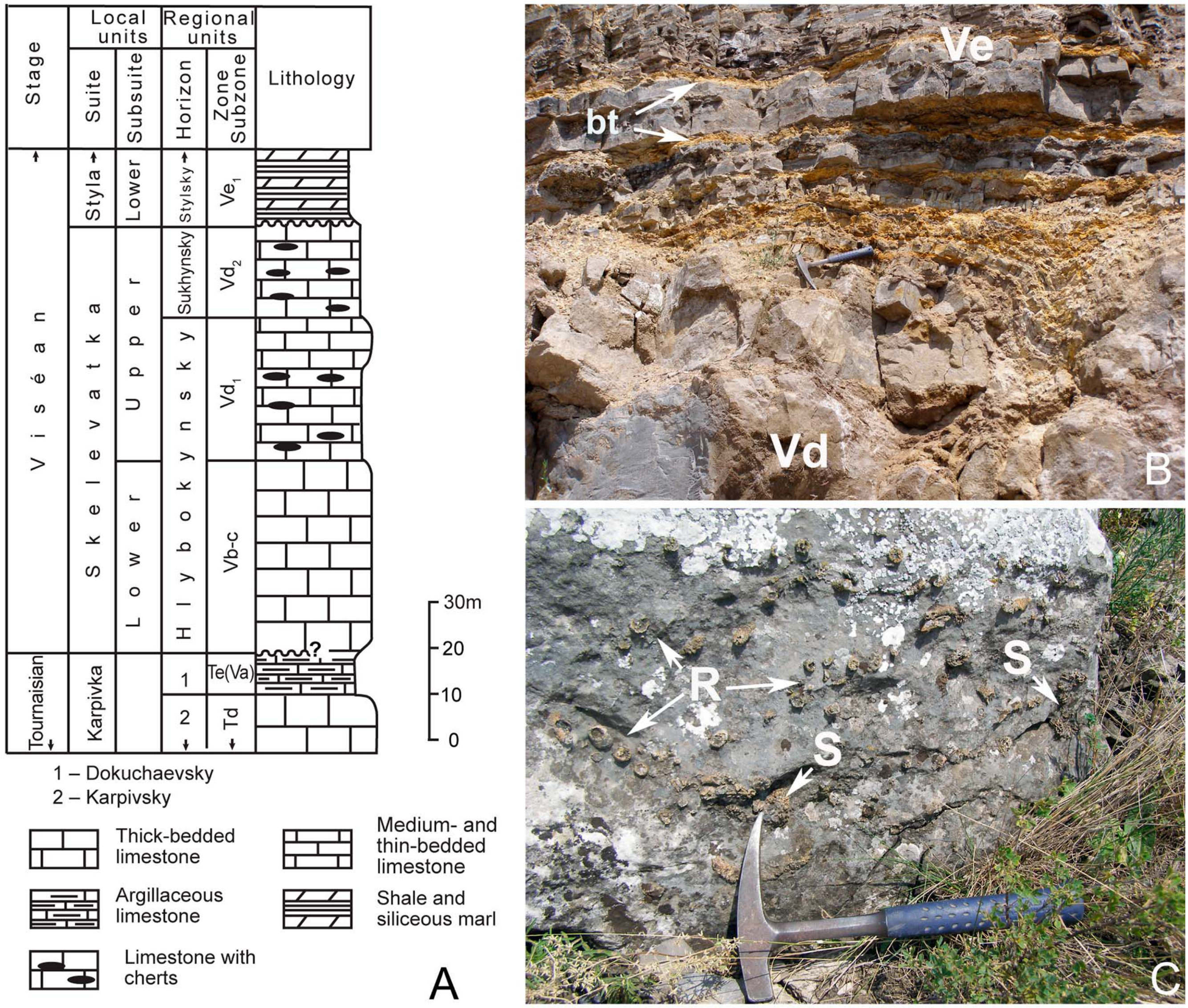

Figure 2. **A**, general stratigraphic chart of the lower Viséan strata of the Donets Basin. After Poletaev *et al.* (2011); Poletaev & Vdovenko (2013). **B**, karstic surface at the top of the Skelevatka Suite at its contact with the Styla Suite (Vd/Ve zones), Central Quarry: **bt**, bentonite interlayers. **C**, outcrop view of the lower part of the Skelevatska Suite (Vb zone), left bank of the Mokra Volnovakha River near Styla village. Note the abundant coral fragments: **R**, solitary rugose corals (predominantly *Amygdalopyllum tanaicum*); **S**, tabulate corals (mainly *Syringopora*).

The Skelevatka Suite is divided into two parts. In the stratotype section along the Mokra Volnovakha River near the Styla village, the lower part of the suite is composed of dark grey and grey thick-bedded bioclastic limestones, 40–45 m in thickness. This non-siliceous part belongs to the Vb–c zones (Poletaev *et al*., 2011; Poletaev & Vdovenko, 2013).

The upper part of the suite is characterized by limestones with cherts and corresponding to the Vd zone divided into Vd_1 and Vd_2 subzones. The lower subzone is characterized by medium- to thickly bedded grey and dark-grey limestones. This subzone differs from the underlying one by the presence of numerous interlayers, lenses and nodules of cherts (except in its upper 6 m). The thickness of the Vd_1 subzone is about 26 m.

The Vb–d_1 interval contains foraminifers *Pseudolituotubella tenuissima*, *Dainella chomatica*, *Eoendothyranopsis donica*, *Eoparastaffella simplex*, *Endothyra similis*, *Omphalotis minima* and is distinguished as the Hlybokynsky regional horizon with a total thickness of about 60–65 m (Poletaev *et al*., 2011; Poletaev & Vdovenko, 2013). The Vb zone stands out mainly by the presence of brachiopods *Paleochoristites grabovi*, while species *Linoprotonia proba* occurs in the Vd zone.

The limestones of the uppermost part of the Skelevatka Suite again contain black cherts. Its thickness is 30 m. Foraminifers *Paraarcheodiscus*, *Viseidiscus*, *Uralodiscus*, *Archaediscus* and indicate the Vd_2 subzone and the Sukhinsky regional horizon (Poletaev *et al*., 2011; Poletaev & Vdovenko, 2013). Conodonts *Gnathodus texanus texanus* and *Pseudognathodus homopunctatus* were discovered in this subzone (Poletaev *et al*., 1990, 2011).

Therefore, the Skelevatka Suite contains rich micro- and macro-faunal assemblages (Poletaev *et al*., 1990, 2011). Tabulate and rugose corals are common in this suite. In its lowermost part (Vb zone) a 0.5 m-thick horizon enriched with fragments and debris of the rugose corals *Amygdalophyllum* and the tabulate corals *Syringopora* (Figure 2C), is restricted to the Mokra Volnovakha section and unknown in the studied quarries. Besides this horizon, corals occur sporadically throughout the suite, without forming significant accumulations in the studied sections.

Regional biostratigraphic zones of the Donets Basin are compared with regional subdivisions of Western Europe by Hecker (2001), Poletaev *et al.* (2011), Poletaev & Vdovenko (2013) and (Aretz *et al*., 2020).

STUDY HISTORY OF THE RUGOSE CORALS

The lower Carboniferous rugose corals of the Donets Basin have been studied since the beginning of the 20th century. K.I. Lissitzin was the first to describe lower Viséan rugose corals (Lissitzin, 1925). He also introduced the genera *Protodibunophyllum*, *Sublonsdaleia* and *Protolonsdaleia* as well as new species in *Lonsdaleia* McCoy, 1849. Unfortunately, the published images of the corals are of unsatisfactory quality (Lissitzin, 1925, p. 68, pl. 1–2; 1929), and without description. Therefore, in regards of the International Code of Zoological Nomenclature, most of them are considered as invalid.

Later, Zhizhina (1956), based on the materials from the lower Viséan (Vb–c zones) of the Donets Basin, published the new genus *Eolithostrotionella* with *E. longisepta* (Lissitzin, 1925) as type species. In 1960, she described another new species of this genus, *E. cystosa* from the Vb zone (Zhizhina, 1960, p. 250, pl. 61, fig. 1).

The most complete characterization of the lower Carboniferous corals of the Donets Basin is due to N.P. Vassiljuk (Vassiljuk, 1960). From the lower Viséan she described the following taxa: *Amplexus* ex. gr. *coralloides* Sowerby, 1814, *Verneuilites konincki* var. *calmisia* (Lissitzin, 1925) (redescribed herein), *V*. sp. (not figured), *Caninia subibicina* M'Coy (= *Haplolasma subibicina* McCoy, 1851), *C*. cf. *aberrans* Gorsky, 1938 and *C*. sp. (not figured), *Lithostrotion irregulare* Phillips, 1836 (= *Siphonodendron irregulare* Phillips, 1836), *Lithostrotion affine tanaicum* Vassiljuk, 1960 (redescribed herein), *Diphyphyllum lateseptatum* McCoy, 1849 (= ? *Siphonodendron martini* Milne-Edwards & Haime, 1851) and *D*. sp. (not figured), *Lithostrotion columnariformis* Vassiljuk (= *Vassiljukia columnariformis* (Vassiljuk, 1960), *Eolithostrotionella zhizhinae* Vassiljuk, 1960 (redescribed herein), *Protolonsdaleia mariupolensis* Lissitzin, 1925 (redescribed herein), *Dibunophyllum lissitzini* Vassiljuk, 1960, and *Clisaxophyllum brazhnikovae* Vassiljuk, 1960. Note that in her 1960 description, Vassiljuk adopted Lissitzin's initial concept of the species *Lonsdaleia longisepta* and not Zhizhina's (1960) view who chose *L. longisepta* as type species of her new genus *Eolithostrotionella*. Later, Vassiljuk & Zhizhina (1978, 1979) supplemented the list of the lower Viséan taxa with the species *Protolonsdaleia tenuis* Zhizhina, 1979, *Protolonsdaleia intermedia* (Lissitzin, 1925) (= *Sublonsdaleia intermedia* Lissitzin, 1925) and *Diphyphyllum latetabulatum* Volkova, 1941. Questions regarding the taxonomy of these colonial corals were raised by Denayer (2011) and Hecker (2012), notably their relationships with the genus *Dorlodotia* Salée, 1920 and *Acrocyathus* d'Orbigny, 1849.

The taxonomic affiliation of *Lithostrotion columnariformis* Vassiljuk, 1960 was solved through the revision of the type-material and additional colonies from the type localities and from the lower Viséan of NW Turkey by Denayer & Ogar (2016) who established the new genus *Vassiljukia* for this cerioid amygdalophyllid coral.

Based on the generalization of taxonomic diversity and stratigraphic distribution of lower Carboniferous (Mississippian) corals, biostratigraphic zones were distinguished. Thus, the lower Viséan interval of the Donets Basin after Vassiljuk *in* Poletaev *et al.* (1990) corresponded to the coral zone C6. Hecker (2001) allocated for the lower Viséan of the East European Platform and Urals interval zone IV and Zone V.

This paper presents the results of our ongoing study of the Tournaisian and Viséan rugose corals of the Donets Basin (Ogar, 2010, 2017; Denayer & Ogar, 2016; Ohar, 2020).

MATERIAL AND METHODS

The studied collection includes 74 specimens of colonial and solitary rugose corals collected from the key section along the Mokra Volnovakha River near the Styla village, as well as from the Central, Eastern and Southern operating quarries (Figure 1). Additional material from Mokra Volnovakha River (three specimens), as well as in the section along the Kalmius River near Komsomolske (now Kalmiuske) in the Kalmius river valley (eight specimens) were given by N.P. Vassiljuk to D. Weyer who kindly passed them to J.D. for study. The last outcrop is now completely destroyed by anthropogenic activity.

The preservation of the studied corals is not satisfactory. Most of them are recrystallized, dolomitized, and silicified to varying degrees. For the study of corals, traditional study methods were used with the making of thin sections and polish surfaces. Acetate peels have been used occasionally.

The studied material is housed in Museum of Paleontology of Taras Shevchenko National University of Kyiv (Ukraine) under numbers **TSNUK**-2P264-A and 2P267-A. Specimens given by D. Weyer are housed in the Human and Animal Paleontology Collections of the University of Liège (Belgium) under numbers **PA.ULg**.D1 to D11.

SYSTEMATIC PALEONTOLOGY

Phylum CNIDARIA Hatschek, 1888
Class ANTHOZOA Ehrenberg, 1834
Subclass RUGOSA Milne-Edwards & Haime, 1850
Suborder STAURIINA Verrill, 1865
Family AMPLEXIDAE Chapman, 1893

Amplexus Sowerby, 1814

Type species. *Amplexus coralloides* Sowerby, 1814; lower Carboniferous, Limerick, Ireland.

Diagnosis. Solitary coral with scolecoid to cylindrical form. Major septa thin and short, amplexoid. Cardinal fossula marked by the shortened cardinal septum. Minor septa poorly developed. Dissepiments absent. Tabulae complete and mesa-shaped with long downturned edges (after Poty, 1981).

Amplexus coralloides Sowerby, 1814
(Figure 3A)

*1814 *Amplexus coralloides* Sowerby, p. 165, pl. 72, figs. 1–5.
v 1960 *Amplexus* ex gr. *coralloides* Sowerby: Vassiljuk, p. 41.
v *non* 1960 *Amplexus coralloides* Sowerby var. *constaseptata* var. nov.: Vassiljuk, p. 40, pl. 12, fig. 1, 1a.
non 1967 *Amplexus coralloides* Sowerby: Ivanowski, p. 37, text-fig. 10; pl. 1, fig. 1–2.
non 1969 *Amplexus coralloides* Sowerby: Różkowska, p. 124, text-fig. 49B–C; pl. 7, fig. 6–7.
non 1975 *Amplexus coralloides* Sowerby: Ulitina, p. 37, fig. 1.
v 2015b *Amplexus coralloides* Sowerby: Denayer, p. 319, fig. 4e–f [cum. syn.].
2021 *Amplexus coralloides* Sowerby: Badpa *et al*., pl. 1, fig. 7a–b.

Lectotype. BM (NH) 4115, specimen figured by Sowerby (1814), designated by Smith & Thomas (1963); lower Viséan, Chadian and Arundian substages (*Syringothyris* Zone C), Black Rock, Limerick, Ireland.
Diagnosis. *Amplexus* variable in size (up to 50 mm in diameter) having up to 62 septa (after Poty, 1981).
Material. One fragment of adult growth stage, 2P267-A/Vb-2. Central Quarry, Vb zone. Two thin sections.
Description. Cylindrical fragment, septal index 53:20–21 mm. Major septa thin, 2–3 mm-long, often rhopaloid, with thickened base but not included in the wall. Minor septa not developed. Cardinal septum indistinct. Tabulae complete, flat in the central zone, steeply downturned near the wall. Tabulae 2.7–3.0 mm apart. Wall 0.5 mm thick. Microstructure of the wall and septa not preserved.
Remarks. The specimen described and figured here differs from the lectotype, and from the specimens figured by Somerville *et al.* (1986) by its slightly higher number of septa at similar diameters: Welsh specimens have 53 septa at 40 mm of diameter. Conversely, Belgian specimens (Poty, 1981) have on average 42 septa at a diameter of 19 mm. The present specimen is most similar to those described but not figured by Vassiljuk (1960) as *Amplexus* ex gr. *coralloides* Sowerby from the Viséan (Vb and Vf zones) of the Donets Basin. Note, that corals with well-developed minor septa described in some regions of Eurasia (*e.g.* Ivanowski, 1967; Różkowska, 1969; Ulitina, 1975) should be excluded from *A. coralloides*.
Distribution. Upper Tournaisian of the Omolon Massif of Russia (Poty & Onoprienko, 1984), NW Turkey (Denayer, 2015b); Tournaisian and Viséan of Belgium (Poty, 1981; Denayer *et al*., 2011), France (Vuillemin, 1990), Ireland (Somerville, 1994), North Wales (Somerville *et al*., 1986), Iran (Badpa *et al*., 2021), the Donets Basin (Vassiljuk, 1960; Ohar, 2020) and upper Viséan of Scotland (Hill, 1938–1941).

Family ZAPHRENTOIDIDAE Schindewolf, 1938

Sychnoelasma Lang, Smith & Thomas, 1940

Type species. *Verneuilia urbanowitschi* Stuckenberg, 1895, lower Carboniferous, Ural Mountains, Russia.

Diagnosis. Ceratoid to cylindrical solitary coral. Major septa pinnately arranged, long or withdrawn. Minor septa poorly developed or half as long as the major septa. Cardinal fossula long, wide and surrounded by thick major septa. Dissepiments absent. Tabulae complete or not, downturned towards the periphery, strongly depressed in the cardinal fossula (after Cotton, 1973).

Sychnoelasma hawbankense Mitchell & Somerville, 1988
(Figures 3B–E)

v 1960 *Verneulites konincki* var. *calmisia* (Lissitzin): Vassiljuk: p. 48, pl. 12, figs. 2, 2a–c.
1972 *Sychnoelasma urbanowitschi* (Stuckenberg): Weyer: p. 468, figs. 1–2.
1975 *Sychnoelasma urbanowitschi* (Stuckenberg): Weyer: p. 872, pl. 5, fig. 4.
v 1981 *Sychnoelasma urbanowitschi* (Stuckenberg): Poty: p. 19, pl. 3, figs. 1–3; 8, 9.
*1988 *Sychnoelasma hawbankense* Mitchell and Somerville: p. 158, fig. 3a–g [cum. syn.].
1990 *Sychnoelasma urbanowitschi* (Stuckenberg): Vuillemin: p. 41, pl. 1, figs. 12–13.
v 2011 *Sychnoelasma hawbankense* Mitchell & Somerville: Denayer *et al.*: p. 155, pl. 4, fig. F.
2015b *Sychnoelasma hawbankense* Mitchell & Somerville: Denayer, p. 317, fig. 3a [cum. syn.].

Holotype. Specimen BGS Dw 3554 (PF 2027, PF 1269-72); Haw Bank Quarry, Skipton, Yorkshire, upper Tournaisian, Courceyan Regional Substage.
Diagnosis. Small ceratoid *Sychnoelasma*, 24 mm in diameter and having 46 major septa. Major septa thick, thigh to the fossula. Minor septa short or half as long as the major septa. Cardinal septum shorter. Cardinal fossula long and closed. Outer wall very thick. Tabulae numerous, irregular and vesicular (after Mitchell & Somerville, 1988).
Material. Eight specimens recrystallized to various degree without calice not and with external surface partly preserved. 2P267-A/Vb-39, Vb-62, 64 and 65, Vc-2, Central Quarry; 2P267-A/Vbc-6, Vbc-5/1, Southern Quarry and 2P267-A/Vbc-1/4, Eastern Quarry; Vb–c zones. Seven thin sections and three polished surfaces available.
Description. Subcylindrical corals up to 9 cm-long with a maximum diameter of 22 mm. Corallite surface bears growth striae (Figure $3C_1$). There are 48 septa of both orders at a diameter of 21 mm. Tabulae are complete or slightly incomplete, strongly concave in the central part of the tabularium and very steeply inclined in the fossulae. Tabulae thickened with stereoplasma in the fossula. There are 10

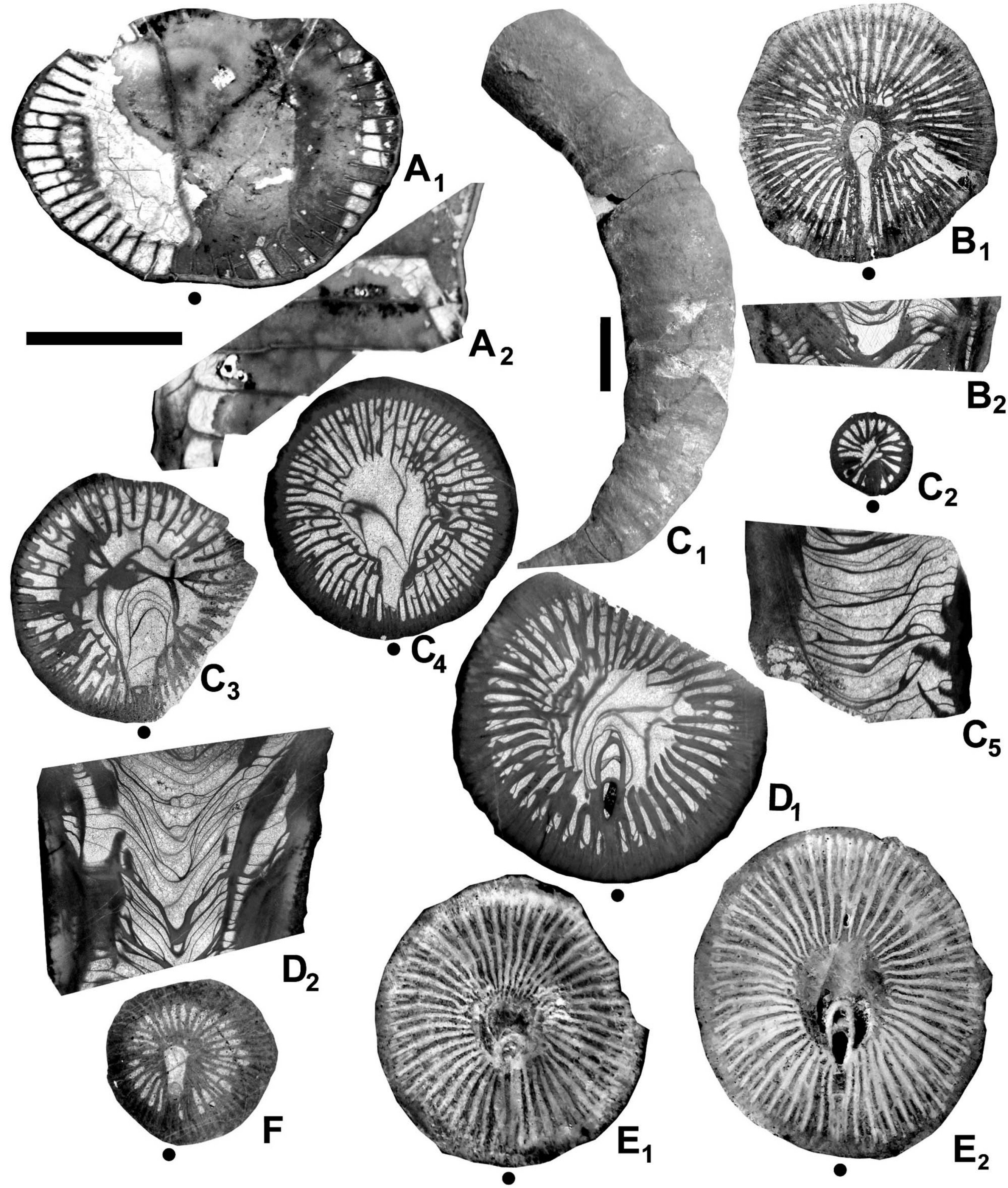

Figure 3. *Amplexus coralloides* Sowerby, 1814. **A**, specimen TSNUK 2P267-A/Vb-2, Central Quarry, Vb zone; $\mathbf{A_1}$, transverse section; $\mathbf{A_2}$, longitudinal section. *Sychnoelasma hawbankense* Mitchell & Somerville, 1988 ="*Verneulites konincki calmisia*" (Lissitzin *in* Vassiljuk, 1960). **B**, specimen MNH 1405/2, Kalmius River, Coralova Balka, Vd zone; $\mathbf{B_1}$, transverse section; $\mathbf{B_2}$, longitudinal section. *Sychnoelasma hawbankense* Mitchell & Somerville, 1988. **C**, specimen TSNUK 2P267-A/Vbc-6, Southern Quarry; $\mathbf{C_1}$, side view; $\mathbf{C_2}$, transverse section through late neanic growth stage, $\mathbf{C_{3\text{-}4}}$, mature stage; $\mathbf{C_5}$, longitudinal section. **D**, specimen TSNUK 2P267-A/Vc-2, Central Quarry, Vc zone; $\mathbf{D_1}$, transverse section through mature stage; $\mathbf{D_2}$, longitudinal section. **E**, specimen TSNUK 2P267-A/Vb-39, Central Quarry, Vb zone; $\mathbf{E_{1\text{-}2}}$, transverse section, polished surfaces. *Sychnoelasma konincki* (Milne-Edwards & Haime, 1851). **F**, specimen TSNUK 2P264/16-1; transverse section, Central Quarry, Vb zone, acetate peel. Cardinal septum is marked by a dot in transverse section. Scale bars = 10 mm.

tabulae on a 10 mm-long vertical section. In early growth stages (Figure $3C_2$) at diameter 5.4 mm, there are 23 major septa slightly withdrawn from the axis. Shortened cardinal septum in the cardinal fossula. Fossula with thick sidewalls, not reaching the coral axis. Minor septa marked in counter quadrants as short, subtriangular spikes with sharp ends. At 15 mm of diameter (Figure $3C_3$) there are 41 septa of both orders, minor septa being on average 0.9 mm-long. Cardinal septum shortened in a pear-shaped fossula. At 16 mm of diameter, there are 41 septa of both orders, minor septa being half as long as the major septa (Figure $3C_4$). Cardinal septa short. Fossula wide and open. There are 9–10 tabulae on a 10 mm-long vertical section. Outer wall (septotheca) up to 1.1 mm thick.

Remarks. Lissitzin (1929) was the first to document the presence of *Sychnoelasma* in the lower Carboniferous of the Donets Basin at the same stratigraphic level as *Zaphrentis konincki* var. *calmisia* (Lissitzin, 1925) and *Zaphrentis konincki* var. *kentensis* (Lissitzin, 1929). However, Lissitzin did not described these corals and only figured them (1929, pl. 15, fig. 4, 10) as large *Sychnoelasma* without explanation. For specimens with larger size and higher number of septa occurring in the Vb zone, Vassiljuk applied the name *Verneulites konincki* var. *calmisia* (Lissitzin *in* Vassiljuk, 1960). However, the illustrated specimen of the Donets variety (Vassiljuk, 1960, pl. 12, fig. 2–2a) and Figure 3B with a diameter of 16–17 mm and 44 major septa does not correspond to Vassiljuk's description (36–38 septa at a diameter of 16 mm). The presence of large specimens of *Sychnoelasma konincki* is also characteristic the upper Tournaisian assemblage of other regions such as the Kuznetsk Basin where Dobrolyubova & Kabakovitsh (1966) indicated the occurrence of specimens up to 50–60 mm long and up to 25–28 mm in diameter and having 54 major septa (p. 37, pl. 1, fig. 15). *Sychnoelasma hawbankense* differs from *Sychnoelasma konincki* (Figure 3F) by a larger size and more septa (see remarks by Mitchell & Somerville, 1988, p. 160). At a diameter of 5.4 mm our *S. hawbankense* specimen has major septa not connected by their axial ends (Figure $3C_2$). Such septal arrangement differs from early growth stages of *Sychnoelasma konincki* from the Northern Urals (*e.g.* Soshkina, 1960, fig. 2; Sayutina, 1976, pl. 2, fig. 4a) and Pomerania (Chwieduk, 2005, pl. 16, fig. 1). The minor septa of *S. hawbankense* Mitchell & Somerville, 1988 (figs. 3a–g) holotype and paratypes are long, half as long as the major septa. In the specimens from the Donets Basin, minor septa are noticeably shorter. Shortened minor septa are also characteristic of the species *Sychnoelasma urbanowitschi* (Stuckenberg, 1895), *e.g.* in Poty (1981, pl. 3, figs. 4a–b; 7; note that only the specimen figured in fig. 8 has long minor septa). Hence, the length of minor septa is probably an intraspecific variation. Belgian specimens – initially described as *S. urbanowitchi* by Poty (1981) – very similar to the Donets ones were re-attributed to *S. hawbankense* by Denayer *et al.* (2011). The present material differs from *Sychnoelasma urbanowitschi* (Stuckenberg, 1895) primarily in their smaller maximum diameters and fewer septa with equal diameter, shorter major septa, and the usually unfused axial ends in the early growth stages. The early growth stages of *Sychnoelasma urbanowitschi* studied by Sayutina (1976) and attributed by her to that species display a sub-triangular fossula expanded to the periphery of the coral. With an increase in diameter, the fossula becomes narrow slit-like with parallel walls (Sayutina, 1976, pp. 116–118, pl. 2, fig. 2). Large *Sychnoelasma magna* (Gorsky, 1938), (*i.e.* in Gorsky, 1938, text-fig. 3, pl. 2, fig. 3) differs from *S. hawbankense* by the presence of 50 very thickened septa in a corallite diameter of 17 mm and a narrow slit-like fossula.

Distribution. Upper Tournaisian and lower Viséan, RC4 biozone of Belgium (Poty *et al*., 2006, not RC3β as incorrectly reported by Poty, 2016), Northern France (Poty & Hannay, 1994) and Brittany (Vuillemin, 1990); uppermost Courceyan to Chadian regional substages of the British Isles (Mitchell & Somerville, 1988), lower Viséan of the Rügen Island (northern part of Germany) (Weyer, 1975), upper middle Viséan of Morvan in the French Massif Central (Weyer, 1972). In the Donets Basin this species occurs in the lower Viséan (Vb–d zones).

Suborder CYATHOPHYLLINA Nicholson, 1889
Family CYATHOPSIDAE Dybowski, 1873

Haplolasma Semenoff-Tian-Chansky, 1974

Type species. *Caninia subibicina* McCoy, 1851; lower Viséan (Arundian Substage); Kendal, Westmoreland, England.

Diagnosis. Solitary coral. Major septa long but withdrawn from the axis with a large free zone in the central part of the tabularium. Minor septa short (<1/2 major). Small cardinal fossula with a shorter major septum. Dissepimentarium of various width, made of small simple and V-shaped dissepiments (after Semenoff-Tian-Chansky, 1974).

Haplolasma subibicinum (McCoy, 1851)
(Figure 4A)

1851a *Caninia subibicina* McCoy, p. 167.
1851b *Caninia subibicina* McCoy, p. 89.
*1855 *Caninia subibicina* McCoy: McCoy, pl. 3i, figs. 35, 35a.
1913 *Caninia subibicina* McCoy: Garwood, p. 561, pl. 49, fig. 3.
1916 *Caninia subibicina* McCoy: Garwood, pl. 13, fig. 3.
1930 *Caninia subibicina* McCoy: Delépine, p. 30, pl. 3, fig. 2.
v 1960 *Caninia subibicina* McCoy: Vassiljuk, p. 58, pl. 13, figs. 1, 1[a].
1974 *Haplolasma subibicinum* (McCoy): Semenoff-Tian-Chansky, p. 196, text-fig. 74, pl. 50, figs. 2–4.
1986 *Haplolasma subibicinum* (McCoy): Somerville *et al*., p. 72, fig. 7e.

Holotype. SM A2358, figured by McCoy (1855, pl. 3i, fig. 35) and by Semenoff-Tian-Chansky (1974, text-fig. 74, pl.

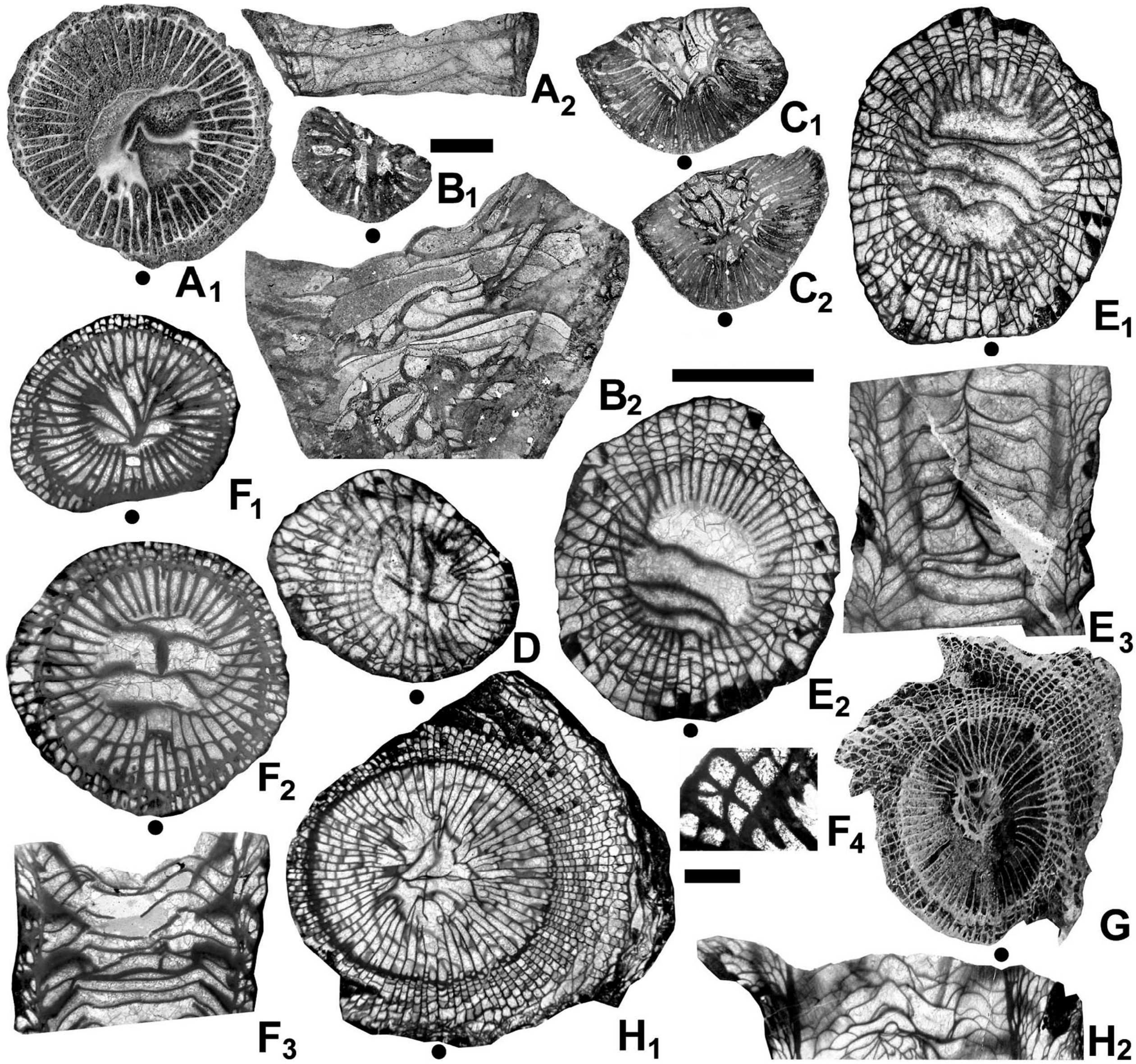

Figure 4. *Haplolasma subibicinum* (McCoy, 1851). **A**, specimen TSNUK 2P267-A/bc-3, Eastern Quarry, Vb-c zones; $\mathbf{A}_1$, transverse section, polished surface; $\mathbf{A}_2$, longitudinal section – acetate peel. *Caninophyllum* cf. *robustum* Dobrolyubova, 1966. **B**, specimen TSNUK 2P267-A/d-21, Central Quarry, Vd zone; $\mathbf{B}_1$, transverse section; $\mathbf{B}_2$, longitudinal section, acetate peels. **C**, specimen TSNUK 2P267-A/d-22, Central Quarry, Vd zone; $\mathbf{C}_{1\text{-}2}$, transverse sections, acetate peels. *Caninophyllum* sp. **D**, specimen TSNUK 2P267-A/Vb-17, Central Quarry, Vb zone, transverse section. **E**, specimen TSNUK 2P267-A/b-19, Central Quarry, Vb zone; $\mathbf{E}_{1\text{-}2}$, transverse sections; $\mathbf{E}_3$, longitudinal section. *Amygdalophyllym* cf. *meathopense* (Garwood, 1913). **F**, specimen TSNUK 2P267-A/Vb-6, Central Quarry, Vb; $\mathbf{F}_{1\text{-}2}$, transverse sections; $\mathbf{F}_3$, longitudinal section; $\mathbf{F}_4$, transverse section of the dissepimentarium (enlarged from F_1). **G**, specimen TSNUK 2P267-A/Vb-24, Central Quarry, Vb zone, transverse section, acetate peel. **H**, specimen TSNUK 2P267-A/Vb-25, Central Quarry, Vb zone; $\mathbf{H}_1$, transverse section; $\mathbf{H}_2$, longitudinal section. Cardinal septum is marked by a dot in transverse section. Scale bars: $A_{1\text{-}2}$, B_2–F_3, G–H_2 = 10 mm; B_1 = 2 mm; F_4 = 1 mm.

50, figs. 2–4); lower Viséan (Arundian regional substage) of Kendal, South Cumbria.

Diagnosis. Coral with 54–65 major septa at a diameter of 34–38 mm with fibrous microstructure. Minor septa nearly half the length of the major septa. Tabulae flat, complete, and slightly divided and depressed in periphery. Dissepimentarium consisting of 4 to 8 concentric regular rows (based on McCoy, 1851a, 1851b; Semenoff-Tian-Chansky, 1974, and Somerville *et al*., 1986).

Material. One specimen 2P267-A/bc-3, Southern Quarry, Vb–c zones; the outer surface of early growth stages is weathered out and the calice part is filled with sediment; two crushed fragments from Vc zone, Southern Quarry and Central quarries. Two polished surfaces.

Description. Subcylindrical fragments of solitary coral with diameter up to 18–20 mm. Major septa half as long as the corallite radius, thin in the dissepimentarium and slightly thickened in the tabularium. Inner ends of the septa sharp.

Minor septa long half as long as the major septa. Septal index 41:20 mm. Shortened cardinal septum in the open fossula. Cardinal-lateral septa long. Narrow dissepimentarium made of rows of concentric interseptal dissepiments, the inner one being slightly thickened. Tabularium biform. Tabulae flat, downturned near the dissepimentarium, widely spaced.

Remarks. The diameter of the described coral is less than the diameter of the holotype and the specimen described by Somerville *et al.* (1986, fig. 7e). All the other features especially long minor septa, suggest an attribution to *Haplolasma subibicinum*. *H. densum* (Lewis, 1930) from the Arundian Regional Substage of the Isle of Man differs by its minor septa restricted to the dissepimentarium. The length of the minor septa in *Haplolasma subibicinum* described and illustrated by Vassiljuk (1960, pl. 13, fig. 1, 1a) is more variable. Along with short minor septa, it has a septal index (40–45:18 mm) similar to the present specimen. *H. conili* (Poty, 1981) is characterized by a higher number of septa (septal index 49:20 mm); minor septa only slightly entering the dissepimentarium, as well as the presence of occasional lonsdaleoid dissepiments. As originally established by Semenoff-Tian-Chansky (1974) *Haplolasma lamelliferum* from the upper Viséan of Sahara and Spain differs from *Haplolasma subibicinum* by the lamellar microstructure of the septa (Rodríguez *et al*., 2016).

Distribution. Lower Viséan (Arundian Regional Substage) of the British Isles (Somerville *et al*., 1986); Brittany (Delépine, 1930); Vb–d zones of the Donets Basin.

Family BOTHROPHYLLIDAE Fomichev, 1953

Caninophyllum Lewis, 1929

Type species. *Cyathophyllum archiaci* Milne Edwards & Haime, 1852; Viséan of Wales.

Diagnosis. Large solitary coral. Major septa numerous, long, thick in the tabularium, particularly in the cardinal quadrants, thinning towards the axis. Cardinal septum short. No axial structure, but some septa can fuse in a group near the axis. Cardinal fossula well defined with depressed tabulae. Dissepimentarium of various width made of simple, V-shaped or herringbone dissepiments. Tabulae more or less complete, horizontal in the central part of the tabularium but usually depressed in the periphery (after Poty, 1981).

Caninophyllum cf. *C. robustum* Dobrolyubova, 1966
(Figures 4B, C)

Material. Two coral fragments 2P267-A/d-21 and A/d-22 included in the rock. Only early growth stages are preserved. Polished surfaces and peels available for study. Five acetate peels.

Description. Trochoid corals with long and thick septa. Septal index: 19:6 mm; 28–30:9-10 mm; 39:20 mm. Cardinal septum long at all stages. In the early growth stages, cardinal septum connected with the counter septum. Alar septa shortened and located in pseudo-fossulae in early growth stages. Cardinal septum and several elongated major septa sporadically reaching the axis where they connected (Figure $4C_2$). Minor septa poorly developed, appearing in the counter quadrants at a corallite diameter of c. 14 mm together with the first dissepiments. Dissepimentarium concentric, consisting of rectangular dissepiments. Outer wall up to 0.3–0.5 mm thick.

Remarks. This species is most similar to *Caninophyllum robustum* Dobrolyubova, 1966 from the lower Viséan of the Kuznetsk Basin. The characteristic features of this species are the thickened major septa at all growth stages and an elongated cardinal septum at early stages. However, the limited material from the Donets Basin does not allow to confidently attribute these specimens to *Caninophyllum robustum* as mature stages are not preserved. Therefore, we refer the Donets specimens with a confer to Dobrolyubova's (1966) species.

Distribution. *Caninophyllum robustum* occurs in the lower Viséan, Podyakovsky horizon of the Kuznetsk Basin (Dobrolyubova & Kabakovitsh, 1966). The specimens described here are from the lower Viséan (lower part of the Vd zone).

Caninophyllum sp.
(Figures 4D, E)

Material. Three coral fragments 2P267-A/Vb-17, 2P267-A/b-19 and 2P267-A/b-23, Central Quarry. Four thin sections.

Description. Sub-cylindrical coral. Major septa thin and radially 1/2 to 2/3 of corallite radius in length. Cardinal septum shortened and placed in poorly conspicuous open fossula. Counter septum of equal length or slightly shortened. Axial ends of the septa in the cardinal quadrants slightly thickened. Septal indexes: 41:13–14 mm; 46:16 mm; 48:20 mm; 56:22 mm. Minor septa absent or rudimentary. Dissepimentarium up to 1/2 of the major septa length in width. Dissepiments rectangular and frequently irregular in shape. In longitudinal section dissepimentarium consisting of 3–4 rows moderately inclined (50º) dissepiments variable in size. Tabulae predominantly complete, flat, or slightly concave in the central part and plunging down near the dissepimentarium. Average distance between tabulae c. 1.2 mm. Occasionally (Figure $4E_3$) a short axial plate turned upwards the axis probably in continuation with elongated major septum.

Remarks. The specimens from the Donets Basin are very similar to *Caninophyllum* sp. nov. A (Denayer *et al*., 2011, pl. 4, fig. J) from the upper Tournaisian of Belgium. The Belgian species has short minor septa but in regard to its small diameter, the figured specimen is possibly a juvenile. Nevertheless, both *Caninophyllum* sp. nov. A in Denayer *et al.* (2011) and the present specimen differs for juvenile *C. patulum* by thinner septa and a simpler dissepimentarium.

Distribution. Similar specimens of Belgium occurrences from the upper Tournaisian, RC4α. *Caninophyllum* sp. in the Donets Basin collected from the lower Viséan, upper part of Vb zone.

Family AULOPHYLLIDAE Dybowski, 1873
Subfamily AMYGDALOPHYLLINAE Grabau in Chi, 1935

Amygdalophyllum Dun & Benson, 1920

Type species. *Amygdalophyllum etheridgei* Dun & Benson 1920, Burindi Series, Viséan, Babbinboon, New South Wales.

Diagnosis. Small to large solitary coral with more or less dense axial structure. Axial structure composed of thick median plate and more or less contiguous thickened septal lamellae and axial tabellae. Axial structure may be cuspidate towards the cardinal septum and sometimes towards the counter one. Cardinal fossula more or less conspicuous. Septa numerous, carinate or not, more thickened along the whole length or only in tabularium. Major septa extending to axial structure or a few withdrawn. Minor septa usually long and thinner than the major ones, occasionally contraclined or contratingent. Dissepimentarium wide, with small concentric dissepiments and with occasional peripheral lonsdaleoid dissepiments. Inner margin may be thickened. Tabulae incomplete, conical, and commonly thickened near the axis, moderately to strongly declined, sometimes forming a peripheral gutter. Limited increase occurs sporadically (after Poty, 2007).

Remarks. Poty (2007) revised the diagnosis of the genus *Amygdalophyllum* based on a review of Australian types and widely distributed species in Eurasia. Therefore, several previously identified genera, including *Kiyasarophyllum* Ogar *et al*., 2013 have to be included in *Amygdalophyllum* Dun & Benson, 1920.

Amygdalophyllym cf. *A. meathopense* (Garwood, 1913)
(Figures 4F, G)

Material. Six specimens TSNUK 2P267-A/Vb-6, Vb-24, Vb-25, Vb-26, Central Quarry; 2P267-A/Vbc-5; Vbc-6, South Quarry included in the rock without early growth stages and calices. Two specimens have a preserved outer surface. Five thin sections and one acetate peel.

Description. Trochoid solitary corals with outer surface covered with growth striae. Septal indexes: 41–42:17–20 mm; 48:22 mm; 60:24 mm; 64:30 mm. Major septa long (2/3 to 3/4 of the corallite radius), thickened in the tabularium area. Minor septa 1/3–1/2 as long as the major septa in length, slightly entering into the tabularium. Major and minor septa commonly interrupted by lonsdaleoid dissepiments. Cardinal septum shortened, located in a conspicuous open fossula. Counter septum elongated. Some major septa reach the axial structure. Dissepimentarium 7 mm-wide, composed of an inner zone (5 mm), consisting of 2–12 rows of concentric rectangular dissepiments, and a narrow outer zone (up to 2 mm) comprising of 1–3 rows of lonsdaleoid dissepiments, appearing only where the corallite diameter is > 25 mm (Figure 4H_1). Dissepimentarium separated from the tabularium by a clear inner margin. Tabularium biform. Tabulae complete in early growth stages, incomplete and vesicular in mature stages, slightly upturned towards the axial structure. The axial structure is variable. Corallite > 18 mm in diameter display an axial structure spindle-shaped, 0.5–0.7×1.8–2 mm (Figure 4 F_2) or bent thickened median plate (Figure 4 F_1) attached to axial ends of some major septa. In more mature stages (Figure 7G), the axial structure consists of the long and curved median plate with short septal lamellae, inner ends of some major septa and upturned tabulae. It is separated from the tabularium by a thickened wall and is cuspidate towards the cardinal septum. In larger stages, the axial structure is an irregularly curved thin median plate displaced towards the cardinal septum and few bent septal lamellae (Figure 7H).

Remarks. With the poorly developed axial structure, reduced to a thin, vertically discontinuous plate, the present specimens are similar to several early Viséan species of *Amygdalophyllum*, such as *A. meathopense* (Garwood, 1913), *A. carlyanense* (Smyth, 1915) and *A. praecursor* (Howell, 1938). From the latter two, the Ukrainian material differs by a larger diameter, a tabularium more irregular and a larger dissepimentarium. With *A. meathopense*, it shares septa slightly withdrawn from the axis, tabellae slightly upturned towards the axis. The occurrence of lonsdaleoid dissepiments is not frequent in *Amygdalophyllum* spp. but has been documented in some species such as *Amygdalophyllum vesiculosum* (Garwood, 1913) – possibly a yet unnamed subgenus – and occasionally in other large-sized species. Second order lonsdaleoid dissepiments are common in *A. parecursor* but the latter is smaller and has a stouter columella. Because the lonsdaleoid dissepiment could also be of ecological origin, it is not sufficient in our opinion to reject the present specimens from the genus *Amygdalophyllum* and, without this character; it is more similar with the species *A. meathopense*. From *Amygdalophyllum tanaicum* (Vassiljuk, 1960) the present material differs by its larger dimensions and looser axial structure.

Distribution. Lower Viséan (Vb zone) of the Donets Basin. *Amygdalophyllym meathopense* (Garwood, 1913) occurs in the Chadian and Arundian regional substages, lower Viséan of NW England.

Amygdalophyllum tanaicum (Vassiljuk, 1960)
(Figures 5, 6)

v*1960 *Lithostrotion affine tanaicum* Vassiljuk, p. 86, pl. 22, fig. 1-1a–c.
2011 *Amygdalophyllum* sp. nov. B: Denayer *et al*., p. 165, pl. 5, fig. G.

Holotype. National Museum of Natural History of Ukraine, No. 1405/48. Illustrated by Vassiljuk (1960, pl. 22, fig. 1, 1a) and by authors (Figure 5A); right bank of Kalmius River, Donkushi-Tukhaya valley, Vb zone.

Diagnosis. Solitary or gregarious ceratoid or cerato-cylindroid corals, up to 16 mm in diameter and 42–44 major septa maximum. Major septa long, commonly thickened in

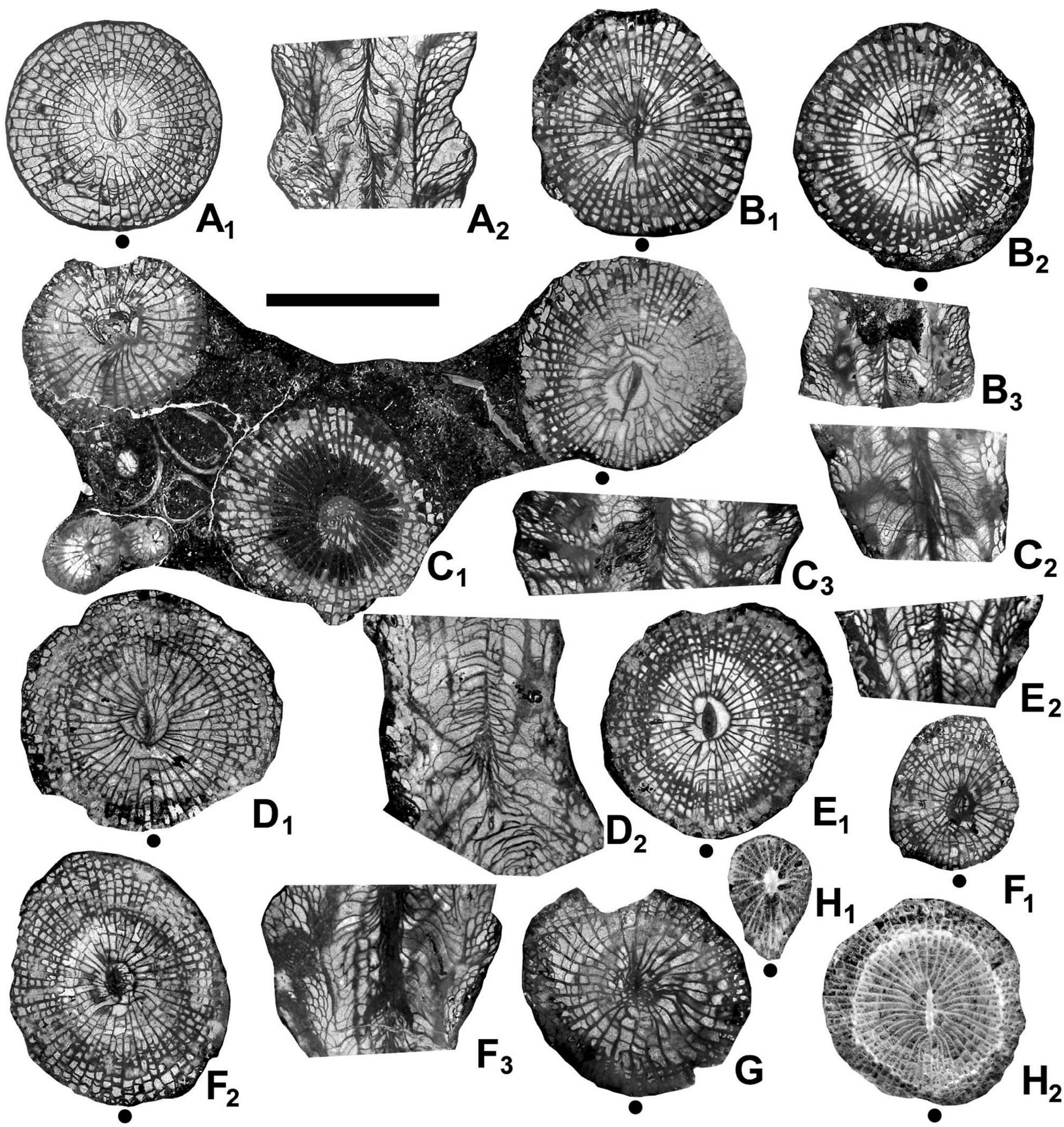

Figure 5. *Amygdalopyllum tanaicum* (Vassiljuk, 1960). **A**, "*Lithostrotion affine tanaicum*" Vassiljuk, 1960 (p. 22, fig. 1, 1a), subspecies type specimen MNH 1405/48, right bank of the Kalmius River, Donkushi-Tikhaya Balka, Vb zone; $\mathbf{A}_1$, transverse section of the corallite; $\mathbf{A}_2$, longitudinal section. **B–F**, left bank of the Mokra Volnovakha River near Styla village. **B**, specimen TSNUK 2P267-A-b-7; $\mathbf{B}_{1\text{-}2}$, transverse sections; $\mathbf{B}_3$, longitudinal section. **C**, specimen TSNUK 2P267-A-b-4. $\mathbf{C}_1$, transverse section through densely packed corallites, $\mathbf{C}_{2\text{-}3}$, longitudinal sections. **D**, specimen TSNUK 2P267-A-b-1; $\mathbf{D}_1$, transverse section; $\mathbf{D}_2$, longitudinal section. **E**, specimen TSNUK 2P267-A-b-5. $\mathbf{E}_1$, transverse section, $\mathbf{E}_2$, longitudinal section. **F**, specimen TSNUK 2P267-A-b-6. $\mathbf{F}_{1\text{-}2}$, transverse sections, $\mathbf{F}_3$, longitudinal section. **G**, specimen TSNUK 2P267-A-b-2, transverse section. **H**, specimen TSNUK 2P267-A/Vbc-5/2, Southern Quarry, Vb-c. $\mathbf{H}_{1\text{-}2}$, transverse sections, polished surfaces. Cardinal septum is marked by a dot in transverse section. Scale bar = 10 mm.

tabularium. Minor septa long, entering the tabularium. Fossula conspicuous. Cardinal and counter septa long and connected in axial area. Dissepimentarium wide, consisting of small concentric dissepiments and occasional peripheral lonsdaleoid dissepiments. Inner margin commonly thickened. Tabularium biform and consisting of incomplete tabulae, upturned towards the axial structure and vesicular near the dissepimentarium. Axial structure variable, consisting of a thickened median plate, thickened septal lamellae and thickened, strongly upturned axial tabulae (after Vassiljuk, 1960).

Material. Seven specimens 2P267-A-b-1, A-b-2; A-b-4; A-b-5; A-b-6; A-b-7; left bank of the Mokra Volnovakha River,

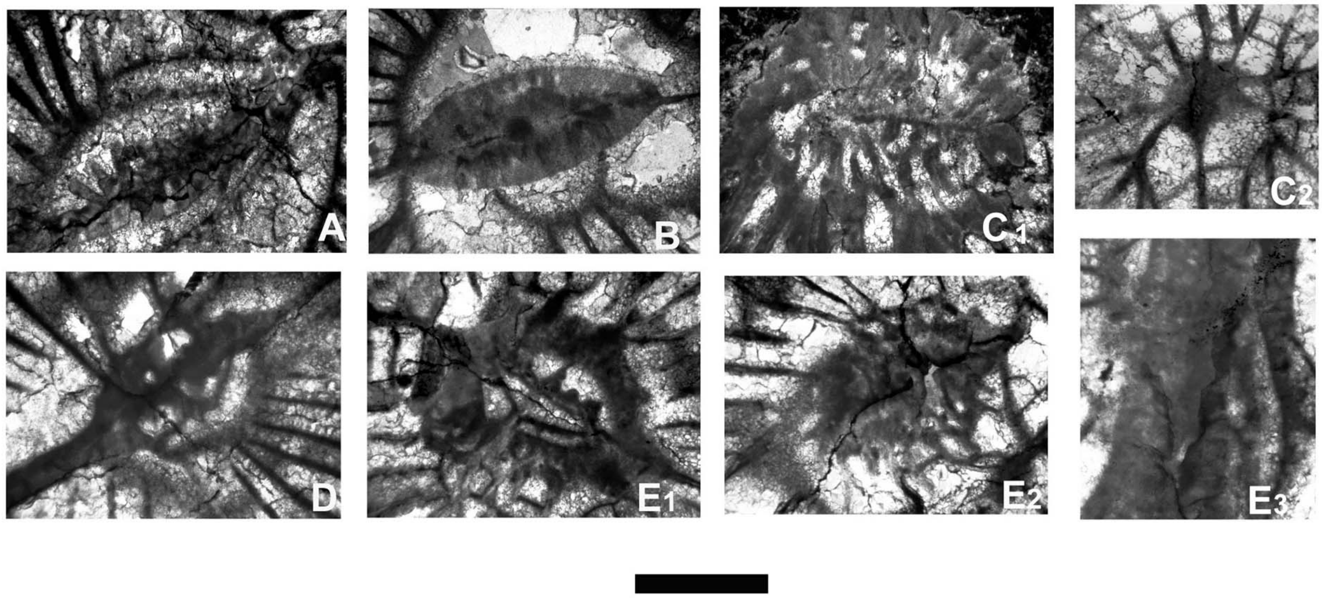

Figure 6. *Amygdalophyllum tanaicum* (Vassiljuk, 1960). Close-up views of the axial structure. Locality and stratigraphic position see on the explanation to Figure 5. **A**, specimen TSNUK 2P267-A-b-1, transverse section (enlarged from Figure $5D_1$). **B**, specimen TSNUK 2P267-A-b-5, transverse section (enlarged from Figure $5E_1$). **C**, specimen TSNUK 2P267-A-b-4; $\mathbf{C_1}$, transverse section (enlarged from Figure $5C_1$); $\mathbf{C_2}$, transverse section (enlarged from Figure $5C_1$, note the young corallite on the bottom left). **D**, specimen TSNUK 2P267-A-b-7, transverse section (enlarged from Figure $5B_1$). **E**, specimen TSNUK 2P267-A-b-6; $\mathbf{E_{1\text{-}2}}$, transverse sections ($\mathbf{E_1}$, enlarged from Figure $5F_1$; $\mathbf{E_2}$, enlarged from Figure $5F_2$); $\mathbf{E_3}$, longitudinal section (enlarged from Figure $5F_3$). Scale bar = 1 mm.

near Styla village; specimen 2P267-A/Vbc-5/2, Southern Quarry. Seventeen thin sections and two polished surfaces.

Description. Solitary but commonly gregarious (see Figure $5C_1$), cerato-cylindroid coral with predominant cylindrical part. Maximal diameter of 16.5 mm. Outer surface of corals covered with longitudinal growth striae. Major septa long, only slightly withdrawn from the axis, thin in the dissepimentarium and commonly thickened in the tabularium area. Minor septa thick, 1/3 to 2/3 of the major septa length, appearing in the counter quadrant where the diameter > 4.5 mm. Septal indexes: 26:5 mm; 32:8 mm; 32–35:10–13.0 mm; 34–35:13.0–14.0 mm; 37:12–14.2 mm, tabularium 6.5–8 mm-wide. Cardinal septum long, reaching the axial structure, in inconspicuous fossula. Cardinal-lateral septa occasionally shortened with their axial ends inclined towards the cardinal septum. Dissepimentarium 1.8–4.5 mm-wide, with an inner zone of 6–8 rows of concentric rectangular dissepiments and an outer zone including some large lonsdaleoid dissepiments. Dissepimentarium not developed in coral < 5 mm in diameter. Conspicuous inner wall made of thickened inner row of dissepiments. Spindle-shaped axial structure thickened with stereoplasma; 0.6–1.2 mm-thick, connected to cardinal and counter septa, irregularly thickened and curved septal lamellae and intersection of axial tabulae immersed in stereoplasma. Tabularium biform, consisting of incomplete, commonly vesicular tabulae, thickened, and upturned towards the axial structure. Smaller observed growth stages (Figure $5C_1$) with septal index 22:4.5 mm where nine major septa including the cardinal septa reach the axial structure. Cardinal septum located in conspicuous fossula. Minor septa only developed in cardinal quadrants < 1/3 of the major septa in length. Circular axial structure 0.6 mm in diameter cuspidate and connected to cardinal and counter septa immersed in a stereoplasma. Axial ends of some major septa joining the axial structure. Wall 0.7 mm-thick, formed by the fused bases of septa.

Intraspecific variations. The species is characterized by significant variability affecting primarily the development of the axial structure, the degree of thickening of the septa in the tabularium and the composition of the dissepimentarium. The range of variability of the axial structure are illustrated in Figure 6 with corals from a uniform assemblage from the same locality. In mature stages, the axial structure varies from lenticular to thickened rectilinear or S-shaped (Figure $3B_2$). The development of stereoplasma is inconsistent. The variability of the dissepimentarium is expressed by its width, in the presence or absence of lonsdaleoid dissepiments and thickening of the inner row.

Remarks. *Amygdalophyllum praecursor* – especially Howell's (1938, pl. 1, figs. 16–18) '*Koninckophylloid varians*' – is very similar to present material and differs only by a larger size (up to 24 mm), higher number of septa (up 46) and more complex axial structure. *A. tanaicum* differs from *A. sudeticum* Żołyński, 2000 which has similar dimensions, by a smaller axial structure and a larger disseppimentarium. *Amygdalophyllum tanaicum* is very similar to specimens from the uppermost Tournaisian of Belgium and South Wales (Poty, 2007, Denayer *et al.*, 2011, pl. 5, fig. G).

Distribution. Lower Viséan (Vb–c zones), left bank of the Mokra Volnovakha River, Eastern Quarry.

Cyathoclisia Dingwall, 1926

Type species. *Cyathoclisia tabernaculum* Dingwall, 1926; Tournaisian of England.

Diagnosis. Major septa thickened in the cardinal quadrant of the tabularium. Minor septa as long as the dissepimentarium width, contratingent in some cases. Axial structure large, made of a thickened axial plate, numerous radial lamellae and axial tabulae. Cardinal fossula well-developed, with a short cardinal septum. Radial lamellae connected to the axial ends of the major septa, commonly arranged in spiral. Dissepimentarium narrow made of simple interseptal, V-shaped and second order lonsdaleoid dissepiments. Base of the septa dissected near the lonsdaleoid dissepiments. Axial tabulae upturned towards the axial structure and densely packed. Periaxial tabulae downturned toward the dissepimentarium and more spaced (after Poty, 1981).

Cyathoclisia sukhensis sp. nov.
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(Figures 7A–E)

Etymology. After Sukha Valley on left bank of the Mokra Volnovakha River near Styla village, where Vd strata are exposed.
Holotype. TSNUK 2P267-A/Vd-5, Central Quarry, lower Viséan, Vd zone.
Diagnosis. Solitary coral, 14–25 mm in diameter and 43–46 septa of both order. Major septa thick in tabularium and thin in dissepimentarium. Minor septa long, entered in tabularium. Axial structure simple, disintegrated in adult stage, consisting of thick median plate connected with counter septa and few septal lamellae. Dissepimentarium consists of concentric dissepiments arranged in inclined rows. Tabularium biform; tabulae incomplete, slightly inclined upwards to the median plate.
Material. Holotype and six specimens; eight thin sections made from the holotype 2P267-A/Vd-5 and from three paratypes (2P267-A/Vd-7, Vd-9, Vd-13). Other specimens (including paratypes 2P267-A/Vd58, Vd59 and Vd60) were studied on polished surfaces. Most specimens are slightly silicified; outer wall, calice and apex are not preserved.
Description. Trochoid solitary corals with a maximum diameter of c. 43 mm. Septal indexes: 30–31:5.5–7.2 mm; 40:13.5 mm; 41–42:15–20 mm; 44–46:21–25 mm; 45–47:34 mm; 70:40 mm; 82:43 mm. Major septa long, thick, reaching the axis and connected to the median plate in early growth stages (Figure 7A). In late growth stages, major septa withdrawn from the axis and bent towards the cardinal septum (Figure $7E_1$). Cardinal and counter septa long and connected to median plate in early growth stages then withdrawn in later stages. Alar septa shortened and limiting a conspicuous alar pseudofossulae or do not differentiate from other major septa. Minor septa thin in the dissepimentarium, variable in length, usually entering the tabularium. Axial structure consisting of thick median plate with conspicuous dark midline in continuation with cardinal and counter septa. Axial structure already complex in juvenile stages (4 mm-wide where corallite < 13 mm in diameter) displaying 6–8 septal lamellae adjacent or somewhat separated from the median plate by intersections of 3–4 axial tabellae. Septal lamellae variably thickened, with indistinct connections with major septa. In adult growth stages, axial structure commonly disintegrated with axial plate reduced near cardinal septum (Figure $7E_1$). Dissepimentarium up to 6 mm-wide, comprising of 10–12 row of rectangular dissepiments, separated from tabularium by thickened inner margin. In longitudinal sections dissepiments moderately inclined (40º). Tabularium biform, divided into axial and peripheral zones. Axial tabellae slightly upturned towards the median plate, peripheral tabellae complete or incomplete, less inclined towards the axial column (Figure $7E_2$).
Remarks. Based on the early growth stages of *Cyathoclisia modavensis* (Salée, 1913), described by Soshkina (1960, figs. 6, 7) and Weyer (2006, abb. 2), it is clear that the present specimens belong to the genus *Cyathoclisia*. The main difference from species with long minor septa, which are widespread in the Tournaisian, is the structure of the axial column. In the new species, the axial column seen in transverse section is of *Dibunophyllum*-type with a prominent axial plate. This similarity apparently led Lissitzin (1925) to introduce the new name *Protodibunophyllum* for such corals. However, Lissitzin (1925) proposed no type species nor figuration for the new genus; consequently, it is considered as a *nomen nudum*. Besides its simplified axial structure, *Cyathoclisia sukhensis* sp. nov. differs from *Cyathoclisia modavensis* (Salée, 1913) by relatively sparse and more concave tabula. From *Cyathoclisia uralensis* Sayutina, 1970 and *C. soshkinae* Sayutina, 1973, it differs by a more complex axial structure with a thickened median plate at all growth stages. *Rhodophyllum dubium* Gorsky, 1932 (Gorsky, 1932, p. 51–52, pl. 5, fig. 14–17) from the upper Tournaisian (Iljina, 1939, p. 96, pl. 3b, fig. 12) and Viséan (Soshkina *et al*., 1962, p. 237, pl. 14, fig. 3) of Kazakhstan, displays a similar morphology. However, only the mature stages of the type specimen were described and illustrated, precluding a comparison of the early stages of growth with those of the present species.
Distribution. Same as for the holotype.

Vassiljukia Denayer & Ogar, 2016

Type species. *Lithostrotion columnariformis* Vassiljuk, 1960 from the lower Viséan of the Donets Basin.

Diagnosis. Cerioid or sub-cerioid coral showing a variably thickened amygdalophylloid axial structure. Long major septa reaching the axis of the coral. Minor septa long, entering into the tabularium. Minor septa usually less thickened than

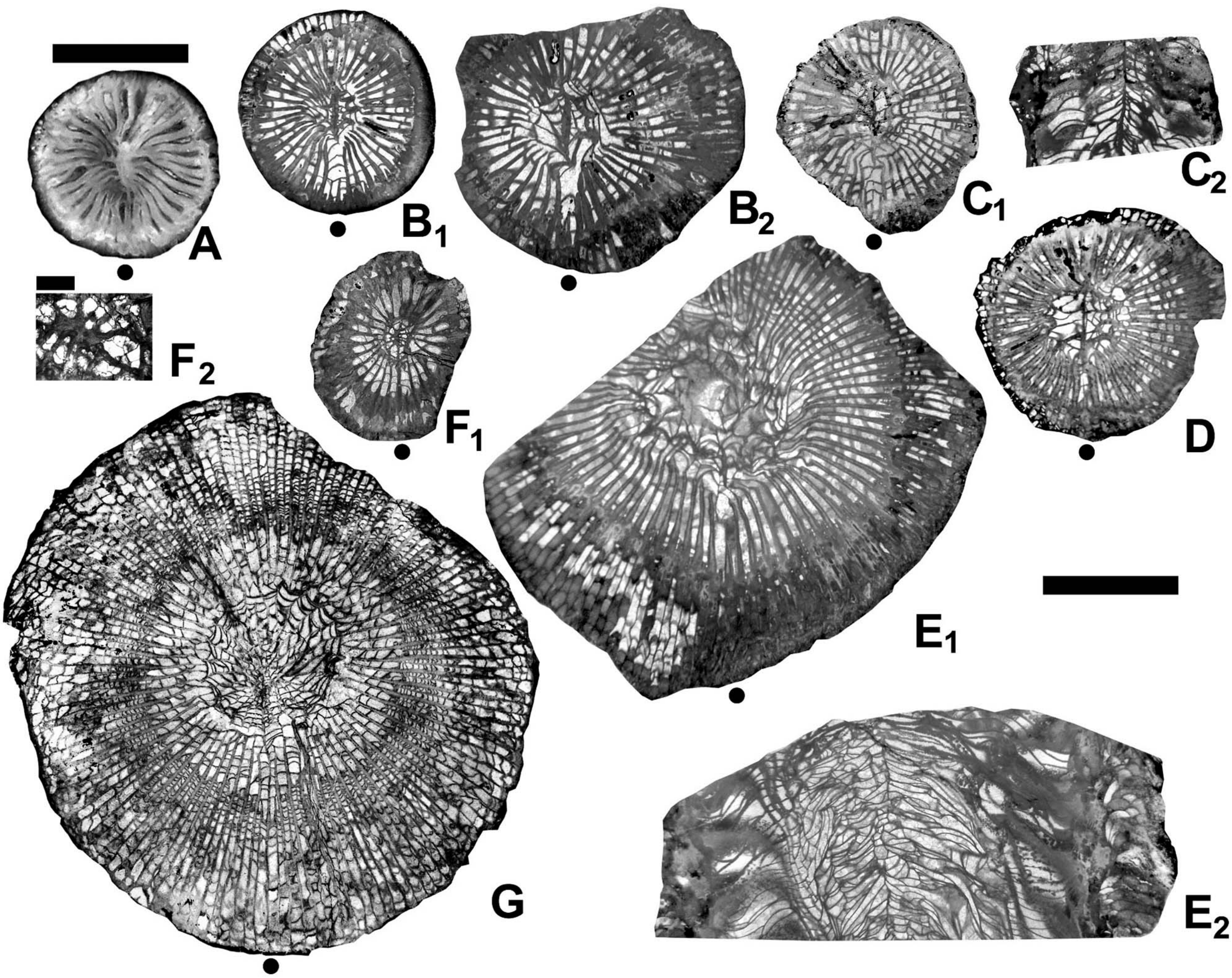

Figure 7. *Cyathoclisia sukhensis* sp. nov. **A–E**, Central Quarry, Vd zone; **A**, paratype TSNUK 2P267-A/Vd-58, transverse section, polished surface. **B**, paratype TSNUK 2P267-A/Vd-7, $\mathbf{B}_{1\text{-}2}$, transverse section. **C**, holotype TSNUK 2P267-A/Vd-5; $\mathbf{C}_1$, transverse section, $\mathbf{C}_2$, longitudinal section. **D**, paratype TSNUK 2P267-A/Vd-9, transverse section. **E**, specimen 2P267-A/Vd-13; $\mathbf{E}_1$, transverse section; $\mathbf{E}_2$, longitudinal section in adult growth stage. *Axophyllum simplex* (Garwood, 1913). **F**, specimen TSNUK 2P267-A-b-3, left bank of the Mokra Volnovakha River, Vb zone; $\mathbf{F}_1$, transverse section; $\mathbf{F}_2$, axial structure, enlarged from F_1. *Clisiophyllum* cf. *multiseptatum* Garwood 1913. **G**, specimen TSNUK 2P267-A/Vd-1, Central Quarry, Vd zone, transverse section. Cardinal septum is marked by dot in transverse section. Scale bars: A = 5 mm; B–F_1, G = 10 mm; F_2 = 1 mm.

the major septa. Dissepimentarium composed of concentric interseptal dissepiments and occasional second order lonsdaleoid dissepiments. Tabulae incomplete, conical, commonly thickened near the axial structure. Increase lateral and non-parricidal (Denayer & Ogar, 2016).

Vassiljukia columnariformis (Vassiljuk, 1960)
(Figure 8B)

v*1960 *Lithostrotion columnariformis* Vassiljuk, p. 90, pl. 22, figs. 4, 4a.
1972 *Lithostrotion columnariformis* Vassiljuk: Rogosov, p. 49, pl. 12, fig. 3.
v 2016 *Vassiljukia columnariformis* (Vassiljuk, 1960): Denayer & Ogar, p. 913, figs. 1–3.

Holotype. National Museum of Natural History of Ukraine (Kyiv, Ukraine), specimen 1405/11, from the lower Viséan (Vc zone) of the Mokra Volnovakha River valley, Donets Basin. Figured by Vassiljuk (1960, pl. 22, figs. 4–4a) and Denayer & Ogar (2016, figs. 1a–b).

Diagnosis. As for the genus.

Material. Fragment of colony consisting of corroded corallites with outer wall partly dissolved and inner structure silicified; TSNUK 2P267-A/Vd-14, Central Quarry. Four thin sections.

Description. Colony fasciculate partly sub-cerioid. Major septa long, reaching the median plate of the axial structure in early growth stages (Figure $8B_5$). In mature corallites septa withdrawn from the axial structure. Minor septa half as long as the major, entering into the tabularium. Cardinal septum slightly shortened; counter septum long and commonly connected to median plate. Major and minor septa commonly thickened in the tabularium and thin in the dissepimentarium. Septal indexes: 26:8 mm; 33:15 mm; 38:22 mm. Axial structure 1.5–3 mm-long, composed of thickened spindle-

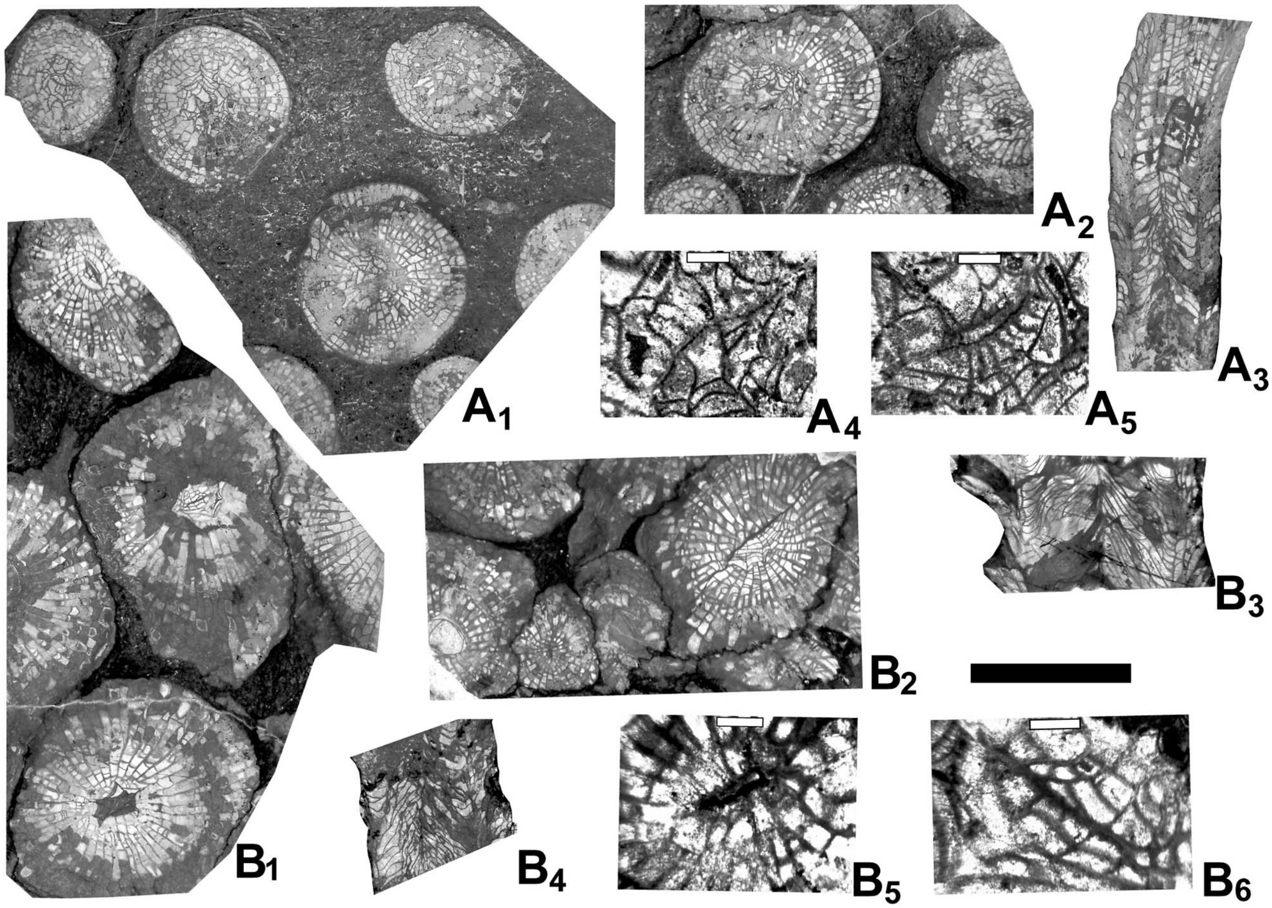

Figure 8. *Siphonodendron ondulosum* Poty, 1981. **A**, specimen TSNUK 2P267-A/Vd-3, Central Quarry, Vd zone; $\mathbf{A}_{1-2}$, transverse sections; $\mathbf{A}_3$, longitudinal sections of the corallites; $\mathbf{A}_{4-5}$, transverse sections (enlarged from A_1). *Vassiljukia columnariformis* (Vassiljuk, 1960). **B**, specimen TSNUK 2P267-A/Vd-14, Central Quarry, Vd zone; $\mathbf{B}_{1-2}$, transverse section of the destroyed colonies fragment; $\mathbf{B}_{3-4}$, longitudinal sections of the corallites; $\mathbf{B}_{5-6}$, transverse sections of the corallites axial zone; B_5 enlarged from B_2 and B_6 enlarged from B_1. Scale bars: A_{1-3}, B_{1-4} = 10 mm; A_{4-5}, B_{5-6} = 0.5 mm.

shaped median plate associated with the counter (?) septum, 10–14 axial lamellae and 3–5 axial the tabulae intersections. Dissepimentarium 2.5–3.0 mm-wide, commonly separated from the tabularium by a thickened margin, composed of 6-8 rows of concentric rectangular dissepiments. Lonsdaleoid dissepiments occasionally observed where the peripheral parts of the corallite are not eroded. Tabularium clearly biform, composed of densely packed (10 tabulae per 5 mm), steeply inclined (c. 40°) incomplete conical tabulae.

Remarks. The described specimen does not differ significantly from the previously described holotype and specimens from the Donets Basin and NW Turkey.

Distribution. Donets Basin Vc–d zones; uppermost Moliniacian, RC5B coral zone of NW Turkey (Denayer & Ogar, 2016); lower Viséan (Syradasaisky horizon) of Eastern Taimyr (Rogosov, 1972).

Subfamily CLISIOPHYLLINAE Nicholson, 1889

Clisiophyllum Dana, 1846

Type species. *Clisiophyllum keyserlingi* McCoy, 1849; (Lower Carboniferous) of Derbyshire, England.

Diagnosis. Ceratoid to cylindrical solitary coral. Axial structure well developed, made of an axial plate thin of various length, numerous radial lamellae connected or not to the axial ends of the septa, and axial tabulae. Cardinal fossula opened, with shorter cardinal major septum or connected to the axial plate. Minor septa long. Dissepimentarium large, made of small simple interseptal dissepiments. Tabulae incomplete, axial tabulae upturn toward the axial plate, periaxial tabulae slighty downturned toward the dissepimentarium (after Poty, 1981).

Clisiophyllum cf. *C. multiseptatum* Garwood, 1913
(Figures 7G)

Material. One fragment of a large corallum enclosed in the rock, 2P267-A/Vd-1, Central Quarry, Vd zone. One thin section.

Description. Large solitary coral up 38 mm in diameter. Septal index: 68:38 mm. Major septa long, up to 3/4 of the corallite radius in length, spindle-shaped, thickened both in the outer tabularium and inner dissepimentarium. Minor septa noticeably thinner than major septa and up to 4/5 of the major in length, slightly entering into the tabularium. Cardinal septum long and connected to the median plate.

Cardinal fossula conspicuous. Axial structure rounded, up to 10 mm in diameter, composed of an indistinct median plate connected to the cardinal septum, 30 slightly curved and twisted septal lamellae and 6–8 intersections of axial tabulae. Dissepimentarium 10–11 mm-wide, composed of up to 18 rows of concentric rectangular and irregular dissepiments. Dissepiments small in the inner part of coral and increasing in size towards the periphery. Small lonsdaleoid dissepiments occasionally developed. Tabularium biform, 20 mm in diameter. Axial tabulae more densely packed than peripheral ones. Outer wall 0.3 mm thick.

Remarks. The present specimen is similar to large *Clisiophyllum multiseptatum* (Garwood, 1913; Somerville *et al*., 1986) and differs by longer cardinal septum connected with median plate; wider dissepimentarium (up 18 rows of dissepiments compared up to 8 in *C. multiseptatum*) consisted of less regular dissepiments. It is very similar to some late Viséan species such as *Clisiophyllum keyserlingi* McCoy, 1849 (compare with *e.g.* Denayer *et al*., 2011 pl. 9, fig. C) and differs from letter species by relatively compact axial structure reaching only 1/4 of corallite diameter.

Distribution. Lower Viséan, Vd zone of the Donets Basin. *Clisiophyllum multiseptatum* occurs in the upper part of the Arundian regional substage in the Dyserth area of North Wales (Somerville *et al*., 1986).

Suborder LONSDALEIINA Spassky, 1974
Family AXOPHYLLIDAE Milne-Edwards & Haime, 1851
Subfamily AXOPHYLLINAE
Milne-Edwards & Haime, 1851

Axophyllum Milne-Edwards & Haime, 1850

Type species. *Axophyllum expansum* Milne-Edwards & Haime, 1850; upper Viséan, Visé Formation, Belgium.

Diagnosis. Solitary coral with two orders of septa usually interrupted by lonsdaleoid dissepiments. Axial structure made of a strong axial plate, thick irregular and braided radial lamellae and upturned edges of tabulae. Fossula inconspicuous or absent. Dissepiments long in longitudinal section. Axial tabulae upturned towards the axis. Periaxial tabulae horizontal or upturned toward the axis. Outer wall usually festooned (after Poty, 1981).

Axophyllum simplex (Garwood, 1913)
(Figure 7F)

*1913 *Carcinophyllum simplex*: Garwood, p. 556, pl. 48, figs. 3a–3c; 4a–4b.
1930 *Carcinophyllum simplex* Garwood, 1913: Ryder, p. 343.
v 2003 *Axophyllum simplex* (Garwood, 1913): Poty *et al*., pl. 3, fig. 4, 5.
v 2011 *Axophyllum simplex* (Garwood, 1913): Denayer *et al*., p. 168, pl. 6, fig. C.

Holotype. BGS, Keyworth, UK, NW England, Meathop, *Seminula gregaria* Sub-zone, Chadian Substages), illustrated by Garwood (1913, pl. 48, fig. 4).

Diagnosis. *Axophyllum*, 12 mm (maximum 17) in diameter, having 29 major septa. Minor septa short but reaching the inner edge of the dissepimentarium. Cardinal fossula inconspicuous. Axial structure made of a thick axial plate connected to the cardinal septum, surrounded by several thickened radial lamellae not connected to the septa, and axial tabulae. Dissepimentarium present only in mature stages made of simple interseptal and first order lonsdaleoid dissepiments. Axial tabulae small, disserted by the radial lamellae of the axial structure. Periaxial tabulae irregular and vesicular. Outer wall thick and festooned (after Garwood, 1913).

Material. Three specimens TSNUK 2P264-A-b-3; b-6; b-7; two thin sections and nine polished surfaces were studied. Left bank of the Mokra Volnovakha River, Vb zone.

Description. Solitary corals with maximal diameter of 14 mm, with slightly ribbed outer surface. Major septa long. Minor septa developed in corallite > 7 mm in diameter, only slightly entering in the tabularium. Major and minor septa thickened in the dissepimentarium and often interrupted by lonsdaleoid dissepiments. Long cardinal septum reaching axial area. Septal indexes: 20:5–6 mm; 22–23:7–10 mm; 26–27:11–14 mm. Axial structure 2.0–2.2 mm-wide consisting of thickened median plate connected with the cardinal septum and up to 10 short irregularly curved and thickened axial lamellae distinctly unattached to major septa. In the early growth stages axial structure formed by axial end of cardinal septum. Dissepimentarium appearing in corallites > 6 mm in diameter composed of one row of lonsdaleoid dissepiments usually thickened, forming an inner wall. Tabulae incomplete, slightly upturned towards the median plate, horizontal or downturned near the dissepimentarium. Outer wall up to 1 mm-thick in the early growth stages and significantly thinner in the mature stages (up to 0.3 mm).

Remarks. These specimens are the first *Axophyllum simplex* (Garwood, 1913) described from the Donets Basin. According to Garwood (1913) it is characterized by the appearance of large loose dissepiments only in mature growth stages and of simple axial structure. In addition, Ryder (1930) indicates a connection between the median plate (columella) with the counter septum. However, Garwood's illustrations (1913, pl. 48, figs. 3a–b) show that the thickened median plate is connected rather with the cardinal septum. *Axophyllum simplex* belongs to a group of species characterized by scarce lonsdaleoid dissepiments (Rodríguez & Somerville, 2014). The most similar species is *Axophyllum densum* (Ryder, 1930) (see Ryder, 1930, fig. 4) and Poty (1981, fig. 8) with its delayed appearance of dissepiments and the median plate connected with the cardinal septum. Moreover, with a septal index of 34:15 mm it differs from *Axophyllum simplex* that has a septal index of 27:14 mm. Differences with other similar species were discussed by Rodríguez & Somerville (2014, see their figs. 4, 6 and table 1).

Distribution. Chadian and lower part of Arundian regional substages (lower Viséan *Seminula-gregaria* Subzone, *Spirifer furcatus* Band and underlying bed) of NW England, (Garwood, 1913); Chadian Rugose Assemblages A and B of SW England, (Mitchell, 1989); lower part of the Moliniacian (RC4β2 coral zone) Visé Formation, of Belgium (Denayer *et al*., 2011; Poty, 1989; 2007); uppermost part of the Eliaszovka Formation (probable RC4β2) of the Krakow area, Poland (Poty *et al*., 2003). In the Donets Basin it occurs in the lowermost Viséan (Vb zone).

Suborder LITHOSTROTIONINA
Spassky & Kachanov, 1971
Family LITHOSTROTIONIDAE d'Orbigny, 1851
Subfamily LITHOSTROTIONINAE d'Orbigny, 1852

Siphonodendron McCoy, 1849

Type species. *Siphonodendron pauciradialis* McCoy, 1844. Carboniferous arenaceous limestone, Ireland.

Diagnosis. Fasciculate colonial coral. Major septa of various length, reaching commonly the axis. Minor septa half as long as the dissepimentarium width. Axial structure made of a lath-like columella usually connected to the counter septum and commonly to several other major septa. Dissepimentarium usually wide, made of small simple dissepiments, but reduced or absent in species of small diameter. Cardinal fossula small and opened. Tabulae often complete cone-shaped, upturned towards the columella and downturned towards the dissepimentarium. Outer wall thin, straight, undulating or festooned. Increase lateral and non-parricidal (after Poty, 1981).

Siphonodendron ondulosum Poty, 1981
(Figure 8A)

v *1981 *Siphonodendron ondulosum* Poty, p. 26, text-figs. 17–18, pl. 8, fig. 1–3.
1973 *Lithostrotion* aff. *affine tanaica* Vassiljuk: Degtjarev, pl. 5, fig. 4.
1973 *Corwenia vagaeformis*: Degtjarev, p. 197, pl. 3, fig. 3.
v 2011 *Siphonodendron ondulosum* Poty: Denayer *et al*., p. 171, pl. 6, fig. J.
v 2014 *Siphonodendron ondulosum* Poty: Denayer, p. 751, figs. 10B–H, 12A–E [cum. syn.].

Holotype. Colony Cor. 45; Human and Animal Paleontology Collections, Université of Liège, Belgium, Namur Sedimentation Area, Corphalie ravine, Moliniacian (lower Viséan), lower part of the Neffe Formation (RC5β and MFZ11 zones).
Diagnosis. Dendroid, phaceloid or sub-cerioid *Siphonodendron* with corallites 8 to 9 mm in diameter and having 25 to 28 major septa (maximum 33). Two to six rows of regular dissepiments, the inner row often thickened and appearing as an inner wall. Tabulae conical and incomplete. Outer wall particularly undulating (after Poty, 1981).
Material. One fragment of colony (2P267-A-Vd-10) partly recrystallized and silicified. Three thin sections.
Description. Phaceloid colony with cylindrical corallites. Major septa thin and long, not reaching the axial structure. Minor septa 1/2–2/3 as long as the major septa, commonly entering the tabularium. Cardinal fossula inconspicuous. Septal indexes: 26:8 mm; 29–33:10–11 mm. Axial zone occupied by a thin, irregularly bent, median plate connected with the counter (?) septum and rare septal lamellae connected to major septa (Figure 8A$_4$–A$_5$). Dissepimentarium consisting of 4–6 concentric, U-shaped, small (0.8–1.5 mm long and 0.3–0.4 mm high) dissepiments. In longitudinal section, dissepiments declined at 60° towards the tabularium. Tabularium separated from dissepimentarium without clear margin. Tabularium incomplete (Figure 8A$_3$). Axial tabulae not distinctly separated from periaxial ones, cone or tent shaped. Periaxial tabulae vesicular, convex, and concave (biform tabularium). Tabulae irregularly placed (18 tabulae per cm). Outer wall thin (0.1 mm), usually festooned.
Remarks. The specimens described by Vassijluk (1960) as *Lithostrotion affine tanaicum* Vassiljuk, 1960 in our opinion

Table 1. Occurrences of rugose coral genera known from the lower Viséan outside the Donets Basin (references in the main text).

	Amplexus	*Sychnoelasma*	*Haplolasma*	*Caninophyllum*	*Amygdalophyllum*	*Vassiljukia*	*Axophyllum*	*Cyathoclisia*	*Clisiophyllum*	*Siphonodendron*	*Dorlodotia*	*Ceriodotia*	*Protolonsdaleia*
NW Europe	1	1	1	1	1		1	1	1	1	1		
E Europe		1		1	1		1	1		1	?		
NW Turkey				1		1			1	1	1	1	
Omolon & Taimyr				1		1				1		1	
Urals		1		1	1		1		1	1	1	1	1
Sahara		1	1		1		1						
Taurides, Caucausus and Iran	1			1	1				1				

are solitary corals and therefore re-attributed to the genus *Amygdalophyllum*. Denayer (2014) discussed the validity of the name *S. ondulosum* Poty, 1981. Based on the wide intraspecific variability (Poty, 1981; Denayer, 2014) we also attribute to the *Siphonodendron ondulosum* Poty, 1981 the corals described as *Corwenia vagaeformis* Degtjarev, 1973 (p. 197, pl. 3, fig. 3) that co-occurs in South Urals with other corals cited by Degtjarev (1973, pl. 5, fig. 4) as *Lithostrotion* aff. *affine tanaica* Vassiljuk, 1960 (figured but not described).
Distribution. Lower Viséan (Moliniacian Substage) of Belgium (Poty, 1981, 1984, 1993), NW Turkey (Denayer, 2014), England (Javaux, 1994), and possibly in the Omolon Massif (Conil *et al*., 1982). In the Donets Basin its occurrences from the lower Viséan, Vd zone. In the South Urals *Corwenia vagaeformis* and *Lithostrotion* aff. *affine tanaica* cited by Degtjarev (1973) are from pebbles in a middle Viséan conglomerate.

Siphonodendron cf. *S. irregulare* (Phillips, 1836)
(Figure 9A)

Material. One fragment of colony 5 cm in size, 2P267-A/Vd-10, Central Quarry. Two thin sections.
Description. Fasciculate colony, corallites 4–5 mm in diameter. Major septa short, third to half as long as the corallite radius. Minor septa very short, 0.5 mm *i.e.* half of the major septa in length. In early growth stages (corallite diameter < 3 mm), cardinal septum shortened, counter septum slightly longer than other septa. Septal indexes: 15:3 mm; 18–19:4.0–5.0 mm. Columella, short, simple, plate, not developed in some corallites. Dissepimentarium consisting of one row of small (0.5 mm-long, 0.3 mm-high) dissepiments. Tabularium wide, (2.0–2.3 mm in diameter) in mature corallites. Tabulae complete, mesa-shaped, slightly upturned towards the columella, 0.5–0.9 mm apart. Outer wall 0.1–0.15 mm-thick. Increase peripheral, non-parricidal.
Remarks. The described specimen is very similar to *Siphonodendron irregulare* (Phillips, 1836) with a septal index 21–22:5 mm. However, it differs from typical *S. irregulare* by shorter septa that do not reach the axis. Similar small-sized corallites are occasional among colonies of *S. martini* in which offsets never reach an adult size, as reported by Poty (1993) from the middle Viséan of Belgium. The main difference with the Belgian cases is that no *S. martini*-sized corallites can be observed in the present material and the entire colony has *S. irregulare*-sized corallites. A second case is reported from the lower Viséan of NW Turkey (Denayer, 2014, fig. 5C). However, in both cases, the colonies are small and might represent fragments of larger colonies with larger corallites. The lower Viséan '*Lithostrotion*' *irregulare* var. *balachonkaensis* Fomichev, 1931 or '*Lithostrotion*' *balachonkaensis* Fomichev (Dobrolyubova & Kabakovitsh, 1966) from the Kuznetsk Basin is very similar to the Donets specimens, but it has larger corallites and slightly higher septal index 20–22:5-6 mm.
Distribution. Lower Viséan (Vd zone, upper part) of the Donets Basin and from the lower Viséan (RC5A coral zone) of NW Turkey (Denayer, 2014).

DORLODOTIDAE fam. nov.

Genera included. *Dorlodotia* Salée, 1920, *Ceriodotia* Denayer, 2011, *Corphalia*, Poty, 1975, *Protolonsdaleia* Lissitzin, 1925. The inclusion of *Eolithostrotionella* Zhizhina, 1956 *sensu* Sando (1983) and *Acrocyathus* d'Orbigny, 1849 would requires a detailed revision.
Diagnosis. Solitary and colonial corals with axial structure made of a thickened axial plate deriving from the counter septa, occasionally associated with axial lamellae or reduced or vertically discontinuous in small-sized species. Major septa spindle-shaped, minor septa short or not developed, fibrous and covered with lamellar stereoplasma. Dissepimentarium commonly including interseptal and lonsdaleoid dissepiments, lamellar in microstructure. Tabulae horizontal or upturned towards the axial structure. Wall thickened, commonly festooned. Increase lateral.
Remarks. Poty (1975, 1981, 2007) doubtfully included the genus *Dorlodotia* Salée, 1920 within the family Axophyllidae Milne-Edwards & Haime, 1851, subfamily Lonsdaleiinae Chapman, 1893, whereas Hill (1981) include it within the family Lithostrotionidae d'Orbigny, subfamily Thysanophyllinae Hill, 1981. Nudds (1981) who considers that *Dorlodotia* evolved from *Siphonodendron*, followed Hill (1981) in her classification. The diagnosis of the Lithostrotionidae and Axophyllidae (*cf.* Hill, 1981, p. 379 and 398) are however, poorly compatible with that of *Dorlodotia* and allied genera, notably concerning the axial structure. Hence, it is here proposed to create a new family to included those genera. The Dorlodotidae fam. nov. is included within the suborder Lithostrotionina Spassky & Kachanov, 1971 as the axial structure of the Dorlodotidae members, dominated by the axial plate is considered to be closer to that of the Lithostrotionina rather than the axial structure dominated by the axial lamellae characterising the Lonsdaleiina Spassky, 1974. The recently introduced family Colligophyllidae Fedorowski, 2020 in which this author classified various corals of various ages is clearly polyphyletic and unusable since none of the genera included in this family has been revised in the latter systematic paper.

Dorlodotia Salée, 1920

Type species. *Dorlodotia briarti* Salée, 1920. Lower Viséan; Belgium.

Diagnosis. Fasciculate colonies with lateral increase. Major septa usually withdrawn from the axis, minor septa poorly or not developed. Columella present in some species, in some cases discontinuous, composed of a single axial plate, commonly thickened. Dissepimentarium typically composed of large lonsdaleoid dissepiments and two

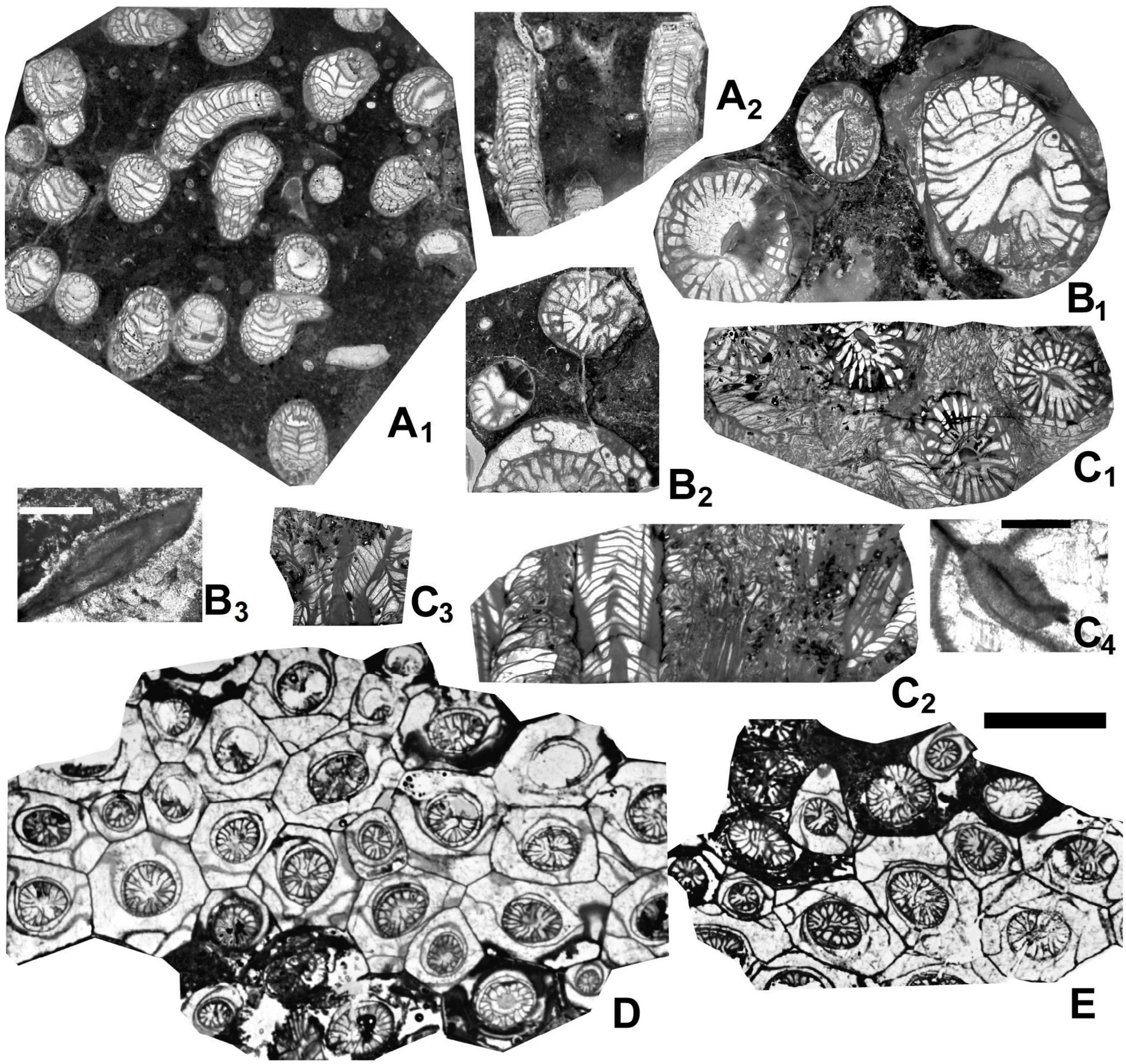

Figure 9. *Siphonodendron* cf. *S. irregulare* (Phillips, 1836). **A**, specimen TSNUK 2P267-A/Vd-10, Central Quarry, Vd zone, upper part; $\mathbf{A_1}$, transverse section; $\mathbf{A_2}$, longitudinal section. *Dorlodotia briarti* Salée, 1920. **B**, specimen TSNUK 2P267-A/Vd-11, Central Quarry, Vd zone; $\mathbf{B_{1\text{-}2}}$, transverse sections; $\mathbf{B_3}$, transverse section of the columella (enlarged from B_1). *Ceriodotia* cf. *bartinensis* Denayer, 2011. **C**, specimen TSNUK 2P267-A/Vd-16, Central Quarry, Vd zone, upper part; $\mathbf{C_1}$, transverse section; $\mathbf{C_{2\text{-}3}}$, longitudinal sections; $\mathbf{C_4}$, transverse section of the columella (enlarged from C_1). *Ceriodotia petalaxoides* Denayer, 2011. **D**, specimen D7; **E**, specimen D3a, Mokra Volnovakha river valley near Styla village, Vd zone, upper (?) part, transverse sections. Scale bars: A–$B_{1\text{-}2}$, $C_{1\text{-}3}$, D–E = 10 mm; B_3, C_4 = 1 mm.

rows of simple interseptal dissepiments. The lonsdaleoid dissepiments are usually absent or poorly developed in small-sized corallites. The inner row of simple dissepiments is commonly thickened and forms an inner wall. Tabulae complete, conical where the columella is present, flat, or domed where it is absent. The outer wall is thick and festooned (after Denayer, 2011).

Dorlodotia briarti Salée, 1920
(Figure 9B)

*1920 *Dorlodotia briarti*, sp. nov.; Salée, p. 150, figs. 5–6.

1994. *Dorlodotia briarti* Salée, 1920: Weyer, p. 161, fig. 6.7.

v 2010 *Dorlodotia pseudovermiculare* (McCoy, 1849): Ogar, p. 91, fig. 6P.

v 2011 *Dorlodotia briarti* Salée, 1920: Denayer, p. 1438, figs. 5, 6A–J [cum. syn.].

v 2011 *Dorlodotia briarti* Salée, 1920: Denayer *et al.*, p. 173, pl. 6, fig. I.

v 2011 *Dorlodotia briarti densa* Poty, 1981: Denayer *et al.*, p. 173, pl. 6, fig. H.

v 2014 *Dorlodotia briarti* Salée, 1920: Ogar, p. 6, figs. 1–4.

Lectotype. Specimen 1/78, Collection A. Salée (housed in the University of Liège), lower Viséan (MFZ11 and RC5), path from Forêt to Magnée, Eastern Belgium.

Diagnosis. Phaceloid colony with corallites 13–16 mm in diameter and 26–28 septa, commonly thickened. Minor septa poorly developed or absent. Columella strongly thickened, commonly connected to the counter septum, but absent in some cases. Dissepimentarium made of simple and lonsdaleoid dissepiments. The inner edge of the dissepimentarium is thickened. Cardinal fossula inconspicuous. Tabulae complete and upturned towards the columella. Wall thick, undulate, or festooned (after Denayer, 2011).

Material. Seven fragments of colonies from the Central Quarry: 2P264-A/16; 2P267-A/Vb-52, 53; Vb zone; 2P267-A/Vd-11; Vd-54, 55, 56 and one separate corallite 2P267-A/Vd-57; Vd zone. Two transverse and one longitudinal thin section, one polished surface were studied.

Description. Fragments of dendroid colonies consisting of sub-cylindrical corallites, maximum 15 mm in diameter (tabularium: 12 mm). Septal indexes: 19:7.5 mm; 22–28:14–20 mm. Major septa short, half of the corallites radius in length. Septa connected to the wall in early growth stages but separated from the wall by lonsdaleoid dissepiments in later stages. Thickness of septa increasing near the inner edge of the dissepimentarium. Dark median line conspicuous in the septa. Minor septa not developed, but counter-lateral minor septa occasionally developed (*cf.* upper corallite in Ogar, 2010, fig. 6P). Cardinal and counter septa elongated and occasionally connected to the axial structure in early stages, staying longer than other septa in later stages of growth. Columella thin and attached to the cardinal septum in the early growth stages, thickened (0.7–1 mm-large, 3–3.1 mm-long), spindle-shaped, with conspicuous median line in later stages of growth, occasionally missing. Dissepimentarium divided into two zones: inner zone consisting of one row of interseptal dissepiments, peripheral zone consisting of 1–2 rows of lonsdaleoid dissepiments. The first isolated dissepiments develop where corallite diameter > 4.5 mm. Continuous zone of lonsdaleoid dissepiments appearing where corallites > 8 mm in diameter. Tabularium 8–8.5 mm-wide in the mature corallite. Tabulae complete, tent-shaped, or bell-shaped, subhorizontal and upturned towards the columella. Tabulae 0.5–0.9 mm apart in vertical row. Outer wall 0.15–0.25 mm-thick, undulated or festooned. Dissepiments 5–6 mm-long and the up to 2 mm-large.

Remarks. The described specimens are almost identical to the type-material from Belgium. Some differences consist of slightly longer septa and the occasional development of the minor septa in the type-material. *Dorlodotia euxinensis* Denayer, 2011 from the uppermost Moliniacian (lower Viséan, not basal Livian as reported by Denayer, 2011) of NW Turkey has larger and more complex corallites, with more septa (septal index 30:20 mm) and a more complex axial structure. *D. pseudovermiculare* (McCoy, 1849) differs from *D. briarti* by the underdevelopment of the columella. However, it should be noted that many colonies of *D. briarti* have diphymorphic corallites (*e.g.* Poty, 1981, pl. 33, fig. 6).

Distribution. In Western Europe *D. briarti* is known typically from the Moliniacian regional substage, RC4β2- RC5α (MFZ9-11) of the southern Belgium, the Boulonnais and Avesnois areas in France and the Aachen region in Germany (Denayer *et al*., 2011), and NW Turkey (Denayer, 2011, subzone RC5B of Denayer, 2014) and from the equivalent level (Arundian regional substage) of northern Germany (Loissin borehole, Weyer, 1994). In northern England and in NE Wales this species is present in the Arundian (Nudds, 1981; Somerville & Strank, 1984; Somerville *et al*., 1989). In the Donets Basin this species is found in the lower Viséan (Vb-d zones). The specimen 2P264-A/16 initially was attributed to the species *Dorlodotia pseudovermiculare* by Ogar (2010), but actually belongs to *Dorlodotia briarti* Salée, 1920. Unfortunately, Ogar's (2010) fig. 5 caption mistakenly mentioned Volnovakha Suite (C_1^tc), Tournaisian, but the correct stratigraphic level is Vb-d zones.

Ceriodotia Denayer, 2011

Type species. *Ceriodotia bartinensis* Denayer, 2011; Moliniacian (lower Viséan, RC5B and MFZ11B biozones, cf. Denayer, 2014), NW Turkey.

Diagnosis. Cerioid corallum similar to *Dorlodotia* with major septa withdrawn from the axis. Minor septa not developed. Columella composed of a single plate, thickened and, in some cases, bearing spiny radial lamellae. Rare, upturned tabulae involved in the axial structure. Large lonsdaleoid dissepiments and interseptal concentric dissepiments commonly thickened to form an inner wall. Tabulae complete, conical or tent shaped, or flat where the columella is absent. Outer wall is thick and festooned. Increase is non-parricidal and lateral, in the lonsdaleoid dissepimentarium (after Denayer, 2011).

Remarks. Denayer (2011) introduced the genus *Ceriodotia* for *Dorlodotia* having a cerioid habitus, underdeveloped minor septa, complex axial structure involving upturned tabella and a wide dissepimentarium. The most similar genus is *Protolonsdaleia* Lissitzin, 1925 (here synonymised with *Eolithostrotionella* Zhizhina, 1956) from which *Ceriodotia* differs by the underdevelopment of the minor septa and a simpler axial structure dominated by the median plate. *Stelechophyllum* Tolmatchev, 1924 differs from *Ceriodotia* Denayer, 2011 by its usually well-developed minor septa, long and thin major septa, weak columella and, above all, by its axial increase. Note, that an important difference is also the absence of a conspicuous connection between the columella and the counter septum in *Stelechophyllum*.

Included species. *Ceriodotia bartinensis* Denayer, 2011; *Ceriodotia petalaxoides* Denayer; 2011; *Stylastraea columellata* Rogozov, 1972; *Eolithostrotionella grechovkae* Degtjarev, 1973; *Thysanophyllum druzhininae* Degtjarev, 1973.

Ceriodotia cf. *bartinensis* Denayer, 2011
(Figure 9C)

Material. One colony fragment with partly destroyed corallites, TSNUK 2P267-A/Vd-16, Central Quarry. Three thin sections.

Description. Cerioid colony, corallites 11–13 mm large. Tabularium 7–8 mm-wide, septal index 21:11–13 mm. Major septa long, thick, and wedge-shaped. Minor septa not developed. Cardinal septum shortened. Axial structure simple and spindle-shaped (0.8 mm-large, 2 mm-long) with dark middle line (Figure 9C$_4$). Dissepimentarium consisting of inner two rows of concentric rectangular dissepiments and several rows of lonsdaleoid dissepiments (crushed in this colony). In longitudinal section, dissepiments appearing flat and inclined, separated by c. 2 mm vertically. Tabulae predominantly complete, tent-shaped, slightly upturned towards the columella, densely packed (17 tabulae per vertical 1 cm). Wall 0.15–0.2 mm-thick.

Remarks. The present colony is similar to *Ceriodotia bartinensis* Denayer, 2011 but differs from it by a thinner outer wall and slightly smaller corallites (tabularium 7–8 mm in diameter and 21 septa compared to 25 septa and 8.2 mm for *C. bartinensis*). As only a single specimen is available so far, these characters might be part of the intraspecific variability (compare to Denayer, 2011, text-fig. 11) but the poor state of preservation precludes a certain attribution.

Distribution. Vd zone (upper part) of the Donets Basin. *Ceriodotia bartinensis* is known from the uppermost part of the Moliniacian (lower Viséan, RC5B and MFZ11B) of Bartın and Zonguldak areas in NW Turkey (Denayer, 2014; Denayer & Ogar, 2016) and not from the Livian substage as incorrectly reported by Denayer (2011).

Ceriodotia petalaxoides Denayer, 2011
(Figures 9D, E)

v *2011 *Ceriodotia petalaxoides* sp. nov.; Denayer, p. 1448, figs. 12 A–I.

Holotype. Colony PA.ULg.K.5.5, Animal and Human Paleontology Collection of the University of Liège, Belgium; Kokaksu section, along Kokaksu creek near Caydamar village, 2 km south of Zonguldak town, Zonguldak Municipality, NW Turkey; figured by Denayer (2011, figs. 10B–C, E).

Diagnosis. Small *Ceriodotia* with a mean tabularium diameter of 4.3 mm. There are on average 17 short major septa but no minor septa. Columella made of a single short plate, in some cases sinuous and continuous with the counter septum in the young stages. Two–four rows of lonsdaleoid dissepiments and 1–2 rows of interseptal dissepiments. Complete conical to tent-shaped tabulae. Wall festooned and thick (Denayer, 2011).

Material. Three colonies D3, D6, D7 from the Mokraya Volnovakha river valley near Styla village. Eight thin sections.

Description. Cerioid colonies with corallites polygonal but irregular in shape and separated by thin, commonly curved wall. Corallites 5–8 mm-large (average: 6.7 mm) and tabularium 3–4.5 mm in diameter (average: 3.7 mm). 15–17 long major septa, some reaching the axis, thin and irregularly curved or undulating. Counter major septa usually longer. All septa irregularly disposed, rarely radially disposed. Axial ends of the septa commonly curved or hooked. In some corallites, cardinal major septum slightly shorter and adjacent septa curved towards the cardinal septum. Minor septa developed in corallites with tabularium larger than 2 mm in diameter and entering the tabularium on 0.6–0.8 mm. Where developed, minor septa commonly shorter or underdeveloped in cardinal quadrants. Axial structure made of inflated axial end of the elongated counter major septum. In longitudinal section, tabulae dome-shaped or flat, irregularly spaced (nine tabulae per cm). Dissepiments almost flat near the wall and plunging axially to be almost vertical near the tabularium; 8–10 dissepiments per cm. Interseptal dissepiments almost vertical. Increase lateral in outer lonsdaleoid disspimentarium. Axial division observed in one colony.

Remarks. This species is very similar to *Ceriodotia petalaxoides* Denayer, 2011 and differs from it only by slightly developed minor septa and somewhat smaller corallites (tabularium 3.7 mm in average diameter) but it could be part of the intraspecific variability as most corallites display juvenile characters, including poor development of the axial structure. Indeed, the three colonies from the Donets Basin probably preserved only juvenile stages of growth that can be compared to early stages of *C. petalaxoides* from NW Turkey (*cf.* fig. 12E in Denayer, 2011).

Distribution. Upper part of the Moliniacian (lower Viséan) Yılanlı Formation, RC5B rugose coral biozone and MFZ11B foraminiferan biozone of NW Turkey; Vd zone, upper part (?) of the Donets Basin. Note that Denayer (2011) incorrectly reported a Livian (middle Viséan age) for this assemblage, but revision of the foraminifers led to consider an older age (see Denayer, 2014 for details).

Protolonsdaleia Lissitzin, 1925

Type species. *Protolonsdaleia mariupolensis* Lissitzin, 1925, designated here instead of the invalid *Protolonsdaleia carcinophyllosa* Lissitzin, 1925 (*nomen nudum*); lower Viséan of the Donets Basin.

1925 *Protolonsdaleia* Lissitzin, p. 62–63.
1956 *Eolithostrotionella* Zhizhina, p. 39.
1960 *Protolonsdaleia* Lissitzin, 1925: Vassiljuk, p. 106.
part 1973 *Eolithostrotionella*: Degtjarev, p. 182.
?part 1974 *Lithostrotionella* Yabe and Hayasaka, 1915: Minato & Kato, p. 65.
1978 *Protolonsdaleia* Lissitzin, 1925: Vassiljuk & Zhizhina, p. 30.
?part 1983 *Acrocyathus* d'Orbigny, 1849: Sando, p. 9.

Diagnosis. Colonial rugose coral forming colonies of prismatic, irregular polygonal or rounded corallites. Lonsdaleoid dissepimentarium, septa of both orders thickened, with cuneiform base, axial structure consisting of thickened curved plates forming an irregular structure (modified from Zhizhina *in* Vassiljuk, 1960, p. 106).

Remarks. In our opinion, the genus *Protolonsdaleia* Lissitzin, 1925, displays sufficiently distinct characters to allow a conspicuous separation from related genera. Nevertheless, the validity of the genus is not entirely accepted (see discussion by Hecker, 2012, p. 298–299). The type-species of this genus, *Protolonsdaleia carcinophyllosa* Lissitzin, 1925 was not adequately illustrated by Lissitzin (1925, pl. 1, fig. 3; 1929, pl. 19, fig. 15) and never received a proper description (not even in Zhizhina's unpublished thesis in 1948). In addition, Lissitzin's collection specimen numbers were not provided, and the specimens are most probably lost nowadays. Hence, it is suggested to designate *Protolonsdaleia mariupolensis* Lissitzin, 1925 (holotype CNIGRI Museum, nº 6579 15/3) as the type species of the genus *Protolonsdaleia*. *Protolonsdaleia* differs from the genus *Lonsdaleia* McCoy, 1849 in the irregular axial structure, which is composed of irregularly curved or twisted lamellae, as well as the lack of a clear differentiation of the tabulae into axial and periaxial. In *Ceriodotia* Denayer, 2011 the minor septa are usually not developed, and the axial structure is a simple but thickened plate-like columella. The genus *Eolithostrotionella* Zhizhina, 1956 was erected for colonies with corallites having a simple axial structure, usually appearing in transverse section as an irregularly curved axial plate, commonly reduced or underdeveloped. However, similar, simple axial structures are rather common in colonies of *Protolonsdaleia mariupolensis*, together with diphymorphic corallites and normal corallites with regular axial structure. The development and complexity of the axial structure is therefore considered as part of the intra- and intercolonial variability. Consequently, the genus *Eolithostrotionella* Zhizhina, 1956 should be considered as a junior synonym of *Protolonsdaleia* Lissitzin, 1925. The cerioid colonies of *P. cystosa*, *P. rotai* and *P. lissitzini* described by Zhizhina (1960) predominantly from the upper Viséan of the Donets Basin display underdeveloped minor septa but have a more complex axial structure consisting of a median plate and few short septal lamellae.

Included species. *Lonsdaleia longisepta* Lissitzin, 1925, *Protolonsdaleia mariupolensis* Lissitzin, 1925, *Protolonsdaleia tenuis* Zhizhina, 1978 (in Vassiljuk & Zhizhina, 1978), *Sublonsdaleia intermedia* Lissitzin, 1925, *Eolithostrotionella cystosa* Zhizhina, 1960, *E. rotai* Zhizhina, 1960, *E. lissitzini* Zhizhina, 1960, *E. utkae* Degtjarev, 1973.

Protolonsdaleia mariupolensis Lissitzin, 1925
(Figure 10)

**Protolonsdaleia mariupolensis* Lissitzin 1925, p. 15, pl. 1, fig. 9.
1925 *Protolonsdaleia ramulosa* Lissitzin, pl. 1, fig. 10.
1929 *Protolonsdaleia ramulosa* Lissitzin 1925: Lissitzin, pl. 17, fig. 1.
1929 *Protolonsdaleia mariupolensis* Lissitzin 1925: Lissitzin, pl. 19, fig. 15.
v 1960 *Protolonsdaleia mariupolensis* Lissitzin 1925: Vassiljuk, p. 107, pl. 25, figs. 2, 2b.
v 1960 *Eolithostrotionella zhizhinae* Vassiljuk: Vassiljuk, p. 95, pl. 25, figs. 1, 1a.
v 2017 *Dorlodotia* cf. *vermiculare* (Degtjarev, 1973): Ogar, p. 8, figs. 5–8.

Holotype. CNIGRI Museum, three thin sections in Lissitzin's original collection. Zhizhina, nº 6579 (15/3), Sukha Volnovakha River mouth, lower Viséan. Figured by Lissitzin (1925, pl. 2, fig. 9).

Diagnosis. Cerioid and subcerioid colonies. Corallites 15–20 mm-large with 19–24 major septa. Minor septa irregularly developed. Dissepimentarium separated from tabularium by a thick margin. Axial structure variable, consisting of few curved, often thickened axial lamellae (after Vassiljuk, 1960).

Material. colonies D1, D4I, D4II, D4III, D5I, D5II, D5III, D5IV, from the Kalmius River valley near Komsomolske (now Kalmiuske) town, Vc zone; fragments of three colonies from the Central Quarry 2P267-A/Vb-50 and 51, Vb zone; 2P267-A/Vd-4, Vd zone. Three transverse and two longitudinal thin sections were studied.

Description. Cerioid and subcerioid colonies with thick and festooned wall. Corallites 10–20 mm-large, maximum 26 mm (average: 13.7 mm) with tabularium diameter 5.5–8.5 mm (average 7.3 mm). Septa numerous (20 to 30), radially disposed, straight or slightly undulating, thickened (base cuneiform) with a dark median line. Counter major septum slightly longer and/or thicker than the other major septa, attached or not to the axial structure. Other major septa leaving a free zone around the axial structure. Minor septa occasionally developed, up to 1 mm-long and thinner than the major ones but with base thickened. Dissepimentarium wide, made of 2–3 rows of interseptal dissepiment, concentric and thin except the outer row, thickened in continuation with the base of the septa and forming an inner wall. Outer 1–4 rows of large lonsdaleoid dissepiments. Axial structure varying from a simple thickened lath-like columella, straight or curved and commonly connected to the counter major septa, to a reticulate structure with short radial lamellae irregular in number, length and disposition, and some axial tabellae. Diphymorphic individuals occur. In longitudinal section, tabulae conical to tent-shape with axial tabellae around the irregular axial structure, 15–20 tabulae per cm. Dissepiments up to 1 mm-high and 6 mm-long, regularly disposed, declined towards the tabularium at 30–40°. Increase lateral with offsets developed in outer lonsdaleoid dissepimentarium and typically *Dorlodotia*-like. Axial division suspected.

Discussion. *Protolonsdaleia longisepta* (Lissitzin, 1925), type-species of the genus *Eolithostrotionella* Zhizhina, 1956, has a slightly narrower dissepimentarium but the tabularium, 5–9 mm in diameter is comparable to the present material. The number and length of major septa is also very similar to the specimens described and figured by Zhizhina (1956). These specimens present a size similar to that of *Protolonsdaleia tenuis* Zhizhina *in* Vassiljuk & Zhizhina, 1978 and *Protolonsdaleia utkae* (Degtjarev, 1973) but have more septa (< 20 septa in *P. tenuis* and 22–25 in *P. utkae*) and a wider and more complex dissepimentarium. They differ from

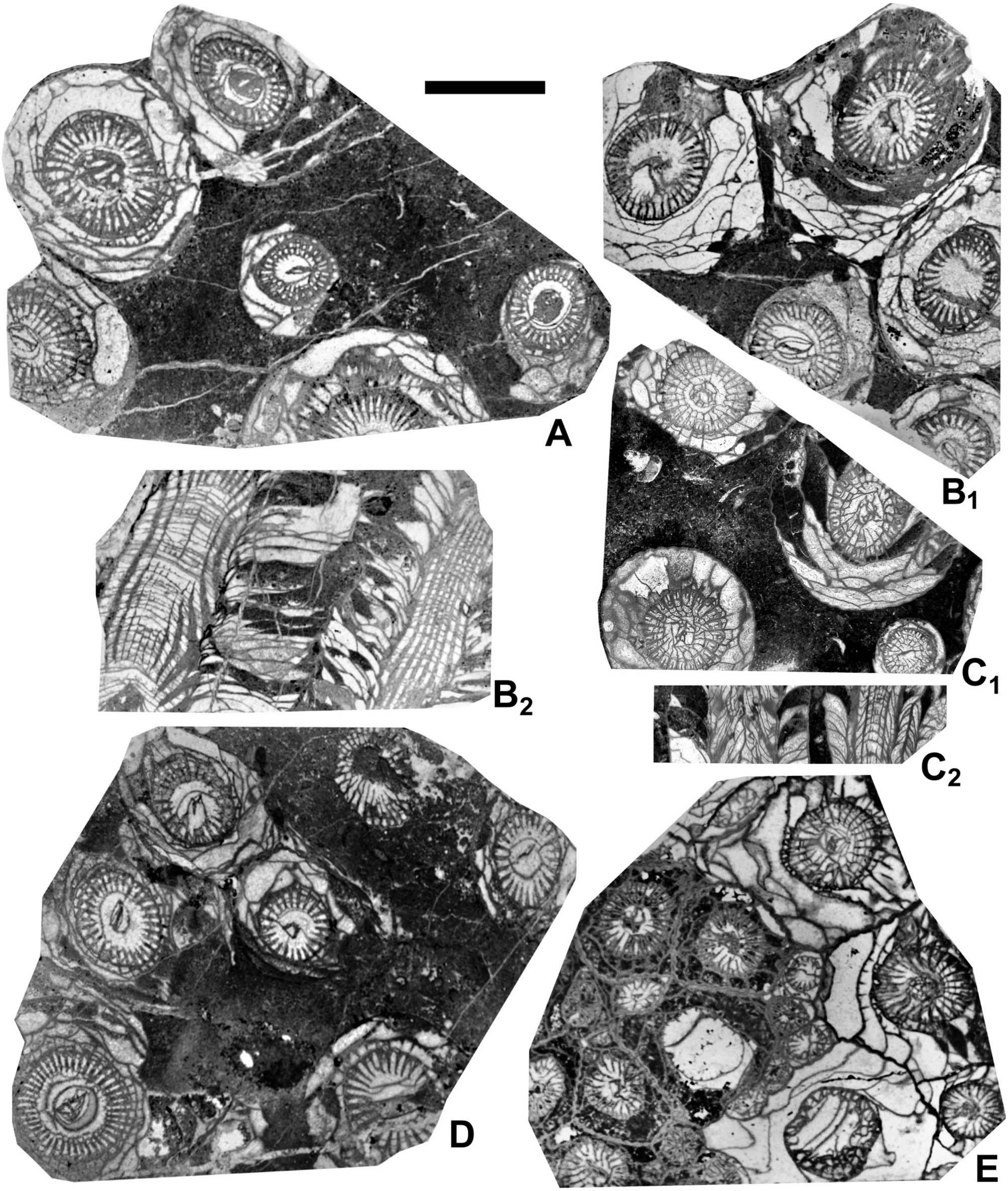

Figure 10. *Protolonsdaleia mariupolensis* Lissitzin, 1925, Specimen D5II, Kalmius River valley near Komsomolske (Kalmiuske) town, Vc zone. **A**, transverse section. **B**, specimen D5III, Kalmius River valley near Komsomolske (Kalmiuske) town, Vc zone; **B**$_1$, transverse section; **B**$_2$, longitudinal section. **C**, specimen TSNUK 2P267-A/Vd-4, Central Quarry, Vd zone; **C**$_1$, transverse section; **C**$_2$, longitudinal section. **D**, specimen D5I, Kalmius River valley near Komsomolske (Kalmiuske) town, Vc zone, transverse section. **E**, specimen D5, Kalmius River valley near Komsomolske (Kalmiuske) town, Vc zone, transverse section through a cerioid part of the colony. Scale bar = 10 mm.

Protolonsdaleia intermedia (Lissitzin, 1925) by their shorter major septa and less developed minor septa.
Distribution. Lower Viséan, Vc-d zones; the Donets Basin.

DISCUSSION

Stratigraphic distribution of the uppermost Tournaisian and lower Viséan rugose corals in the Donets Basin

The black bituminous rocks of the Dokuchaev Member (Te = Va zone) of the Donets Basin are here regarded as being the result of the global Avins event at the end of Tournaisian (Poty, 2007). At this time, cosmopolitan species of various faunal groups appeared in the basin, for example, the brachiopod *Levitusia humerosa*, the tabulate coral *Syringopora* and the solitary rugose corals *Proheterolasma* Cotton, 1973, *Cyathoclisia*, *Caninophyllum*, *Merlewoodia* and *Siphonophyllia* Scouler *in* McCoy, 1844.

A rather rich assemblage of rugose corals is characteristic of the uppemost Tournaisian in the Donets Basin (Ohar, 2020). It includes *Caninophyllum kosvensis*, *Proheterolasma omaliusi*, *Cyathoclisia modavensis*, *Calmiussiphyllum calmiussi*, *Siphonophyllia caninoides* and *Merlewoodia*. The absence of colonial rugose corals is an important feature of this assemblage, as it is the case everywhere in the Eurasian provinces.

Seventeen rugose corals species are herein described from the lower Viséan of the Donets Basin. Only a few taxa (*e.g. Amplexus coralloides* and *Sychnoelasma konincki*) continue to exist on the early Viséan. The appearance of colonial taxa sharply distinguishes this rugose coral assemblage from the previous one. Such change in rugose coral faunal assemblage from upper Tournaisian to lower Viséan is associated with the restoration of shallow-water carbonate sedimentation in the Donets Basin, which occurred after the global Avins event.

The typical markers of the lower Viséan coral zone RC5 are present: *Siphonodendron ondulosum*, *Vassiljukia columnariformis* and *Dorlodotia briarti*. Additionally, representatives of the genus *Cyathoclisia* are described in the lower Viséan. It should be noted, that I.I. Gorsky (*in* Vassiljuk, 1960, p. 11) indicated in his faunal list the species *Cyathoclisia donaicum* a *nomen nudum*, from the Vb zone. The species *Ceriodotia petalaxoides* which was previously known only from NW Turkey (Denayer, 2011) occurs in the Donets Basin. Species of the genera *Caninophyllum*, *Clisiophyllum*, *Amygdalophyllum*, *Siphonodendron* and *Ceriodotia* are left in open nomenclature because of the limited material available. Some of them might turn out to be new species in the course of further research.

From the Vb–d zone of the Kalmius River valley, Vassiljuk & Zhizhina (1979) listed without illustration the following species: *Diphyphyllum lateseptatum* McCoy, *D. latetabulatum* (= ? *Siphonodendron martini*), *Dorlodotia fomitschevi* (= *Dorlodotia briarti*) and *Protolonsdaleia intermedia*. These specimens need revision but are here included in the stratigraphic distribution in Figure 11.

Axophyllum simplex, *Amygdalophyllum tanaicum* and *Amygdalophyllym* cf. *A. meathopense* are typical for the lower part of the Skelevatka Suite (Vb–c zones) that could be equated with the rugose coral zone RC4β2 of Poty *et al.* (2006), with the lower part of Zone V of Hecker (2001) and lower part of coral zone C5 (Vassiljuk *in* Poletaev *et al.*, 1990). The RC4β2 is characterized by the first occurrence of the genera *Haplolasma* and *Axophyllum*, which both occur at the base of the Vb zone in the Donets Basin. *Dorlodotia briarti*, which is a very typical component of the next zone (RC5) is known to occur sporadically in older strata (top of RC4β2, Poty *et al*., 2006) as it is the case here. Alternatively, the RC5 zone could comprise the Vb-c zones. In this case, the RC4β2 would not be recorded in the Donets Basin, which is not entirely impossible as this subzone covers a time-slice characterized by a very low sea-level with very few deposits on shelves (sequence 5 in Hance *et al*., 2001) or even no deposition. This explanation is supported indirectly by a sharp change in the composition of rocks in the upper part of the uppermost Tournaisian Karpivka Suite (see Figure 2A), possibly indicating a hiatus of the entire lowermost Viséan, which is usually observed in northwestern Europe (Poty, 2016).

The upper part of the Skelevatka Suite (Vd zone) is characterized by *Cyathoclisia sukhensis* sp. nov., *Clisiophyllum* cf. *C. multiseptatum*, *Siphonodendron ondulosum*, *Siphonodendron* cf. *S. irregulare*, *Ceriodotia petalaxoides*, *C.* cf. *bartinensis* and *Vassiljukia columnariformis* (that occurs already in the Vc zone). Except *Cyathoclisia* which is mostly a Tournaisian genus (occurs also in the Chadian of England, Mitchell & Somerville (1988) and in Normandy (Vuillemin, 1990); the other coral species are typical of the lower Viséan. *Siphonodendron ondulosum* is the guide taxa for the rugose coral zone RC5 of Poty *et al.* (2006) whereas *Ceriodotia* species are used by Denayer (2014) to introduce the local subzone RC5B in NW Turkey. This subzone is recognised in the Donets Basin based on the occurrence of *Ceriodotia*. The Vd zone is also correlated to the upper part of Zone V and possibly the lower part of Zone VI of Hecker (2001) and to the coral zone C5 (upper part) of Vassiljuk *in* Poletaev *et al.* (1990).

The coral species, *P. longisepta* and *Sychnoelasma hawbankense* are found throughout the entire lower Viséan sequence, the latter two being also present higher in the Styla Suite (Ve_2 subzone, Poletaev *et al.* (2011).

Paleogeographic distribution of the early Viséan rugose corals

With some exceptions, most species and genera described here are known from lower Viséan strata outside the Donets Basin (Table 1). *Sychnoelasma*, *Caninophyllum*, *Axophyllum* and *Amygdalophyllum* are known from the British Isles (Somerville *et al*., 1986, 1989; Mitchell & Somerville, 1988), the Namur-Dinant Basin of Belgium (Poty *et al*., 2006; Denayer *et al*., 2011), Normandy (Vuillemin, 1990), the Krakow area of Poland (Poty *et al*., 2003) the Ural Mountains (Degtjarev, 1967, 1973; Sayutina, 1976) and N Africa (Semenoff-Tian-Chansky, 1974; Rodríguez *et al*., 2020). *Dorlodotia briarti* and *Siphonodendron ondulosum* also

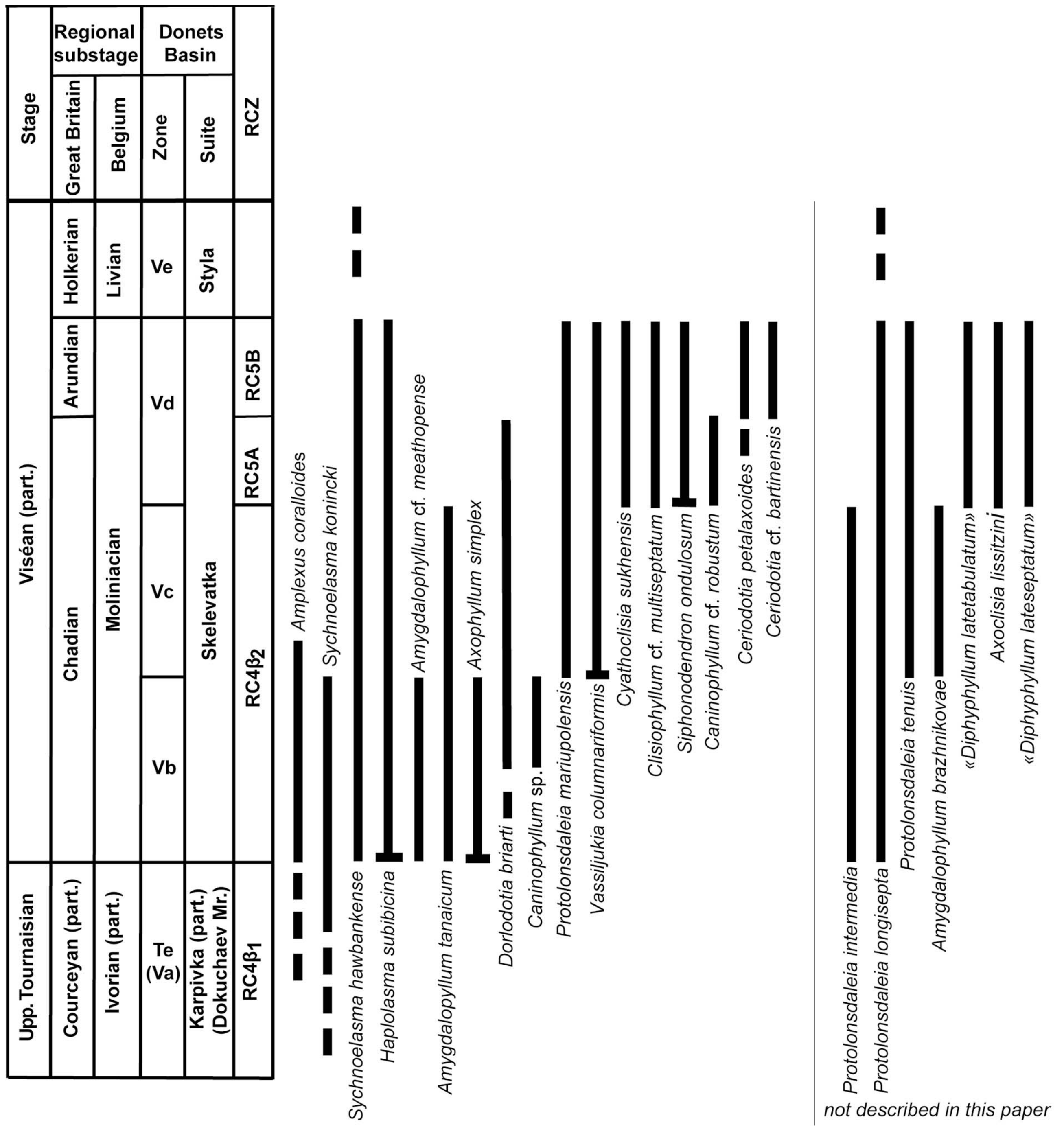

Figure 11. Stratigraphical distribution of the lower Viséan rugose corals of the Donets Basin. Stratigraphic frameworks of the Donets Basin after Poletaev *et al.*, 2011 and Poletaev & Vdovenko, 2013; W Europe (Great Britain and Belgium) after Aretz *et al.* (2020). Some species identified by Vassiljuk (1960) and Vassiljuk & Zhizhina (1978, 1979) but not described in the present paper are indicated on the right. The continuous and dashed lines indicate reliable and predicted stratigraphic intervals of species distribution, respectively; the line constraints mark First Appearance Data (FAD) known also outside the Donets Basin. RCZ Rugose coral zones and subzones (after Poty *et al.*, 2006, emended by Denayer, 2014).

occur commonly in the first two areas but also in NW Turkey (Denayer, 2011, 2014), whereas a closely related species of the latter is known from the Omolon Massif (Onoprienko, 1976).

With thirteen rugose genera recognised in the lower Viséan, the Donets Basin appears less diverse than other areas in W Europe, such as Britain (16), Belgium (20) and Germany (22,) but closer to Poland (after Rodríguez *et al.*, 2020, table 2). This might reflect a sampling bias as the latter areas were abundantly studied.

Solitary undissepimented corals (*e.g. Rotiphyllum*, *Zaphrentites*, *Ufimia*, *Rylstonia*, *Cravenia*) as well as larger dissepimented *Paleosmilia* and *Siphonophyllia* have not yet be found in the Donets Basin. Moreover, the fasciculate *Solenodendron*, recorded in the lower Viséan in the British

Isles, France, and Germany, is absent from both the Donets Basin and NW Turkey (see Rodríguez *et al*., 2020, table 2). Heterocorals are not yet recorded in the lower Viséan rocks in the Donets Basin.

It is difficult to say whether this is due to the regional or paleoecological features of this basin or a simple sampling bias. We believe that these differences are related to facial environments. In fact, the lower Viséan of the Donets Basin are composed mainly bioclastic rocks, formed in clean shallow-water conditions. Relatively deep-water argillaceous limestones accumulated in turbid waters are missing here. Nevertheless, colonial *Solenodendron* and most solitary undissepimented genera contained predominantly in the latter rocks (Hill, 1938; Somerville, 1994; etc.).

The occurrence of *Siphonophyllia*, *Bifossularia* Dobrolyubova, 1966, and *Rylstonia* Hudson & Platt, 1927 in the lower Viséan reported by Rodríguez *et al.* (2020, tab. 2) is possibly a mistake from these authors as none of these genera have been collected so far in the Donets Basin.

There are significant differences in the composition of the rugose coral assemblages from the Taurides Mountains in southern Turkey (Denayer, 2015a), Transcaucasia (Papojan, 1970), Iran (Ogar *et al*., 2013), Middle Tien Shan (Ogar, 2006, 2008b), South China (Xu & Poty, 1997). The reasons for this rather long known paleogeographic distribution (Dubatolov & Vassiljuk, 1980; Fedorowski, 1981; Sando, 1990) have not yet found a satisfactory explanation. Denayer (2015a) suggested the presence of a paleogeographic barrier (possibly stable cold currents) separating the Western and Eastern Tethys and preventing the migration of rugose coral larvae in the early Viséan times. Based on the composition of coral associations, this barrier was located approximately to the east of the NW Turkey - S Urals line and is mostly exemplified by the maximum extension of the emblematic Asian genus *Kueichouphyllum*.

CONCLUSIONS

The lower Viséan succession of the Donets Basin contains a rich and diverse rugose coral fauna, which is remarkedly different to the faunas of the upper Tournaisian and the middle and upper Viséan. The characteristic feature of the lower Viséan assemblages is the presence of the colonial rugose coral genera *Dorlodotia*, *Siphonodendron*, *Vassiljukia*, *Ceriodotia* and *Protolonsdaleia*, the latter being probably endemic to the Donets Basin (occurrences in the Urals Mountains have to be checked).

The occurrence of these common genera allows to compare the Donets assemblages with the lower Viséan associations known from various regions of the western Paleotethys Ocean. This indicates stable marine connections between the Donets Basin and the Western European basins as well as with the Ural Ocean. However, the rarity of *Siphonophyllia* and *Axophyllum* and absence of the genera *Paleosmilia*, *Cravenia*, and *Solenodendron* in the Donets Basin and NW Turkey allow separating lower Viséan rugose assemblages from Western and Eastern Europe. Endemic coral genera such as *Vassiljukia* and *Ceriodotia* seems also diagnostic for the area.

At the same time, the lower Viséan assemblages in a number of regions of the eastern Paleotethys (Iran, Transcaucasia, Middle Tien Shan, South China) are characterized by assemblages different at the generic level or with few common rugose coral species, cosmopolitan taxa excepted (*e.g. Caninophyllum*, *Amygdalophyllum*). These differences are due to paleogeographic peculiarities during early Viséan times, which remain to be clarified.

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