Solitary rugose corals from the Givetian of the Khoshyeilagh Formation (Eastern Alborz Mountains, NE Iran)

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Abstract

The Khoshyeilagh Formation in the Eastern Alborz Mountains (north-eastern Iran) consists of rocks ranging from the Givetian to the Tournaisian. We here describe a collection of Givetian solitary rugose corals from the type section of this formation. Among the reported taxa, four species are assigned to *Spinophyllum* Wedekind, 1922, including *S. zhongguoense* (He, 1978), *S. blacourti* (Rohart, 1988), *S. longiseptatum* (Lütte, 1984), and *S. arduum* (Lütte, 1985). The genus *Temnophyllum* Walther, 1929 is represented by *T. occidentale* Hill & Jell, 1970, *T.* sp. 1, and *T.* sp. 2. Furthermore, *Chostophyllum metula* Pedder, 1982, *C. gregorii* Etheridge, 1892, *Aristophyllum luetti* Coen-Aubert, 1997, *Glossophyllum ceratites* (Goldfuss, 1826) and *G.* cf. *schouppei* Lütte, 1990 are recorded.

Key words: Devonian, Givetian, Rugose corals, Khoshyeilagh Formation, Eastern Alborz Mountains, Iran.

1. Introduction

The Khoshyeilagh Formation is widely distributed across the Eastern Alborz Mountains in northeast Iran. The type section of the formation, which has been firstly studied and named by Bozorgnia (1973), is exposed along a road, approximately 60 km northeast of the city of Shahrood in northeast Iran. Although some workers (e.g., Bozorgnia 1973; Hamdi & Janvier 1981; Ashouri 2001) dated this formation into the Emsian or Eifelian, but many other workers (e.g., Brice et al. 1974, 1978; Stampfli 1978; Weddige 1984; Ashouri 1990; Wendt et al. 2005) argued that the onset of fully marine sedimentation (lower limit of the Khoshyeilagh Formation) is Givetian in age. The upper parts of the formation extend to the Famennian (Bozorgnia 1973) or latest Famennian and late Tournaisian (Ashouri 1990, 1994). The Khoshyeilagh Formation is a heterogeneous sequence of limestones, dolomites, marls, shales and sandstones with abundant and diverse groups of fossils including brachiopods, corals, trilobites, bryozoans, conodonts and tentaculites. Rugose corals are one of the main faunal groups in the fully marine Givetian to Famennian deposits of the Khoshyeilagh Formation, however, our knowledge about their systematic framework is scarce.

The aim of this paper is the description of some rugose corals coming from the Givetian rocks of the Khoshyeilagh Formation at its type section. The investigated coral fauna is a part of a large collection and the remaining material is still under study by the authors.

The material and thin sections are deposited in the museum of Geology Department, Sciences Faculty, Ferdowsi University of Mashhad, Iran.

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2. Geological setting

The Alborz Range is a gentle and sinuous east-west belt across the North of Iran in the South of the Caspian Sea. Structurally, this range is considered as a northern folded belt of the Central Iran. The Caspian Sea and the Central Iran are the northern and southern boundaries of this range, respectively. Unlike the northern and southern borders, there is no consensus about the eastern and western limits of the Alborz Mountains. Conventionally, the Binalud Mountains represents the eastern and the mountains of Azerbaijan the western prolongations of the Alborz Range. Geographically, terms such as western, central and eastern are used for subdivisions of the Alborz Mountains. The Eastern Alborz Mountains include eastern parts of the mentioned range bordered by the Binalud Mountains in the East.

Devonian deposits are widespread in the Eastern Alborz Mountains. These deposits are rather thick and fossiliferous. Generally, it is believed that the Early Devonian sequences in most parts of Iran have been deposited on a siliciclastic shelf. This condition has changed to a fully marine setting in the Middle to Late Devonian extending to the early Late Carboniferous. The Middle to Late Devonian sea level rise in the Eastern Alborz Mountains led to the deposition of a thick sequence of skeletal limestones, shales, dolomites and siliciclastic rocks which are named the Khoshyeilagh Formation (Bozorgnia 1973). Bozorgnia (1973) subdivided this formation into 6 members and 17 units ranging from the Eifelian to the

Famennian. At the type section, the formation shows a total thickness of 1200 m mainly consisting of carbonates, shales, marls and sandstones with different fossil groups. The Khoshyeilagh Formation is underlain by the ?Emsian–Eifelian Padeha Formation, characterized by sandstones, siltstones, conglomerates, and basalts. The uppermost Tournaisian–Visean Mobarak Formation covers the discussed formation in most parts of the Eastern Alborz Mountains.

Wendt et al. (2005), who gave one of the last reassessments on the Devonian and Lower Carboniferous sequences in northern Iran, assigned three members to the Khoshyeilagh Formation including Lower Carbonate Member, Siliciclastic Member and Upper Carbonate Member. The Givetian and early Frasnian Lower Carbonate Member is mainly composed of alternations of limestones, dolomites and shales. The Siliciclastic Member, which is barren of any faunal remains, consists of reddish to white sandstones, siltstones and shales. Based on underlying and overlying fossils, middle Frasnian age is inferred for this member. The Upper Carbonate Member is very rich in skeletal remains and its age is said to be late Frasnian to early Tournaisian (Brice et al. 1974; Ashouri 1994, 2004; Wendt et al. 2005).

3. Locality, description of the outcrop and age determination

The type section of the Khoshyeilagh Formation is exposed 60 km northeast of the city of Shahrood, near the village of Khoshyeilagh. The outcrops of this formation occur in the west of the village, along a road from Shahrood to the city of Azadshahr (Fig. 1).

The Lower Carbonate Member is a sequence of limestones, shales, dolomites and marls. The limestones are generally wackstones and packstones. This member with a thickness of 540 m is very rich in micro- and macrofossils such as brachiopods, corals, tentaculites, trilobites and conodonts. As mentioned earlier, its age has been determined as Givetian to early Frasnian by numerous workers (e.g., Hamdi & Janvier 1981; Kalantari 1981; Morzadec 2002; Ashouri 2006). In total, 29 lithostratigraphic units (units 16 to 44) have been assigned to the Khoshyeilagh Formation (Wendt et al. 2005, text-fig. 10), among which the units 16 to 27 represent the Lower Carbonate Member. Generally, the boundary between the Eifelian and the Givetian (the boundary between the Padeha and Khoshyeilagh formations) appears to be arbitrary, and Wendt et al. (2005: 44) placed this boundary in the unit 16, characterized by occurrences of skeletal limestones.

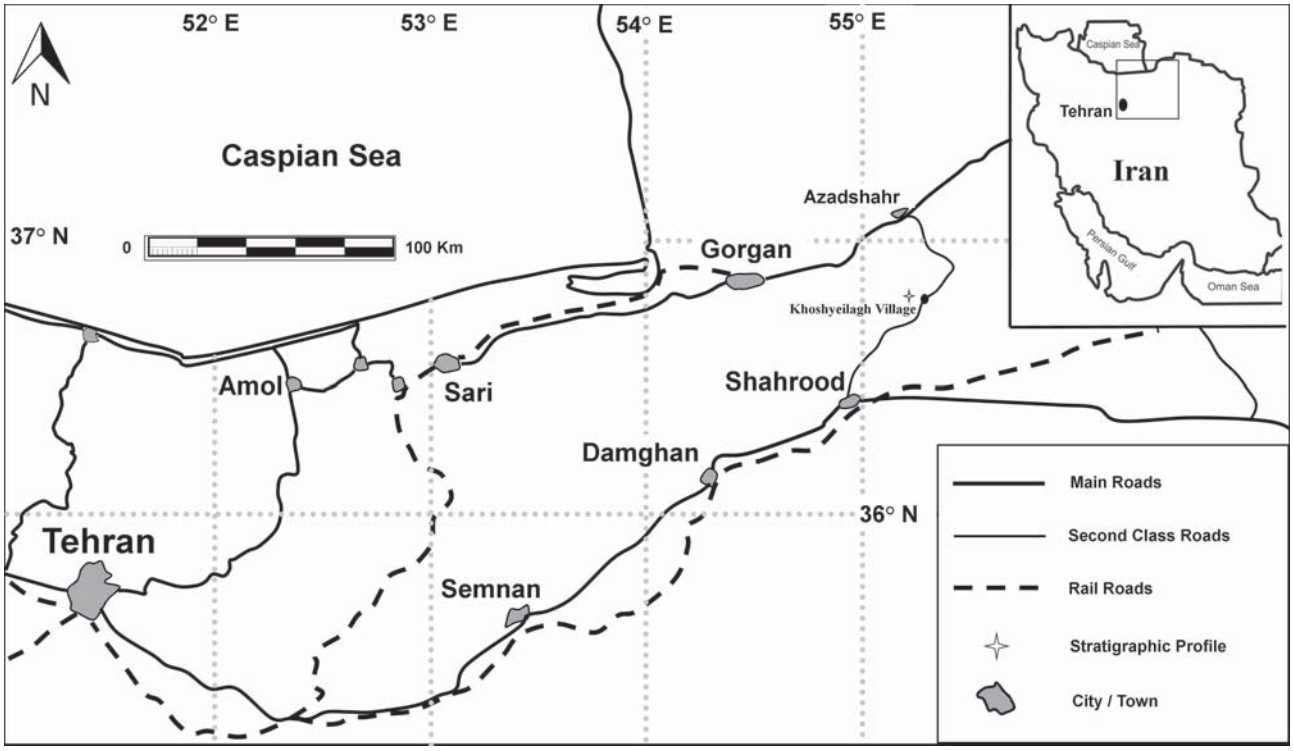

Fig. 1. Location map of the studied section.

Based on WENDT et al. (2005) the corals studied herein have been collected from the units 16 to 18 corresponding to the Givetian. Our studied section is 125 m thick and composed of alternations of thin- to thick-bedded limestones, shales, dolomites and marls. The limestones are mainly skeletal, being interbedded by frequent thin layers of marls and shales in the lower parts of the section. The coral fauna comes from the limestone beds of these parts. Towards the upper parts of the section, the limestones are mostly brecciated and more or less poor in rugose corals. The measured section is represented by:

34 m alternations of thin to thick- bedded of gray, buff and more or less dark limestones and frequent intercalations of marls, sandstones and shales. The limestones are mostly skeletal and contain numerous brachiopods, rugose corals, crinoids, and tentaculitids.

- 8 m Thick-bedded limestones and dolomitic limestones without any macrofauna.
- 14 m Alternations of skeletal and non-skeletal limestones intercalated by layers of shales and marls. The interval contains brachiopods and rugose corals.
- 38 m Thick-bedded and massive dolomites with some intercalations of thick-bedded limestones, dolomitic limestones and shales. The limestones are poor in rugose corals and brachiopods.
- 31 m Alternations of thin to thick-bedded limestones and marly limestones with a few intercalations of shales, marls and dolomites. The limestones are characteristically brecciated. Rugose corals and other macrofossil groups are very rare in this interval.

As mentioned above, our outcrop is stratigraphically correlated with units 16, 17 and 18 of the division used by WENDT et al. (2005) corresponding to the Givetian (Fig. 2). Arbitrarily, these mentioned authors placed the lower limit of the Khoshyeilagh Formation in the unit 16, which is represented by skeletal limestones with brachiopods, rugose corals, tentaculitids, bryozoans, and trilobites. These fully marine strata were attributed to the earliest Givetian (hemiansatus Zone) by BRICE et al. (1974, 1978), STAMPFLI (1978), WEDDIGE (1984), and ASHOURI (1990). Following BOZORGNIA (1973), who subdivided the Khoshyeilagh Formation into 6 members (Member 1: Couvinian, Member 2: Givetian, Member 3: Frasnian, Member 4: Frasnian to Famennian, Members 5 and 6: Famennian); the investigated section is roughly correlated with Member 2. ASHOURI (2006) reported a few conodont taxa such as *Bipennatus bipennatus*, *Icriodus orri*, *Icriodus regularicrescens*, *Icriodus arkonensis*, *Polygnathus alveolus*, and *Polygnathus xylus xylus* from strata which are correlated with Member 2 of BOZORGNIA's divisions (1973). In his attempt, ASHOURI (2006) recognized the fasiovalis Zone of the the latest Middle Devonian–early Frasnian in the middle part of Member 3 based on occurrences of the conodonts *Ancyrodella binodosa* and *Ancyrodella pristine*. The fasiovalis Zone is not included in the stratigraphic range of the material illustrated in this paper. The coral faunas discussed herein belong to a stratigraphic interval ranging from the hemiansatus to pre-fasiovalis zones.

4. Previous studies of the corals

GHODS (1982) described and illustrated several rugose corals from the Givetian and Frasnian of the Khoshyeilagh Formation in the Alborz Mountains including *Ceratophyllum dohmi* (WEDEKIND, 1924), *Charactophyllum nanum* (HALL & WHITFIELD, 1873), *Spinophyllum aiense* (SOSHKINA, 1949), *Macgeea* cf. *proteus* SMITH, 1945, *Spongophyllum imperfectum* SMITH, 1945, and *Hexagonaria* cf. *hexagona* (GOLDFUSS, 1826).

5. Systematic palaeontology

Subclass Rugosa MILNE-EDWARDS & HAIME, 1850
Family Charactophyllidae PEDDER, 1972

Remarks: The family Charactophyllidae was erected by PEDDER (1972: 698). The term "charactophyllid" indicates to the presence of charactophylloid trabeculae. This term was proposed by PEDDER (1972, 1982) to illustrate the coarse monacanthine trabeculae in solitary rugose corals. As seen in longitudinal thin sections, charactophylloid trabeculae are extend upwards from the periphery and flexed first downwards and then upwards when traced adaxially. *Spinophyllum* WEDEKIND, 1922, *Temnophyllum* WALTHER, 1929, *Chostophyllum* PEDDER, 1982, *Charactophyllum* SIMPSON, 1900, *Sinodisphyllum* SUN, 1958, *Hunanophrentis* SUN, 1958, *Piceaphyllum* ROZKOWSKA, 1980, *Alaiophyllum* GORYANOV, 1961, and *Ceciliaphyllum* MCLEAN, 1982 were included in Charactophyllidae by MCLEAN (1993). Charactophyllids are characterized by coarse monacanthine trabeculae, small globose dissepiments and a broad tabularium (MCLEAN 1993). These diagnostic features are common within the family Disphyllidae HILL, 1939 and some workers (e.g., WRZOŁEK 1993; WRZOŁEK & WACH 1994; COEN-AUBERT 2002) therefore described their taxa (namely *Spinophyllum* and *Temnophyllum*) as disphyllids. We follow the classification of MCLEAN (1993) and place *Spinophyllum*, *Temnophyllum* and *Chostophyllum* in Charactophyllidae. The genus *Aristophyllum* is considered here as a disphyllid.

Genus *Spinophyllum* WEDEKIND, 1922

Type species: *Campophyllum spongiosum* SCHLÜTER, 1889, Givetian, Büchel Formation, Germany, by monotypy,

Diagnosis: Solitary tetracorals. Septa of two orders, dilated in dissepimentarium and outer tabularium, heavily or irregularly carinate with yardarm and zigzag carinae. Major septa extending to the centre of corallite or slightly withdrawn. Dissepimentarium composed of some rows of small and globose dissepiments. Tabularium incomplete, differentiated in axial and peripheral regions.

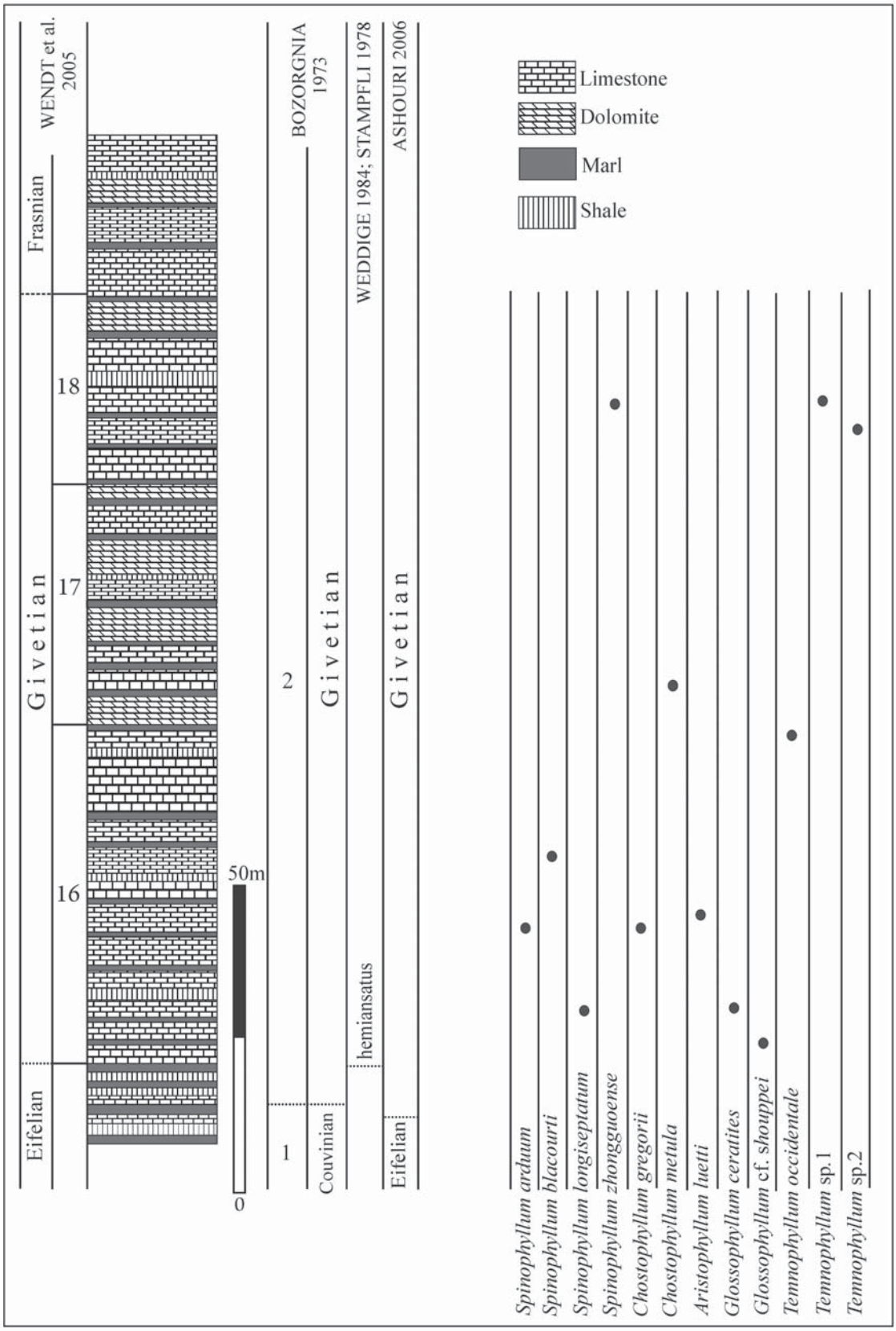

Fig. 2. Simplified stratigraphic column of the studied outcrop and distribution of the discussed coral fauna.

Spinophyllum arduum (LÜTTE, 1985)
Pl. 1, Fig. 1

*1985 *Cyathophyllum* (*Cyathophyllum*) *arduum* n. sp. – LÜTTE, p. 544, figs. 1–2.
1988 *Spinophyllum arduum*. – ROHART, p. 284, pl. 36, figs. 3–4.

Holotype, type locality and horizon: Specimen no. B2.416.34 (LÜTTE 1985: fig. 1a, b), middle Givetian, Kerpen Formation, Sötenich Syncline, North Eifel, Germany.

Material: A single specimen with two thin sections; KA12.

Diagnosis: Species of *Spinophyllum* with 38 major septa at diameter of 23 mm. Thin major septa withdrawn from axis. Septa weakly carinate in dissepimentarium. Zigzag carinae numerous but yardarm carinae very rare. Dissepimentarium composed of several rows of small and globose dissepiments. Tabularium incomplete with flat axial tabellae and axially inclined peripheral tabellae.

Morphology: The only available specimen is a solitary and trochoid form. The diameter of the corallite is 23 mm and its length is 45 mm. The corallite is well-preserved. Both growth lines and longitudinal ribs are strong and prominent. Wall is thin.

In transverse section, the corallite contains 76 (38×2) septa which are straight and radially arranged. Major septa reach unequally to 4/5 of corallite radius, leaving a 4 mm wide free area in the axial part of specimen. Major septa are slightly and locally thickened in the dissepimentarium and thin in the tabularium. Peripheral tips of both orders of septa are dilated near the wall and a narrow stereozone is formed against the wall. The septa are weakly carinate, especially in the thickened parts of outer dissepimentarium. Carination is mostly in the shape of spinose and zigzag-like carinae. Minor septa are thinner than the major ones, reaching to the inner border of the dissepimentarium, where some penetrate into the tabularium. They are about 1/2 corallite radius in length.

In longitudinal section, the relatively wide dissepimentarium is composed of 9 to 13 rows of dissepiments. The latter are predominantly small but locally there are larger ones, which are globose to subglobose. Dissepiments are horizontally arranged at the periphery in some places and slightly inclined in inner rows. The Tabularium is 12 mm wide and incomplete. It is differentiated into two parts. The axial part of the tabularium consists of nearly flat tabellae which are laterally intersected. Tabellae are axially inclined to concave in the peripheral part of tabularium.

Remarks: *Spinophylum arduum* was ascribed to *Cyathophyllum* GOLDFUSS, 1826 by LÜTTE (1985: 544), who found his solitary new species in the middle Givetian Kerpen Formation of the North Eifel. ROHART (1988, 284) reported this species from the Givetian of France and transferred it to *Spinophyllum*.

Cyathophyllum is a phaceloid or cerioid colonial rugose coral with thin septa and weak zigzag-like carinae (see SCHRÖDER 1998: 26), while *Spinophyllum* is a genus of solitary rugose corals with more or less dilated septa and a stronger yardarm and zigzag carination.

Among the different species of *Spinophyllum* which are characterized by weak to strong septal dilation and carination, *Spinophyllum arduum* differs in having slender septa and poorly developed carinae. These features are easily seen among the material figured by LÜTTE (1985) and ROHART (1988: pl. 36, figs. 3–4). In comparison to the material illustrated by LÜTTE (1985) and ROHART (1988) the sole specimen from Iran, with thin septa and zigzag-like carinae, is slightly larger and contains a few more septa.

Distribution: Outside of Iran, *Spinophyllum arduum* has been reported from the middle Givetian Kerpen Formation of the Sötenich Syncline, North Eifel, Germany (LÜTTE 1985) and from the Givetian Blacourt Formation in the Boulonnais, France (ROHART 1988).

Spinophyllum blacourti (ROHART, 1988)
Pl. 1, Fig. 2

*1988 *Truncicarinulum blacourti* n. sp. – ROHART, p. 277, pl. 35, figs. 3–4.
2002 *Spinophyllum blacourti*. – COEN-AUBERT, p. 16, pl. 3, figs. 8–14.
2004 *Spinophyllum blacourti*. – BARCHY et al., pl. 1, fig. 5.
2006 *Spinophyllum blacourti*. – KHAKSAR et al., p. 60, pl. 2, fig. 3.

Holotype, type locality and horizon: Specimen no. GFCL 4556 (ROHART 1988: pl. 35, fig. 3), Bance Noir quarry at Ferques, Boulonnais, France, Blacourt Formation, middle Givetian.

Material: One specimen with two thin sections; KB27.

Diagnosis: Species of *Spinophyllum* with a diameter of 20 mm and 32 major septa. Septa slightly withdrawn from axis, weakly thickened in the dissepimentarium and thin in the tabularium, faintly carinate with rare yardarm carinae. Dissepimentarium composed of some rows of globose and small dissepiments. Tabularium incomplete.

Morphology: The corallite is trochoid in shape with a diameter of 20 mm and a length of 37 mm. The calice is not preserved. The specimen is slightly abraded and longitudinal ribs and growth lines are faintly developed.

In transverse section, the number of septa is 64 (32×2). Septa are radially arranged and differentiated into two orders, majors and minors. The major septa are relatively long, reaching to 4/5 of corallite radius. They leave a 3 mm wide open space in the centre of the tabularium. One of the major septa is longer and the opposite one is shorter than the other septa. The major septa are thickened in the dissepimentarium and thin in the tabularium. Local stereoplasmic thickenings are present against the septa. Axial parts of the major septa are slightly curved and dilated. Peripheral tips of septa are locally thickened near the wall and a narrow stereozone is formed against the wall which

is less prominent. Both orders of septa are slightly carinate in the dissepimentarium, bearing some spinose and knobby carinae. The minor septa traverse the entire dissepimentarium or enter occasionally into the tabularium. They are 1/2 of corallite radius long. The axial tips of two major septa are fused and form a pseudofossula.

In longitudinal section, the dissepimentarium contains 8 to 10 rows of dissepiments. Dissepiments are small to medium in size and predominantly globose. They are horizontally arranged near the wall and inclined in inner rows. The width of incomplete tabularium is 8 mm. Peripheral tabellae consist of relatively large plates with an axially inclined arrangement. Although the nature of the axial tabellae is not clear due to the oblique section, it seems that they may be horizontal. The trabeculae are rather coarse and arise upwardly and inwardly at an angle with the corallite wall.

Remarks: *Truncicarinulum* was first intrdouced by Yu & Kuang (1982: 253) as a subgenus of *Temnophyllum* Walther, 1929, and came from the Givetian of China. This carinate Devonian tetracoral with a peripheral stereozone was considered as synonymous with *Spinophyllum* (McLean 1993: 110; Wrzołek & Wach 1994: 53). In this case, Coen-Aubert (2002: 15) also put *Truncicarinulum* in synonymy with *Spinophyllum*.

Truncicarinulum blacourti was described by Rohart (1988: 277, pl. 35, figs. 3–4) from the Givetian Blacourt Formation in Boulonnais, France, showing more or less dilated septa and weak carination. The latter species was first transferred to *Temnophyllum* by Schröder (2001: 65). We here follow Coen-Aubert (2002: 16), who transferred it to *Spinophyllum*. *Spinophyllum blacourti* described by Coen-Aubert (2002: pl. 3, figs. 8–14) attains a smaller corallite size and slightly thicker septa than in Rohart's material (1988). According to Coen-Aubert (2002: 17) *Spinophyllum blacourti* is in marginal position of the genus *Spinophyllum* because of the scarcity of its carination. Based on Coen-Aubert's definition (2002: 17), *Spinophyllum blacourti* has slightly dilated septa and a weak carination with rare yardarm carinae. These features are present in the material from Iran. In addition, the dimension and number of septa of the discussed coral are similar to the values mentioned by Coen-Aubert (2002).

Distribution: This species has been reported from the Givetian of the Blacourt Formation in the Boulonnais, France (Rohart 1988). It has been also described from lower parts of the Givetian Mont d'Haurs Formation on the southern side of the Dinant Synclinorium in Belgium (Coen-Aubert 2002). In Iran, *Spinophyllum blacourti* has been reported from the Givetian of the Bahram Formation in Eastern Iran (Khaksar et al. 2006).

Spinophyllum longiseptatum (Lütte, 1984)
Pl. 1, Fig. 3

1984 *Charactophyllum longiseptatum* n. sp. – Lütte, p. 184, pl. 1, figs. 5–6; pl. 2, figs. 1–2; text-fig. 2.
1984 *Charactophyllum* sp. – Lütte, p.187, pl. 2, figs. 3–4.
1990 *Spinophyllum longiseptatum*. – Birenheide & Lütte, p. 6.
e.p.1990 *Spinophyllum spongiosum*. – Birenheide & Lütte, p. 5, pl. 1, figs. 1, 2, 5, 6; pl. 2, figs. 11–12; pl. 3, figs. 18–19. [Not: pl. 1, figs. 3, 4, 7, 8; pl. 2, figs. 10, 13, 14; pl. 3, figs. 15–17, 20].
1994 *Spinophyllum longiseptatum*. – Wrzołek & Wach, p. 53, pl. 1, figs. 1–5.
2005 *Spinophyllum longiseptatum*. – Schröder, pl. 3, fig. 8.

Holotype, type horizon and type locality: Specimen no. GIK 961/3 (Lütte 1984: pl. 1, figs. 5–6; text-fig. 2), Kerpen Formation, North Eifel, Germany, Givetian.

Material: A single corallite with two thin sections; KA30.

Diagnosis: A species of *Spinophyllum* with 35 major septa at a diameter of 19 mm. Septa dilated and carinate in dissepimentarium. Stereoplasmic thickening well developed against the septa. Dissepiments small and globose. Tabularium composed of flat axial and inclined peripheral tabellae.

Morphology: The specimen is slightly abraded and conical in shape, with prominent growth lines and longitudinal ribs. The coral is 31 mm wide and 20 mm long.

In transverse section, there are 72 (36 ×2) septa in the corallite. The major septa are about 4/5 of the corallite radius long. They leave a 4 mm wide open space in the centre of the tabularium. The septa bear carinae in the dissepimentarium and are smooth in the tabularium. The carinae are in the knobby and yardarm types. The carination is numerous and strong. The septa are dilated in the dissepimentarium and in the outer tabularium, but slightly thin in the inner tabularium. The peripheral tips of the septa are rather thickened and form a narrow stereozone near the wall. There are deposits of stereoplasmic thickenings against the septa which are in different distance of the wall in the dissepimentarium. The minor septa are as long as the dissepimentarium, reaching about 1/2 of the major septa in length.

In longitudinal section, 8 to 10 rows of dissepiments are present in the dissepimentarium. The dissepiments are small and globose and predominantly obscured by a strong stereome. They are inclined in the inner rows. The incomplete tabularium consists of moderately large, steeply inclined tabellae in the peripheral part and wide horizontal ones in the axial part.

Remarks: Wrzołek & Wach (1994: 53) questioned some assignments of Birenheide & Lütte (1990) to *Spinophyllum spongiosum* and transferred specimens with septotheca and stereoplasmic thickening to *Spinophyllum longiseptatum*. In their opinion, the main diagnostic feature of the latter species is the thickening of the peripheral parts of the septa to form a continuous septotheca. Coen-Aubert (2002: 16) mentioned the presence of

stereoplasmic thickenings in some material of BIRENHEIDE & LÜTTE (1990) and thought that such specimens should be assigned to *Spinophyllum longiseptatum*. These stereoplasmic thickenings are strongly developed in the single specimen assigned to *Spinophyllum longiseptatum* by SCHRÖDER (2005: pl. 3, fig. 8). There was too little information about *Spinophyllum conicum* KETTNEROVA, 1932 before the studys of GALLE (2007) who revised and figured some specimens from the lower Givetian rocks of the Czech Republic. This species is comparable to *Spinophyllum longiseptatum* in some aspects. GALLE (2007: 140) mentioned microstructural differences between the two taxa. In our opinion *Spinophyllum conicum* differs additionally from the typical forms of *Spinophyllum longiseptatum* by lesser stereoplasmic thickenings. The coral from Iran is somewhat similar to S*pinophyllum conicum* but the former is larger and exhibits more septa. Additionally, the specimen from Iran has longer major septa and much more stereoplasmic thickenings and hence we consider it as conspecific with *Spinophyllum longiseptatum*.

Distribution: This species occurs frequently in the middle Givetian Kerpen Formation of the North Eifel, Germany (LÜTTE 1984; LÜTTE & OEKENTROP 1988; BIRENHEIDE & LÜTTE 1990). It has been also recorded from the Upper Givetian of the Holy Cross Mountains, Poland (WRZOŁEK & WACH 1994).

Spinophyllum zhongguoense (HE, 1978)
Pl. 1, Fig. 4

*1978 *Heliophyllum zhongguoense*. – HE, p.126, 560, pl. 64, fig. 4.
1985 *Spinophyllum zhongguoense*. – BIRENHEIDE & LIAO, p. 245, pl. 2, fig. 9.

Holotype, type locality and horizon: Specimen illustrated by HE (1978: pl. 64, fig. 4), Sichuan Province, South China, Givetian.

Material: One specimen with two thin sections; KA 23.

Diagnosis: A species of *Spinophyllum* with 33 major septa at diameter of 21mm. Major septa slightly withdrawn from axis, weakly dilated in dissepimentarium and thin in tabularium. Both orders of septa moderately carinate with yardarm and zigzag carinae in dissepimentarium. Minor septa reaching to 1/2 of corallite radius. Dissepiments small and relatively globose, in 8 to 10 rows. Tabularium differentiated into depressed axial tabellae and inclined peripheral tabellae.

Morphology: The only available specimen is a trochoid corallite with a diameter of 20 mm and a length of 57 mm. Both longitudinal ribs and growth lines are well developed. The calice is not preserved and the wall is thin.

In transverse section, the corallite contains 66 septa (33×2), which are radially arranged. The major septa are about 4/5 of the corallite radius long, leaving an open area as wide as 3 mm in the axial part of the specimen. They are rather thickened in the dissepimentarium, especially in the inner dissepimentarium and in the outer tabularium, but thin in the inner tabularium. Both orders of septa are more or less carinate in the dissepimentarium. Zigzag and yardarm carinae are present and locally strong. The septa sometimes bear some spinose and knobby carinae. The minor septa traverse the entire dissepimentarium; they are about 1/2 of the corallite radius long.

In longitudinal section, the dissepimentarium is composed of 8 to 10 rows of small and globose dissepiments. The dissepiments are inclined or nearly vertical in the inner rows. The tabularium is 11 mm wide and incomplete. It is differentiated into axial and peripheral tabellae. The axial tabellae are depressed, concave, convex and sometimes horizontal. The peripheral tabellae are large plates, which are steeply inclined towards the axis and sometimes concave. The boundary between the dissepimentarium and the tabularium is very sharp. The trabeculae are coarse, being extended inward and upward in the dissepimentarium.

Remarks: In comparison to *Spinophyllum spongiosum* figured by BIRENHEIDE & LÜTTE (1990: pl. 1, figs. 1–2, 5–6; pl. 2, figs. 10, 12; pl. 3, figs. 15–17, 20) from the Givetian of the Rhenish Mountains, Germany, COEN-AUBERT (2002: pl. 3, figs. 3–7) from the Givetian Mont d'Haurs Formation, Belgium and SCHRÖDER (2005: pl. 3, figs. 2–7) from the Givetian of the Rhenish Mountains, Germany, the investigated specimen has a similar dimension and septal number but less dilated septa and weaker carinae. *Spinophyllum hejiazhaiense* KONG in KONG & HUANG, 1978 from the Frasnian of South China is a species resembling the coral from Iran. *Spinophyllum hejiazhaiense* has been also reported by BIRENHEIDE & LIAO (1985: pl. 2, fig. 8) from the Givetian of the Dushan Province, South China and by LIAO & BIRENHEIDE (1989: pl. 2, fig. 12) from the Frasnian of South China. The discussed species from China differs from the Iranian species by their septal dilation near the inner border of the dissepimentarium.

Although our specimen exhibits a few more septa, it is closely related to *Spinophyllum zhongguoense* described and figured by BIRENHEIDE & LIAO (1985: pl. 2, fig. 9) from the Givetian of the Dushan Province, South China, in many aspects including its dimension, carination, septal dilation and tabularium structure.

Distribution: *Spinophyllum zhongguoense* has been described from the Givetian of Guizhou and Sichuan provinces of South China (BIRENHEIDE & LIAO 1985; HE 1978). This is the first record of this species from Iran.

Genus *Chostophyllum* PEDDER, 1982

Type species: *Chostophyllum metula* PEDDER, 1982, pl. 1, figs. 1–17; pl. 2, figs. 1–11, 14; text- fig. 3, Givetian, Hare Indian Formation, District of Mackenzie, north-western Canada.

Diagnosis: Solitary rugose corals with charactophylloid trabeculae. Septa of two orders. Major septa short in adult

stage. Cardinal septum short and counter septum commonly shorter than the other septa. Cardinal fossula well developed. Dissepimentarium very narrow. Tabularium broad, commonly differentiated into two regions. Inner wall formed in the dissepimentarium.

Chostophyllum gregorii Etheridge, 1892
Pl. 1, Fig. 5

*1892 *Campophyllum gregorii*. – Etheridge, p. 60, pl. 3, figs. 15–18.
1895 *Campophyllum gregorii*. – Etheridge, p. 522, pl. 40, fig. 2.
1942 *Disphyllum gregorii*. – Hill, p. 247, pl. 8, figs. 1–4.
1996 *Chostophyllum gregorii*. – Zhen & Jell, p. 82, pl. 13, figs. 7–10.
2010 *Chostophyllum gregorii*. – Blake, p. 121, fig. 86.

Lectotype, type locality and horizon: **S**pecimen no. GSQF1655 (Etheridge 1892, pl. 3, fig. 15), subsequently seleccted by Hill (1942), Burdekin Formation, North Queensland, Australia, Givetian.

Material: One corallite with two thin sections; KC38.

Diagnosis: Species of *Chostophyllum* with 31 major septa and a diameter of 18 mm. Major septa smooth, slightly thickened in the dissepimentarium, thin in the tabularium, rather short, leaving a considerable open space in the axial part. Cardinal septum short. Fossula present. Inner wall formed. Dissepimentarium is composed of a few rows of dissepiments. Tabularium incomplete with flat axial tabellae and inclined peripheral tabellae.

Morphology: The single investigated specimen with a diameter of 18 mm and a length of 30 mm exhibits a subcylindcrical to ceratoid shape. The corallite is slightly abraded, with weak traces of longitudinal ribs and growth lines.

In transverse section, the corallite contains 62 (31×2) septa. Major septa are radially arranged, rather wavy in the tabularium and slightly withdrawn from the axis, reaching to 2/3 of the corallite radius. Both orders of septa are smooth. The tips of the septa are thickened at the periphery, forming a more or less thin stereozone. Septa are rather thickened in the dissepimentarium and dilation of the septa produces an inner wall in the outer dissepimentarium and at the border of the tabularium. This weak inner wall is complete. Major septa are slightly thin in the outer tabularium and rather thickened in their axial parts. The cardinal septum is short, positioned in a fossula. Minor septa are short, about 1/2 to 1/3 of the majors in length, being confined to the dissepimentarium.

In longitudinal section, the dissepimentarium is narrow. It is composed of 3 to 4 rows of dissepiments. The dissepiments are mostly globose and subglobose, but elongated ones also occur. They are rather different in size and locally thickened. The broad tabularium is 12 mm wide. The incomplete tabularium consists of closely arranged, wide and flat axial tabellae, supplemented by a few large tabellae, which are steeply inclined towards the axis.

Remarks: *Chostophyllum gregorii* Etheridge, 1892 was originally described as *Campophyllum gregorii*. Hill (1942) believed that the species may be phaceloid in shape and she described it as *Disphyllum gregorii*. The species was collected from the Burdekin Basin, North Queensland by Zhen et al. (1993) and they tentatively transferred it to *Chostophyllum*. This view was followed by Zhen & Jell (1996) and Blake (2010).

Chostophyllum gregorii reported by Zhen & Jell (1996: pl. 13, figs. 7–10) from the Middle Devonian of the Fanning River Group, North Queensland, and those illustrated by Blake (2010: fig. 86) from the Yarrol Province, Queensland, have longer septa than the specimens figured by HILL (1942). Moreover, these specimens do not show a cardinal septum and fossula. The specimen from Iran is similar to the material described by Zhen & Jell (1996) and Blake (2010) in its dimensions and septal number, but with a better developed cardinal septum and fossula.

Distribution: Outside Iran, this species has been reported from the Middle Devonian of Australia (Queensland, New South Wales).

Chostophyllum metula Pedder, 1982
Pl. 1, Fig. 6

1982 *Chostophyllum metula* n. sp. – Pedder, p. 566, p1. 1, figs. 1–17; p1. 2, figs. 1–11, 14; text- fig. 3.

Holotype, type locality and horizon: Specimen no. GSC 64688 (Pedder 1982: pl. 1, figs. 8, 11, 14–16; text- fig. 3A), Hare Indian Formation, District of Mackenzie, north-western Canada, Givetian.

Material: A single corallite with two thin sections; KA69.

Diagnosis: Species of *Chostophyllum* with 31 major septa at a diameter of 18 mm. Smooth and dilated major septa withdrawn sharply from the axis. Cardinal septum ? short. Narrow dissepimentarium composed of a few rows of small and subglobose dissepiments. Incomplete tabularium composed of wide and flat axial tabellae and inclined lateral tabellae.

Morphology: The corallite is conical to trochoid in shape, with a diameter of 19 mm and a length of 27 mm. It is slightly abraded and the wall is incompletely preserved. Longitudinal ribs and growth line are weakly developed.

In transverse section, the number of septa is 62 (31×2). The major septa are characteristically withdrawn from the axis, leaving an about 11 mm wide open space in the centre of corallite. They are commonly 1/3 of the corallite radius long. One of the major septa, which is assumed to be cardinal septum, is shorter than the other ones. A fossula is not well developed, but the separation of two adjacent septa forms a small open area in the dissepimentarium. Septa are non-carinate and strongly dilated. A thickening of the peripheral tips of the septa forms a narrow stereozone against the wall and a strong dilation of the septa and dissepiments produces an inner wall within the dissepimentarium. This rather strong inner wall is locally merged with

the peripheral stereozone. Minor septa are very short, confined to the dissepimentarium. They are locally replaced by a few rows of herringbone dissepiments.

In longitudinal section, the extremely narrow dissepimentarium contains 2 to 3 rows of dissepiments. The dissepimentarium becomes wider locally, reaching up to 5 rows. The dissepiments are mostly small, globose and subglobose. Sometimes they are thickened and obscured by the stereome. The tabularium is about 13 mm wide. It is incomplete and composed of two parts. The axial part of the tabularium consists of rather wide and flat tabellae, whereas there are a few axially inclined tabellae in the periaxial part of the tabularium.

Remarks: Compared to the material of *Chostophyllum metula* introduced by PEDDER (1982: 566) from the Givetian Hare Indian Formation of north-western Canada, the specimen from Iran shows minor differences in the presence of a few more rows of dissepiments and rather densely spaced axial tabellae. In spite of these differences, our coral is similar to specimens of PEDDER (1982) in corallite diameter, septal number, septal length and tabularium development and thus we assign this specimen to *Chostophyllum metula*.

Alaiophyllum goryanovi PEDDER, 1973 from the Givetian of Canada, which was transferred to *Chostophyllum* by PEDDER (1982: 570), has also short septa among the different species of *Chostophyllum*. The holotype of *Chostophyllum goryanovi* differs from the Iranian material by a few more septa and a strong and prominent peripheral stereozone.

Distribution: Outside Iran, *Chostophyllum metula* occurs only in the Givetian of the Hare Indian Formation of the Mackenzie District, north-western Canada (PEDDER 1982).

Genus *Temnophyllum* WALTHER, 1929

Type species: *Temnophyllum latum* WALTHER, 1929, by subsequent designation of LANG et al. (1940); Upper Middle Devonian, apparently from Bad Grund, Harz Mountains, Germany.

Diagnosis: Solitary rugose corals. Septa of two orders, non-carinate or sometimes faintly carinate. The septa typically dilated in the dissepimentarium, forming an irregular, complete or incomplete stereozone near the wall or within the dissepimentarium. Major septa long, reaching to the centre of the tabularium or slightly withdrawn from the axis. Globose and small dissepiments horizontally arranged at the periphery. Tabularium usually incomplete, with lateral and axial tabellae. Trabeculae monacanthine, coarse and charactophylloid.

Temnophyllum occidentale HILL & JELL, 1970
Pl. 1, Fig. 7

*1970 *Temnophyllum occidentale*. – HILL & JELL, p. 59, pl. 15, figs. 1–9.

e.p. 1993 *Temnophyllum occidentale*. – WRZOŁEK, p. 233, figs. 10A–C. [Not figs. 10D, F, H].

2005 *Temnophyllum* cf. *occidentale*. – SCHRÖDER, p. 44, 45, pl. 9, figs. 1–4.

Holotype, type locality and horizon: Specimen no. SWA F5931/7 (HILL & JELL 1970: pl. 15, fig. 7a–c), Pillara Limestone, Western Australia, late Givetian.

Material: One corallite with two thin sections; KA67.

Diagnosis: A species of *Temnophyllum* with 30 major septa and a diameter of 20 mm. Major septa rather long, thickened variously in the dissepimentarium and slightly dilated in the tabularium. Weak and partial stereozone developed within the dissepimentarium. Dissepimentarium in some rows of small, globose and subglobose dissepiments. Tabularium incomplete, composed of flat axial tabellae and inclined peripheral tabellae.

Morphology: The only available specimen exhibit a trochoid shape. The corallite is up to 20 mm wide and 40 mm long. The calice is not preserved. Longitudinal ribs and growth lines are weakly developed.

In transverse section, there are 60 (30×2) septa in the adult stage. The major septa are radially arranged, more or less straight in the dissepimentarium and slightly curved in the tabularium. The axial tips of some of the major septa are fused. The major septa are long, leaving a small open area in the central part of the tabularium. The septa are rather thickened in the dissepimentarium. The dilation pattern of the septa is variable so that a weak and incomplete stereozone is formed by dilation of the septa in some parts of the outer dissepimentarium. The major septa are slightly swollen and thickened in the tabularium. Both orders of septa are generally smooth, but weak spinose carinae are also developed. The minor septa are thinner than the major ones. They traverse the entire dissepimentarium but are slightly different in size. The minor septa are about 1/2 of the majors ones long.

In longitudinal section, the dissepimentarium contains 6 to 8 rows of dissepiments. The dissepiments are mostly small and globose to subglobose, but a few larger ones are also present. They are locally thickened. The inner rows of dissepiments are steeply inclined towards the axis. The tbularium is differentiated into two parts. In the axial part, the tabellae are more or less flat, domed and closely spaced, whereas they tend to be large and axially inclined in the periaxial part.

Remarks: The specimen described herein is similar to *Temnophyllum occidentale* originally described from the late Givetian of Western Australia (HILL & JELL 1970: pl. 15, figs. 1–9). The specimens from Iran and from Australia have the same dimensions, septal numbers and also share the dilation of the septa in the tabularium. They also show similar septal lengths, an incomplete stereozone and tabularium characteristics. However, the bow ties indicated by HILL & JELL (1970: 59) are not very prominent in our specimen.

The specimens of HILL & JELL (1970) do not show very strong and prominent stereozone at the periphery or

within the dissepimentarium, but some of the material of Wrzołek (1993: fig. 10D, F, H) from the Holy Cross Mountains exhibits a strong stereozone. Coen-Aubert (2003: 19) ascribed the material of Wrzołek (1993) to *Temnophyllum wellinense* Coen-Aubert, 2003, especially the corallites with strong stereoplasmic thickening.

Distribution: The species has been recorded from the late Givetian of the Canning Basin in West Australia by Hill & Jell (1970) and from the Givetian Kowala Formation in the Holy Cross Mountains, Poland (Wrzołek 1993).

Temnophyllum sp. 1
Pl. 2, Figs. 1–2

Material: Two specimens with four thin sections; KC1 and KC40.

Diagnosis: Moderately large species of *Temnophyllum* with 33 to 36 major septa at a diameter of 26 mm to 28 mm. Major septa slightly withdrawn from the axis, slightly bilateral in the tabularium, generally thin in the dissepimentarium, thickened in the tabularium, smooth or faintly carinate. Minor septa reaching 1/2 of the corallite radius. A complete and weak inner wall developed in the middle parts of the dissepimentarium. Fossula present. Dissepimentarium in several rows of globose dissepiments horizontally arranged in the outer row. Tabularium developed in axial and peripheral regions.

Morphology: The specimens are moderately large solitary forms which are subcylindrical to trochoid in shape. They are slightly abraded with more or less fine growth lines and longitudinal ribs. The calice is moderately deep.

In transverse sections, the number of septa is 66 (33×2) at a diameter of 26 mm and 72 (36×2) at a diameter of 28 mm, respectively. The septa are differentiated into two orders, minor and major ones. The major septa are relatively long, reaching 4/5 of the corallite radius. They leave an about 3 mm wide open space in the axial part. One of the major septa is longer than the others. Another septum, located in the opposite side of the longer septum, is shorter than the remaining septa. The septa are radially arranged in the dissepimentarium, but slightly bilateral in the tabularium around the longer and shorter major septa which corresponds to the largest diameter of the specimens. The peripheral tips of the septa are slightly thickened, forming a narrow stereozone at the periphery. The major septa are more or less thin in the outer dissepimentarium and slightly thick in the inner dissepimentarium. They become thinner in the outer tabularium and are dilated in the inner tabularium. The septa are commonly smooth but occasionally faintly carinate. The dilation of the lateral faces of the septa is strong enough to bring adjacent septa into contact, forming an inner wall. This second wall is rather prominent and complete and located in the centre of the dissepimentarium. A fossula is developed. The minor septa are a little thinner than the major ones and confined to the dissepimentarium. They are commonly 1/2 and rarely 2/3 of the major ones long.

In longitudinal sections, there are 8–10 or even 12 rows of dissepiments in the dissepimentarium. The outer row of dissepiments is composed of rather large horizontal and subpeneckielloid dissepiments which are arranged one above another. The dissepiments are small, globose and subglobose in the centre of the dissepimentarium while they are inclined or nearly vertical in the inner rows. The boundary between the dissepimentarium and the tabularium is sharp and distinct. The tabularium is 10–12 mm wide. It is incomplete and differentiated into two parts. There are nearly flat and domed tabellae in the axial part, locally broken into smaller plates. The peripheral part of the tabularium is made up of axially inclined tabellae, which are different in size.

Remarks: Among the different previously described species of *Temnophyllum* Walther, 1929, which are characterized by more or less smooth, not very thickened septa and a rather weak stereozone in the dissepimentarium, the material from can be compared to *Temnophyllum occidentale* Hill & Jell, 1970 originally described from the Givetian of the Canning Basin in Australia, especially in the septal dilation, carination, development of fossula and the presence of thickened septa in the tabularium. Quantitative data including a larger corallite size, more septa and more rows of dissepiments exclude the material from Iran from the synonymy of *Temnophyllum occidentale*. In addition, the former species has stronger and a more or less complete stereozone than the latter. *Temnophyllum turbinatum* Hill, 1954 has been described from the Givetian and Frasnian of Australia (Hill 1954; Hill & Jell 1970; Brownlaw & Jell 2008) and also from the Frasnian of Poland (Brownlaw 2000). This species with a slightly smaller size, a lesser septal number, longer major septa and a stronger stereozone is different from the Iranian species. Our species differs from *Temnophyllum imperfectum* Coen-Aubert, 2002 reported from the Givetian Mont d'Haurs Formation of Belgium in a greater corallite diameter, a few more septa, less dilated septa and a significantly weaker stereozone, positioned in the centre of the dissepimentarium. Compared to *Temnophyllum wellinense* Coen-Aubert, 2003 described from the Givetian Terres d'Haurs Formation of Belgium, the Iranian species is distinguished by its nearly complete stereozone, a larger size, more septa, longer major septa and more dissepiments. *Temnophyllum kroombitense* Blake, 2010 from the Frasnian of central Queensland, Australia, differs from the discussed species by fewer rows of dissepiments, a smaller diameter, fewer septa and shorter minor septa.

We believe that this material represents a new species, but due to limited material we leave it in open nomenclature.

Temnophyllum sp. 2
Pl. 2, Fig. 3

Material: One specimen with two thin sections. KA71.

Diagnosis: A species of *Temnophyllum* with 33 major septa at a diameter of 26 mm. Major septa rather long, faintly carinate, wedge-shaped and strongly dilated in the dissepimentarium. Inner wall formed. Minor septa generally confined to the dissepimentarium. Dissepimentarium composed of some rows of thickened, small and globose dissepiments. Tabularium vesicular.

Morphology: The specimen is solitary and conical to ceratoid in outline. The corallite is 26 mm wide and 52 mm long. Growth lines and longitudinal ribs are strongly developed.

In transverse section, the corallite contains 66 (33×2) septa. The major septa are radial in the dissepimentarium and weakly bilateral in the tabularium. They are slightly different in size but long, leaving a very small open space in the axial part. The axial ends of some of the major septa are fused. One of the major septa is longer than the other septa, extended to the axis. In the opposite side of the longer septum, a pseudofossula is formed by joining of the axial ends of some septa. One of the major septa is shorter than the other ones, positioned in a pseudofossula. Major septa are strongly dilated and wedge-shaped in the dissepimentarium and rather thin in the tabularium. The axial tips of the major septa show a rhopaloid thickening in the tabularium. The peripheral ends of the septa are thickened, forming a narrow stereozone, where the wall is preserved. Dilation in the centre of the dissepimentarium is strong enough to form a second, inner wall. This inner wall is prominent and complete. Laterally the septa are spinose. The minor septa traverse the entire dissepimentarium and are about 1/2 of the major ones long. A few of the minor septa are withdrawn from the border of the dissepimentarium and replaced by a few rows of dissepiments.

In longitudinal section, the dissepimentarium is composed of 9–11 rows of dissepiments. The dissepiments are horizontal or nearly horizontal in the outer row and steeply inclined or nearly vertical near the border of the tabularium. They are generally thickened, small, globose to subglobose and locally obscured by a strong stereome. The tabularium is vesicular. Peripherally, the tabellae are larger than the dissepiments and inwardly inclined. Axially, they form elevated and domed tabularial floors.

Remarks: The specimen fro Iran is similar to *Temnophyllum richardsoni* Meek, 1867, especially in the tabularium structures. The latter species has been reported from the middle Givetian of western Canada. As mentioned by McLean (1993: 111), this species shows great morphological variations concerning septal dilation, carination, corallum size, septal length and stereozone. In spite of some similarities, we exclude our species from the synonymy of *Temnophyllum richardsoni* due to the considerably larger diameter of the coral from Iran. *Temnophyllum astrictum* Walther, 1929, described from the Givetian of the North Eifel, Germany, with commonly vesicular tabularium and axial concave tabellae, is distinguished from the species from Iran by a smaller diameter, a lesser number of septa and the nature of septal dilation. No species illustrated in the literature studied by us can be conspecific with this specimen, but due to the scarcity of our material we leave it in open nomenclature.

Family Disphyllidae Hill, 1939
Genus *Aristophyllum* Bulvanker, Spassky & Kravtsov
in Besprozvannykh et al., 1975

Type species: *Aristophyllum terechovi* Bulvanker, Spassky & Kravtsov, 1975 in Besprozvannykh et al. 1975, pl. 25, fig. 2; pl. 26, figs. 1–2, Salaga Series, Kolyma Basin, Siberia, Frasnian.

Diagnosis: Solitary tetracorals. Septa of two orders, smooth or sometimes weakly carinate. Septa thin or slightly thickened in the dissepimentarium and thin in the tabularium. Major septa short, withdrawn from the axis. Minor septa traversing the entire dissepimentarium. Dissepimentarium narrow, composed of a few rows of small and globose dissepiments. Tabularium broad, incomplete, with wide axial tabulae.

Aristophyllum luetti Coen-Aubert, 1997
Pl. 2, Fig. 4

*1997 *Aristophyllum luetti* n. sp. – Coen-Aubert, p. 16, pl. 1, figs. 5–7; pl. 2, figs. 1–4.
1998 *Aristophyllum luetti*. – Schröder, p. 36, pl. 4, figs. 27–29.

Holotype, type locality and horizon: Specimen no. IRScNB a10553 (Coen-Aubert 1997: pl. 2, figs. 1–2), Hanonet Formation, Pondrôme, Belgium, Givetian.

Material: One specimen with two thin sections; KA70.

Diagnosis: A species of *Aristophyllum* with 36 major septa at a diameter of 21 mm. Major septa non-carinate, commonly thin, withdrawn from the axis, leaving a large open area in the axial part. Dissepimentarium narrow, with a few rows of small and globose dissepiments. Broad tabularium composed of wide and flat axial tabellae and inclined peripheral tabellae.

Morphology: The only available solitary specimen exhibits a subcylindrical shape. The corallite is 21 mm wide and 55 mm long. Growth lines and longitudinal ribs are well developed. The wall is thin.

In transverse section, the corallite contains 72 (36×2) septa. The major septa are about 1/2 of the corallite radius long and sharply withdrawn, leaving an 12 mm wide open area in the central part of the specimen. They are non-carinate, thin and slightly curved in their axial parts. The major septa are faintly thickened in the outer part of the dissepimentarium. The minor septa are variable in length. Most of the minor septa are slightly shorter than the major ones in their length and some of them are extremely shortened, replaced by a few rows of herringbone dissepiments.

In longitudinal section, the dissepimentarium is moderately narrow. It is composed of 6–8 rows of dissepiments. The dissepiments are small, globose to subglobose. They are more or less horizontal in the outer row and inclined and nearly vertical in the inner rows. The tabularium is broad and incomplete, differentiated into two distinctive parts. The tabellae are very wide, flat and sometimes gently domed in the axial part, whereas they are large and axially inclined in the periaxial part.

Remarks: *Aristophyllum luetti* has been introduced from the upper parts of the Givetain Hanonet Formation of Belgium (Coen-Aubert 1997: 16). This species differs from the type species *Aristophyllum terechovi* Bulvanker, Spassky & Kravtsov, 1975 from the Frasnian of Siberia in fewer septa and more dissepiments. The holotype of *Aristophyllum planotabulatum* from the Givetian of North Queensland (Zhen 1994: 339, fig. 12A–B) differs from *Aristophyllum luetti* in its long and thickened septa in the dissepimentarium. The corallite diameter and number of septa in the specimen from Iranian is the same as reported for *Aristophyllum luetti* (cf. Coen-Aubert 1997: 16).

Distribution: This species occurs in the Givetian Hanonet Formation of Pondrôme, Belgium (Coen-Aubert 1997) and in the Givetian Cürten and Loogh formations of the North Eifel, Germany (Schröder 1998).

Family Cyathophyllidae Dana, 1846
Genus *Glossophyllum* Wedekind, 1924

Type species: *Glossophyllum dohmi* Wedekind, 1924, by subsequent designation of Lang et al. (1940).

Diagnosis: Solitary cylindrical to subcylindrical tetracorals. Septa in major and minor orders. Major septa radially arranged, commonly long, reaching to the centre of corallite or slightly withdrawn from the axis in the late growth stages. Septa thin, generally non-carinate but sometimes weakly carinate. Cardinal septum short. Fossula developed in the late stages of ontogeny. Tabularium broad and incomplete.

Glossophyllum ceratites (Goldfuss, 1826)
Pl. 2, Fig. 5

cf. *1826 *Cyathophyllum ceratites*. – Goldfuss, p. 57, pl. 17, fig. 2.
1981 *Glossophyllum ceratites*. – Hill, text-fig. 195/2b–d.
1998 *Glossophyllum* cf. *ceratites*. – Schröder, p. 32, pl. 3, fig. 12.
1999 *Glossophyllum ceratites*. – Schröder & Kazmierczak, p. 99, pl. 2, fig. 6.
non 2006 *Glossophyllum ceratites*. – Khaksar et al., p. 58, pl. 1, fig. 3.

Lectotype, type locality and horizon: See Lütte (1987: 441).

Material: One specimen with two thin sections; KC18.

Diagnosis: A moderately large species of *Glossophyllum* with 37 major septa at a diameter of 29 mm. Major septa slightly withdrawn from the axis, thin, generally smooth. Minor septa also thin, reaching commonly 2/3 of the major ones in length. Cardinal septum short. Fossula developed. Dissepimentarium composed of several rows of small dissepiments. Tabularium incomplete, with wide and horizontal axial tabellae.

Morphology: The specimen is a solitary, cylindrical form with a diameter of 29 mm and length of 70 mm. The corallite shows well developed growth lines and longitudinal ribs. Calice is moderately deep.

In transverse section, the corallite contains 74 (37×2) septa, which are radially arranged. The major septa are long, extending about 4/5 of the corallite radius. They are slightly different in size and leave a 4 mm wide open area in the axial part of the specimen. All septa are smooth and thin except in some places of the dissepimentarium, where a weak and local dilation is developed. The major septa are faintly dilated in the tabularium. The peripheral tips of septa are also weakly thickened near the wall. One of the major septa is shorter than of the other ones. It is assumed to be the cardinal septum, situated in a fossula. The minor septa reach 1/2 to 1/3 of the length of the major septa and extend to the border of tabularium.

In longitudinal section, the dissepimentarium is about 1/2 of the corallite radius long and composed of 6– 9 rows of dissepiments. It consists of small and globose to subglobose dissepiments. The dissepiments are mainly inclined towards the axis. Inner rows of dissepiments are steeply inclined or nearly vertical. The boundary between the dissepimentarium and the tabularium is sharp. The tabularium is 15 mm wide and incomplete. The axial portion of the tabularium is composed of wide and more or less horizontal tabellae, supplemented by large, axially inclined tabellae.

Remarks: The lectotype of *Cyathophyllum ceratites* has been selected by Birenheide (1969: 39). It is a corallite with a short cardinal septum and a fossula. Lütte (1987: 441) transferred this species to *Glossophyllum* and figured some specimens of the species from the Middle Devonian of the Eifel, Germany. *Glossophyllum ceratites* is very similar to *Glossophyllum soetenicum* (Schlüter, 1885) and Schröder & Kazmierczak (1999: 100) believed that the separation of these species is not always satisfactory. Differences between the two mentioned taxa have been illustrated in details by Schröder (1998) and Schröder & Kazmierczak (1999). In fact, the separation of these species is based on the tabularium structure in longitudinal thin sections. *Glossophyllum soetenicum* is characterized by widely spaced and irregular tabulae. Khaksar et al. (2006: pl. 1, fig. 3) reported *Glossophyllum ceratites* from the lower Givetian of the Bahram Formation in the south of Ozbak Kuh (eastern Iran). We exclude this species from the synonymy of *Glossophyllum ceratites* due to fewer septa (only 32 major septa), the absence of a fossula and the occurrence of dilated septa in the tabularium.

Our material is similar to that described by Lütte (1987) in respect of the dimensions, number of septa, the short cardinal septum, and the presence of a fossula and the tabularium development.

Distribution: Outside Iran, this species has been reported from the Eifelian Freilingen Formation (SCHRÖDER 1998) and from the middle Givetian Kerpen Formation (LÜTTE 1987) in the Eifel Mountains, Germany. *Glossophyllum ceratites* has been described also from the Middle Devonian of the eastern Anti-Atlas of Morocco (SCHRÖDER & KAZMIERCZAK 1999).

Glossophyllum cf. *schouppei* LÜTTE, 1990
Pl. 2, Fig. 6

*1990 *Glossophyllum schouppei*. – LÜTTE, p. 348, figs. 20–24.
1998 *Glossophyllum* cf. *schouppei*. – SCHRÖDER, p. 34, pl. 4, figs. 20–23.
2001 *Glossophyllum* cf. *schouppei*. – SCHRÖDER & SALERNO, p. 117, pl.1, figs. 1–5.
2001 *Glossophyllum schouppei*. – SCHRÖDER & SALERNO, pl.1, fig. 6.
2005 *Glossophyllum* cf. *schouppei*. – SCHRÖDER, pl. 7, figs. 4–5.

Holotype, type locality and horizon: Specimen no. 986/58 (LÜTTE 1990: fig. 20), Cürten Formation, North Eifel, Germany, Givetian.

Material: One specimen with two thin sections; KC15.

Diagnosis: A small species of *Glossophyllum* with a diameter of 13 mm and 32 major septa. Thin and smooth major septa withdrawn from the axis. Minor septa short. Fossula developed. Cardinal septum short. Dissepimentarium narrow. Tabularium incomplete, composed of axial and peripheral tabellae.

Morphology: The single corallite has a conical shape with a diameter of 14 mm and a length of 30 mm. Longitudinal ribs and growth lines are faintly developed. Calice is not preserved.

In transverse section, the number of septa is 64 (32×2). The septa are radially arranged. The major septa reach about 2/3 of the corallite radius length, leaving an 4 mm wide open area in the axial part. Both orders of septa are non-carinate, but some of them bear weak carinae. They are thin in the dissepimentarium and slightly thickened in the tabularium. The axial tips of the septa are faintly curved. The minor septa traverse the entire dissepimentarium. They are different in size, reaching generally 1/3 to 1/4 of the majors in length. Some of the minor septa are withdrawn from the tabularium border and replaced by a few rows of dissepiments. One of the major septa is shorter than the other ones and assumed to be cardinal septum, positioned in a fossula. In the opposite side, the longer septum is assumed to be the counter septum.

In longitudinal section, the dissepimentarium is narrow. There are 2–4 rows of dissepiments. The dissepiments are small, slightly different in size, and globose to subglobose. There are also some elongate dissepiments. The tbularium is rather broad. Axially, the tabellae are predominantly flat and laterally intersected. They are sometimes concave to convex. Periaxially, the tabellae are in shape of large plates, which are inclined towards axis.

Remarks: Compared to the specimens of *Glossophyllum schouppei* described by LÜTTE (1990: figs. 20–24) from the Givetian of the North Eifel, the corallite from Iran exhibits a few more septa. In spite of this difference, our species is comparable to *Glossophyllum schouppei* in the corallite diameter, the presence of a fossula, a short cardinal septum, the structure of tabularium and a moderately narrow dissepimentarium.

Distribution: The species has been previously recorded from the Givetian of the North Eifel, Germany (LÜTTE 1990; SCHRÖDER 1998, 2005; SCHRÖDER & SALERNO 2001).

6. Biogeographic implications

Givetian rugose corals of the Alborz Mountains are mostly characterized by cosmopolitan genera including *Disphyllum*, *Hexagonaria*, *Macgeea* and charactophyllids. These taxa with wide geographical distribution have been reported from the western and central Alborz (GHODS 1982) and also from the Eastern Alborz Mountains (GHODS 1982; ABBASI et al. in press). On species level, a faunistic connection or relation cannot be considered between coral faunas of the Alborz Mountains and neighbouring blocks such as Turkey, Karakorum Mountains, the Helmand Block, and the Pamir (see SCHRÖDER 2004).

The composition of the Alborz rugose corals is remarkably similar to the fauna reported from the Eifel region in Germany. The presences of *Glossophyllum ceratites*, *Spinophyllum arduum*, *Spinophyllum longiseptatum* and *Aristophyllum luetti* among the Alborz coral composition show a close affinity of Iranian and German faunas. The occurrence of *Spinophyllum blacourti* and *Aristophyllum luetti*, both reported from the Givetian of Belgium, is an indication of a weak faunistic link between Belgium and Iran. Faunistic similarity to the Canning Basin and Queensland in Australia is supported by occurrences of *Temnophyllum occidentale* and *Chostophyllum gregorii*.

The development of unique species of *Temnophyllum* described herein and further new taxa (under study by authors) is restricted to the Alborz coral faunas. This specific faunistic composition of the Alborz Mountains may indicate a limited faunal exchange.

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Plate 1

Fig. 1. *Spinophyllum arduum* (Lütte, 1985), KA 12, X 2.5. a) Transverse section. b) Longitudinal section.
Fig. 2. *Spinophyllum blacourti* (Rohart, 1988), KB 27, X 2.5. a) Transverse section. b) Longitudinal section.
Fig. 3. *Spinophyllum longiseptatum* (Lütte, 1984), KA 30, X 2.5. a) Transverse section. b) Longitudinal section.
Fig. 4. *Spinophyllum zhongguoense* (He, 1978), KA 23, X 2.5. a) Transverse section. b) Longitudinal section.
Fig. 5. *Chostophyllum gregorii* Etheridge, 1892, KC 38, X 2.5. a) Transverse section. b) Longitudinal section.
Fig. 6. *Chostophyllum metula* Pedder, 1982, KA 69, X 2.5. a) Transverse section. b) Longitudinal section.
Fig. 7. *Temnophyllum occidentale* Hill & Jell, 1970, KA 67, X 2.5. a) Transverse section. b) Longitudinal section.

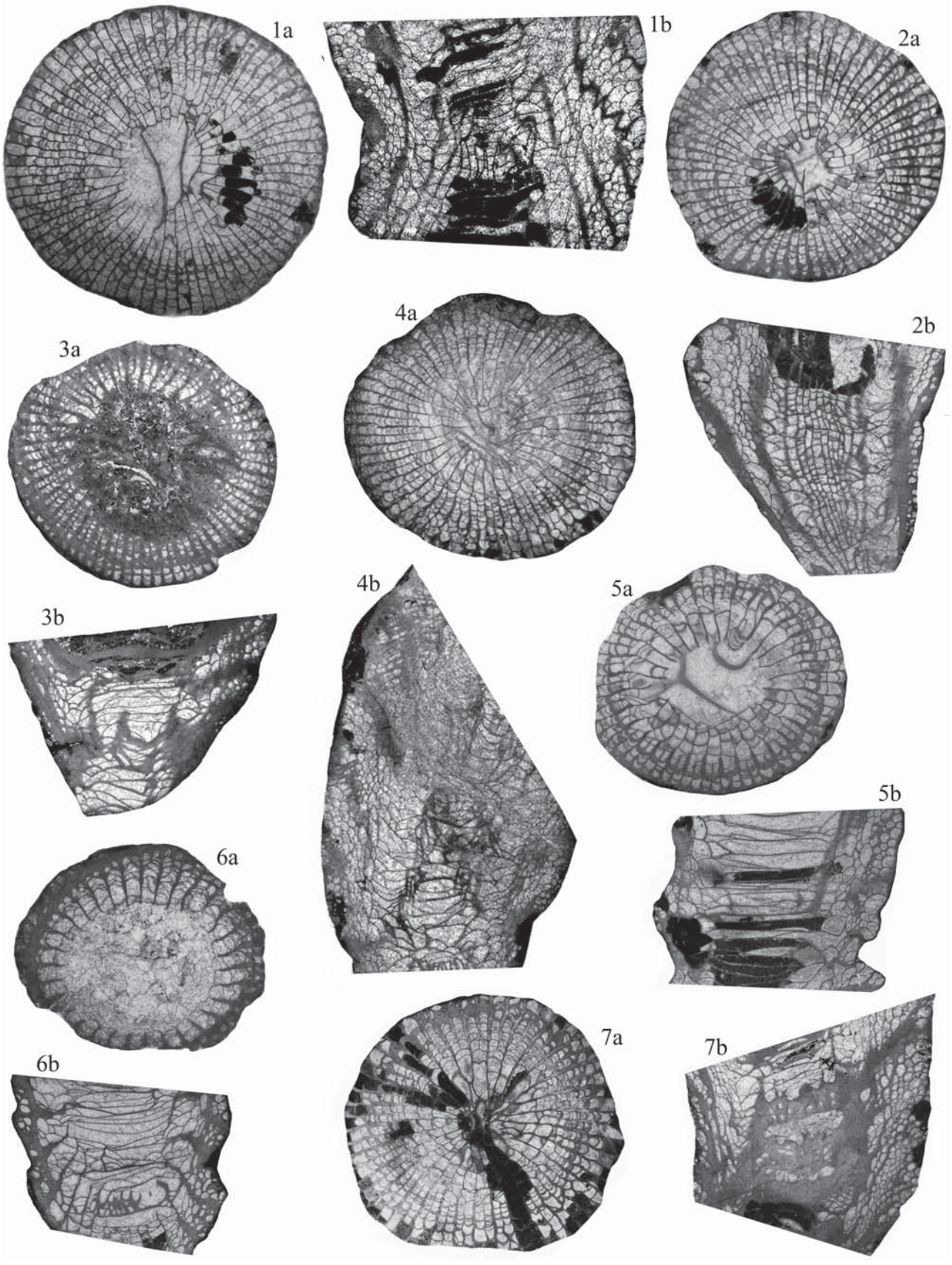
1a
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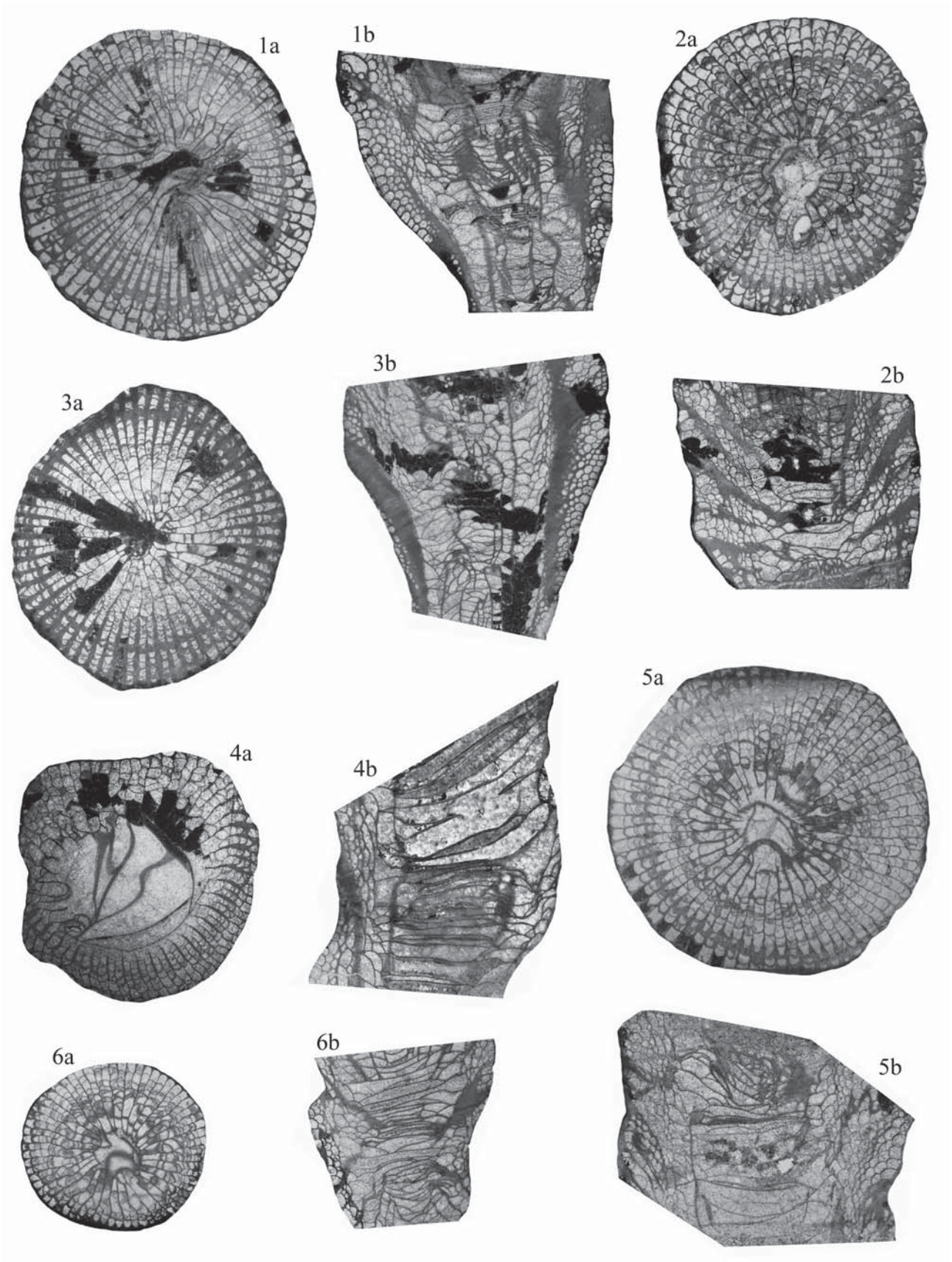
Plate 2

Figs. 1–2. *Temnophyllum* sp. 1. **1.** KC 1, X 2. a) Transverse section. b) Longitudinal section. **2.** KC 40, X 2. a) Transverse section. b) Longitudinal section.
Fig. 3. *Temnophyllum* sp. 2, KA 71, X 2. a) Transverse section. b) Longitudinal section.
Fig. 4. *Aristophyllum luetti* Coen-Aubert, 1997, KA 70, X 2. a) Transverse section. b) Longitudinal section.
Fig. 5. *Glossophyllum ceratites* (Goldfuss, 1826), KC 18, X 2. a) Transverse section. b) Longitudinal section.
Fig. 6. *Glossophyllum* cf. *schouppei* Lütte, 1990, KC 15, X 2.5. a) Transverse section. b) Longitudinal section.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