Devonian corals of the Vosges Mountains, France

JULIEN DENAYER

Denayer, J. 2024. Devonian corals of the Vosges Mountains, France. *Acta Palaeontologica Polonica* 69 (4): 591–605.

The Saxo-Thuringian Zone of western Europe is a tectonostratigraphic unit that includes Devonian sediments. Usually, the sediments are deep-water siliciclastics and variously affected by regional metamorphism. In some points, however, shallow-water carbonates are preserved. Besides Ossa Morena in Spain, the Northern Vosges in Eastern France is one of these rare points. In the Bruche river valley, fossiliferous sediments are known to crop out and fossil invertebrates were first described in the 19th century from the Russ Conglomerate and Russ Marble. The Russ Conglomerate of the Bruche Unit is an olistostrome containing limestone olistoliths. Some of these limestones yielded a fossil coral fauna, though rather poorly preserved. In Russ and Barembach, the olistoliths display reefal facies with stromatoporoids and corals in a sandy carbonate matrix. The rugose coral assemblage in these localities is dominated by "*Fasicphyllum*" *varium*, "*Fasicphyllum*" sp., *Grypophyllum* spp., and *Acanthophyllum* sp., and is of supposed Eifelian age. In Russ, the limestone was quarried in the 19th century as an ornamental stone known as Russ Marble. Near the Schirmeck town, several outcrops of limestone in non reefal facies yield a more diverse coral fauna with genera *Dohmophyllum*, *Stringophyllum*, *Breviphyllum*, *Zonophyllum*, *Mesophyllum*, *Tryplasma*, *Moravophyllum*, and *Spasskyella*, the latter reported for the first time in Western Europe. This assemblage is possibly younger than the previous one, i.e., Givetian in age.

This paper was presented during the 14th Symposium of the International Fossil Coral and Reef Society (IFCRS), Poland, 10–16 September 2023,

Key words: Anthozoa, Rugosa, stratigraphy, Eifelian, Givetian, palaeogeography, Saxo-Thuringian Zone.

Julien Denayer [julien.denayer@uliege.be; ORCID: https://orcid.org/0000-0002-4339-7760], Evolution & Diversity Dynamics Lab, Geology Department, University of Liège, Allée du Six-Août, B18, 4000 Liège, Belgium.

Received 30 May 2024, accepted 19 September 2024, published online 2 December 2024.

Introduction

Corals are abundant fossils in the Devonian of western and central Europe. Uncountable coral faunas were documented during the last 150 years, mostly in the Middle Devonian and Frasnian, Upper Devonian. However, when looking at tectonic or palimspastic maps, a vast majority of the described fauna is situated in the Rheno-Hercynian Zone (extending from south Portugal through SW England, northern France, Belgium, Germany, and Poland), from the Iberian-Armorican-Barrandian Zone or the Moldanubian Zone (northern Spain, Massif Central, Bohemian Massif). The first one represents the southern passive margin of Laurussia whereas the latter two correspond to isolated terranes of Gondwanan origin. However, between these two continental masses exists a strip of terranes forming the Saxo-Thuringian Zone, initially defined by Kossmat (1927). They are part of the Armorican Terrane Assemblage of Tait et al. (2000), a series of small continental and oceanic fragments that originated in the northern Gondwana in the Ordovician and drifted northwards until its collision with the Avalonian Terrane in the Late Devonian–early Carboniferous. During the Devonian, the Armorican Terrane was separated from the coast of Laurussia by the Rheno-Hercynian Ocean and from the Moldanubian terranes by the Saxo-Thuringian Ocean.

Rocks of the Saxo-Thuringian Zone crop out in the southern Bohemian Massif, the Spessart and Odenwal Massifs in eastern Germany, as well as in the northern parts of the German Schwarzwald and French Vosges Massifs. Except for the Bohemian and Vosges Massifs, Paleozoic sedimentary rocks are metamorphosed in the zone. Hence the northern Vosges provide a rare insight into the development of carbonates along a Devonian volcanic arc. Moreover, this is also one of the rare places where Devonian corals are preserved in the Saxo-Thuringian Zone.

The Paleozoic rocks of the Vosges Massif are long known as already cited by Oberlin (1806). Vélain (1887) considered the limestone to be Visean in age but Jaekel (1888) argued a Middle Devonian age based on the fossil fauna, notably the

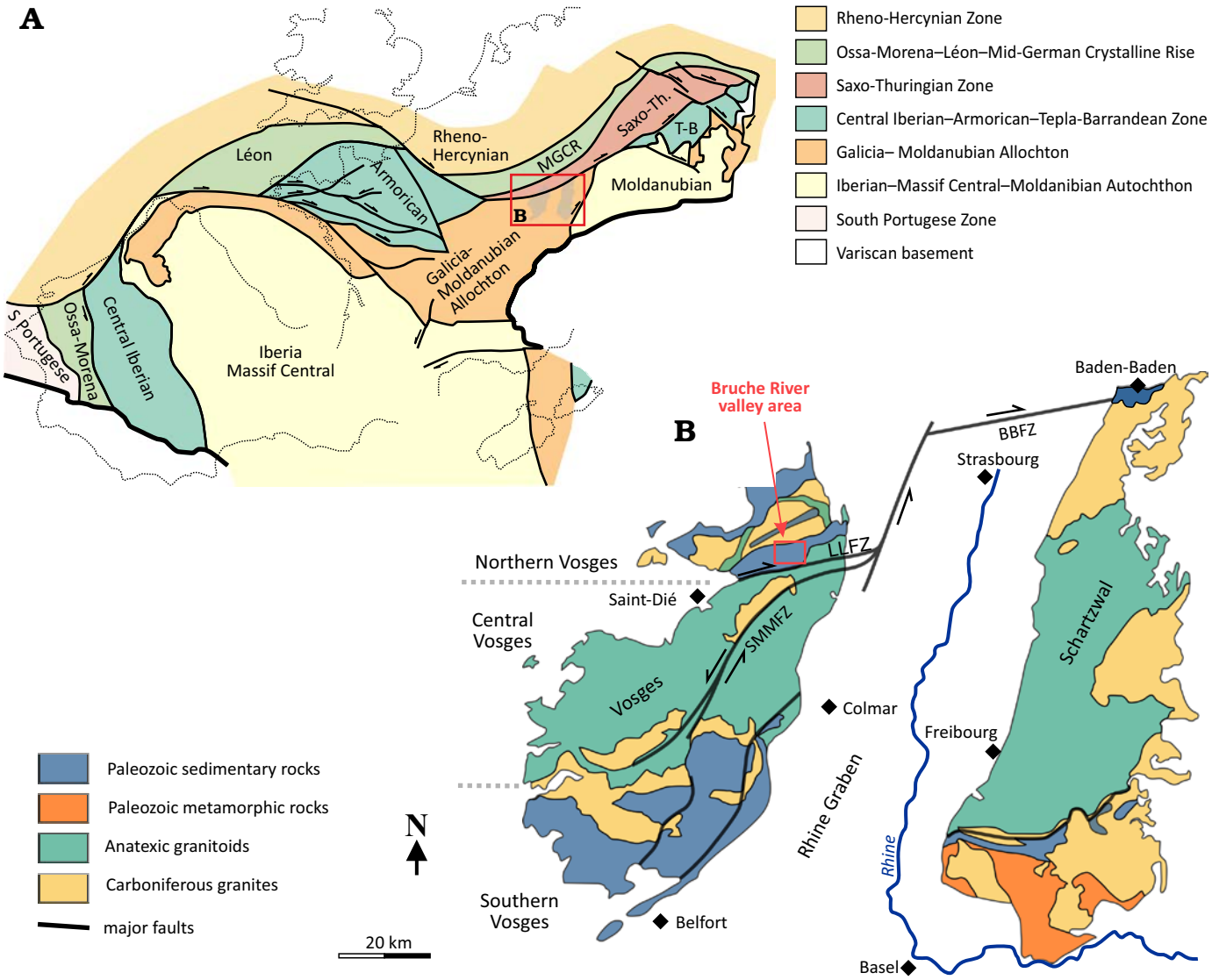

Fig. 1. **A**. General geological map of the Variscan Chain and its tectonostratigraphic components in western Europe. **B**. Close-up map of the Vosges and Black Forest massifs. Abbreviations: BBFZ, Baden-Baden Fault Zone; LLFZ, Lalaye-Lubline Fault Zone; MGCR, Mid-German Crystalline Rise; SMMFZ, Sainte-Marie-aux-Mines Fault Zone; T-B, Telpa-Barrandean Zone. Modified from Franke et al. (2017) and Kreche and Behrmann (2004).

occurrence of the coral *Calceola sandalina*. Since Jaekel (1888), the geological survey of Elsaß-Lothringen (Alsace-Lorraine under Prussian authority between 1871 and 1919) conducted several stratigraphic research and mapping campaigns (e.g., Bücking 1918; Wagner 1923), then continued by the French Service géologique d'Alsace-Lorraine (Firtion 1938, 1945; Dubois, 1946). Firtion (1957) gave a synopsis of a decade of research in the Paleozoic of the Bruche River valley and also the first detailed description and illustration of the fossil fauna. Blanalt (1969), Lillié and Blanalt (1970), Blanalt and Lillié (1973) and Blanalt and Doubinger (1973) provided insight into the depositional settings of the (mostly) Devonian thick sequence of the area.

Institutional abbreviations.—PAULg: Collection de Paléontologie animale et humaine at the Université de Liège, Belgium

Geological setting

Vosges Massif.—The Vosges Massif comprises a metamorphic-granitoid basement partly overlain by Paleozoic sedimentary units, metamorphosed or not, and surrounded by Permian–Triassic sediments. The Massif is divided into three parts (Fig. 1): the Northern Vosges, separated from the crystalline Central Vosges by the Lalaye-Lubline Fault Zone, and the Southern Vosges where the granitic basement is covered with a thick volcano-sedimentary succession. The Northern Vosges is composed of a set of NE-SW striking sedimentary thrust sheets intruded by a belt of granitoid plutons that forms a boundary between two tectonostratigraphic units, namely the Bruche Unit to the north and the Villé and Steige Units to the south. To the East, the Lalaye-Lubline Fault Zone connects to the Baden-Baden Fault Zone of the northern Schwarzwald Massif. This major discontinu-

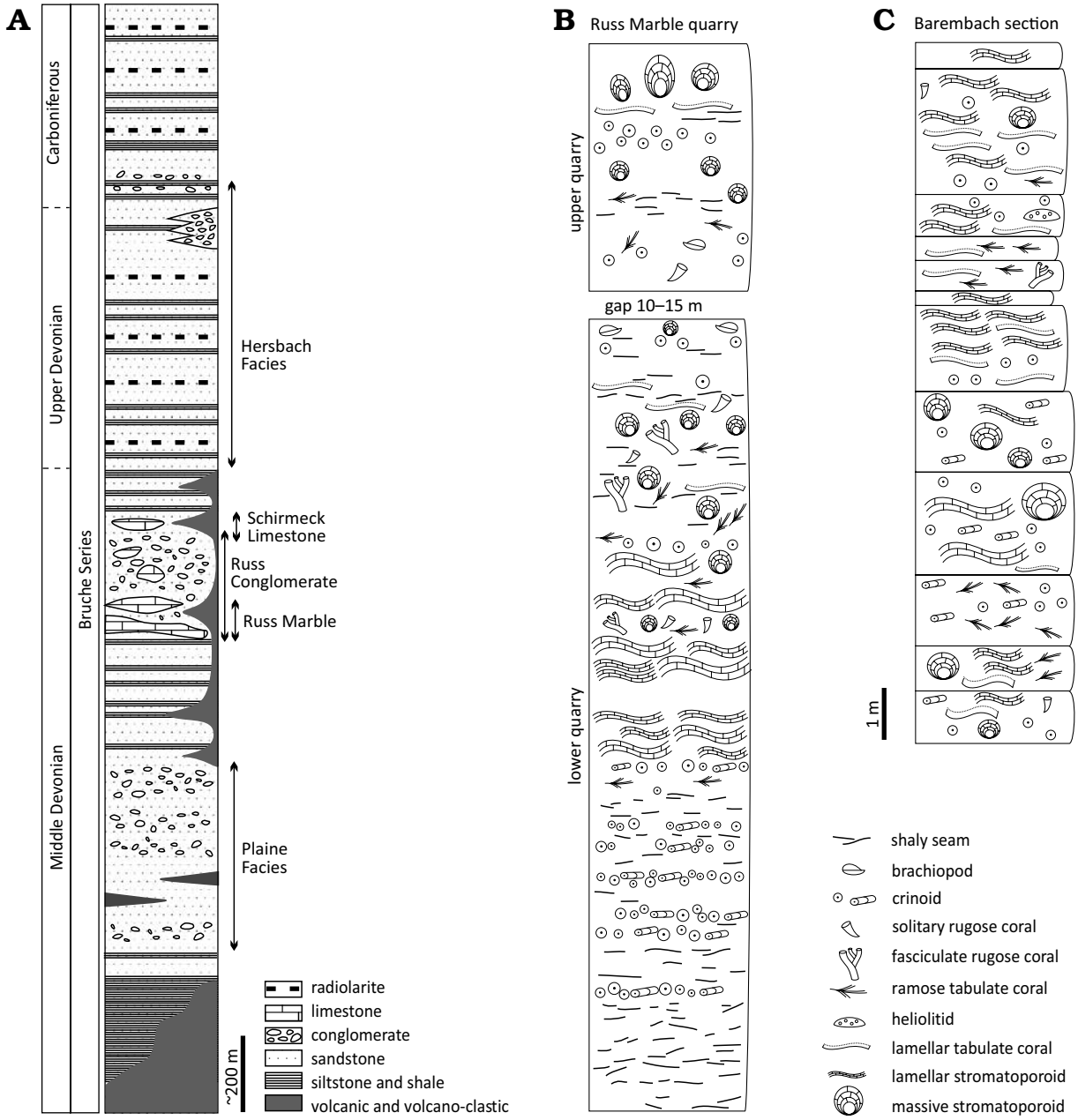

Fig. 2. Devonian–Carboniferous stratigraphy of the Bruche River valley area. **A**. General stratigraphy of the Middle–Upper Devonian of the Bruche River valley area; modified after Skrzypek et al. 2014. **B**. Lithological column of the historical quarry of the Russ Marble, nowadays entirely filled in, after Blanalt (1969). **C**. Lithological column of the Barembach section (new data).

ity is usually interpreted as a dextrally transpressive shear zone limiting the Saxo-Thuringian Zone to the North and Moldanubian Zone to the South (Eisbacher et al. 1989).

Stratigraphy.—The Bruche Unit is a several-kilometre-thick package of sedimentary and volcano-sedimentary rocks forming a vast syncline resting on a Cambrian granitic basement (Fig. 2). At the base of the pile rest basaltic lava flows, volcanoclastics and coarse-grained siliciclastics of supposed Silurian–Early Devonian age (Juteau 1971). The latter are overlain by a Devonian–Carboniferous unit of siliciclastics sediments as well as several horizons with volcanic rocks: submarine basalt flows weathered into spilite-keratophyre rocks and rhyolitic pyroclastic breccia (Rizki and Baroz 1988). The sedimentary succession, or Bruche Series, has been described by Blanalt and Lillié (1973). It includes from the base to the top: (i) Middle Devonian greywacke, siltstone, sandstone (Plaine Facies, Fig. 2) and the Russ Conglomerate; (ii) Upper Devonian siliceous shale and black shale with plant remains (Hersbach Facies, Fig. 2); (iii) Upper Devonian–lower Visean conglomerate, greywacke and arkosic sandstone; and (iv) lower Visean greywacke, siltstone and sandstone with thin coal seams.

The Russ Conglomerate is polymictic and includes pebbles of sedimentary, volcanic and plutonic origin, including granite dated from the late Cambrian (Dörr et al.

1992) as well as fragments of granitoid known in the nearby Champs-de-Feu, which is dated of the Tournaisian–Visean (Montigny et al. 1983). Carbonate pebbles are locally abundant and associated with limestone lenses varying in size from a few metres to several hundreds of metres in lateral extension and up to several tens of metres in thickness (Russ Marble Facies, Fig. 2). The origin of this limestone unit is controversial: interstratified after Firtion (1957) but allochthonous after Wickert and Eisbacher (1988) who consider them as olistoliths. Hence, they would represent the remains of a dismembered carbonate shelf lying originally south of the Northern Vosges. Skrzypek et al. (2014), indicate that the Middle Devonian carbonate sediments deposited in a coastal environment in a relatively shallow-marine siliciclastic or mixed basin in relation with the erosion of a Cambrian substratum.

The Russ Conglomerate (200–250 m thick) is dated as the the Middle Devonian based on the fossil assemblage of carbonate olistoliths but the age of the deposition should be younger as pebbles of Carboniferous granite seems to be reworked in the conglomerate (Fluck et al. 1991; Dörr et al. 1992). However, the Russ Conglomerate is overlain by a thick Upper Devonian sandy-shaly sequence and associated with siliceous shale and radiolarite (Hersbach Facies, Fig. 2). These lithologies yielded a poorly diverse assemblage of small bivalves and a single goniatite determined as *Crickites* sp., hence of Frasnian, Late Devonian age (Blanalt and Doubinger 1973), together with abundant plant remains. The radiolarite yielded an assemblage of conodonts indicative of the Famennian Rhomboidea to Middle Expansa zones (Aghai Soltani et al. 1996). Breccia and conglomerate reworking the underlying lithologies cap the fossiliferous units and are themselves overlain by a thick unit of Visean greywacke and siltstone alternation deposited as turbidites in a flysch (Corsin et al. 1960).

Outcrops and coral assemblages

Russ.—In the Russ village, the type locality of the Russ Marble, the original quarry that yielded the ornamental limestone has been filled up in the 1950s and nowadays, only erratic blocks indicate the occurrence of Devonian limestone there. A precise description of the Russ Marble was provided by Blanalt (1969) in his unpublished Ph.D. Thesis, which was partly used in the explanatory notice of the geological map of the area (Fig. 2).

Three small outcrops in the woody hills south of the village have been sampled (Fig. 3). In Russ I and Russ III the limestone is greyish or reddish, relatively massive, with ribbons of stromatoporoids and tabulate corals highlighting the bedding (Fig. 4A, B). The facies varies from a framestone or coverstone to a floatstone with abundant debris of corals, crinoids, stromatoporoids, and bryozoans (Fig. 5C). The matrix is argillaceous and sandy or purely micritic, and often reddish. An intense stylolithisation affects the rock,

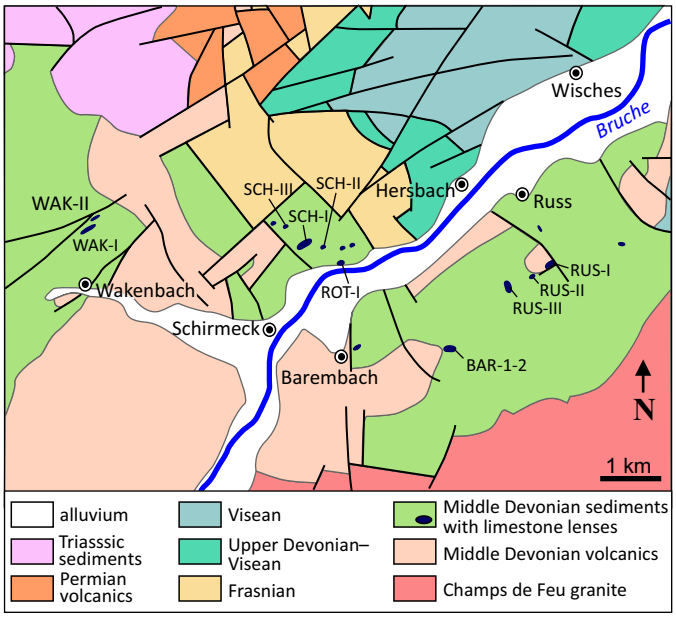

Fig. 3. Localisation of the sampled outcrops on the simplified geological map of the Bruche River valley (modified after Blanalt and Lillé 1973). Abbreviations: BAR, Barembach; ROT, Rotonde de Schirmeck; RUS, Russ; SCH, Schirmeck; WAK, Wakenbach.

making some parts almost nodular. Though some samples display organisms in situ, most of the outcrop is composed of reworked and fragmented coral and stromatoporoid skeletons (Figs. 4A, 5C). After the descriptions of Blanalt (1969) and the facies observed in the "marble" of Russ church, the old quarry was opened in facies similar to those exposed in Russ III. In the outcrop Russ II, the rock is thickly-bedded, stylo-nodular and greenish-grey. The facies is dominantly a rudstone though some coverstone has been observed as well.

The three outcrops in Russ display a similar assemblage dominated by "*Fasciphyllum*" *varium* and *Acanthophyllum* cf. *heterophyllum*. Firtion (1957) reports a single specimen of *Acanthphyllum* cf. *clermontense* here tentatively attributed to *Dohmophyllum* sp. The tabulate corals are represented by *Hillaepora* sp. (= *Pachypora orthostachys* in Firtion 1957) (Fig. 5C) and rare *Heliolites vesiculosum*.

Barembach.—The Barembach outcrop (Fig. 3) is a small quarry where a section of 10 m is more or less exposed but partly covered with mosses and ferns. Beds are 40–160 cm thick and dip at 60–80° south. The facies is a sandy limestone very rich in stromatoporoids, tabulate corals and crinoids forming boundstone and floatstone, often with a brecciated aspect (Fig 5G). The stromatoporoids are bulbous or tabular whereas the tabulate corals (alveolitids) are only laminar. Accumulations of ramose tabulate corals and fasciculate rugose corals form 5–10 cm thick horizons. The matrix is a carbonate sandstone with a dark red colour that displays some dolomite crystals in thin sections (Fig 5G). All carbonate material is recrystallized, often to the point that the corals are not recognisable.

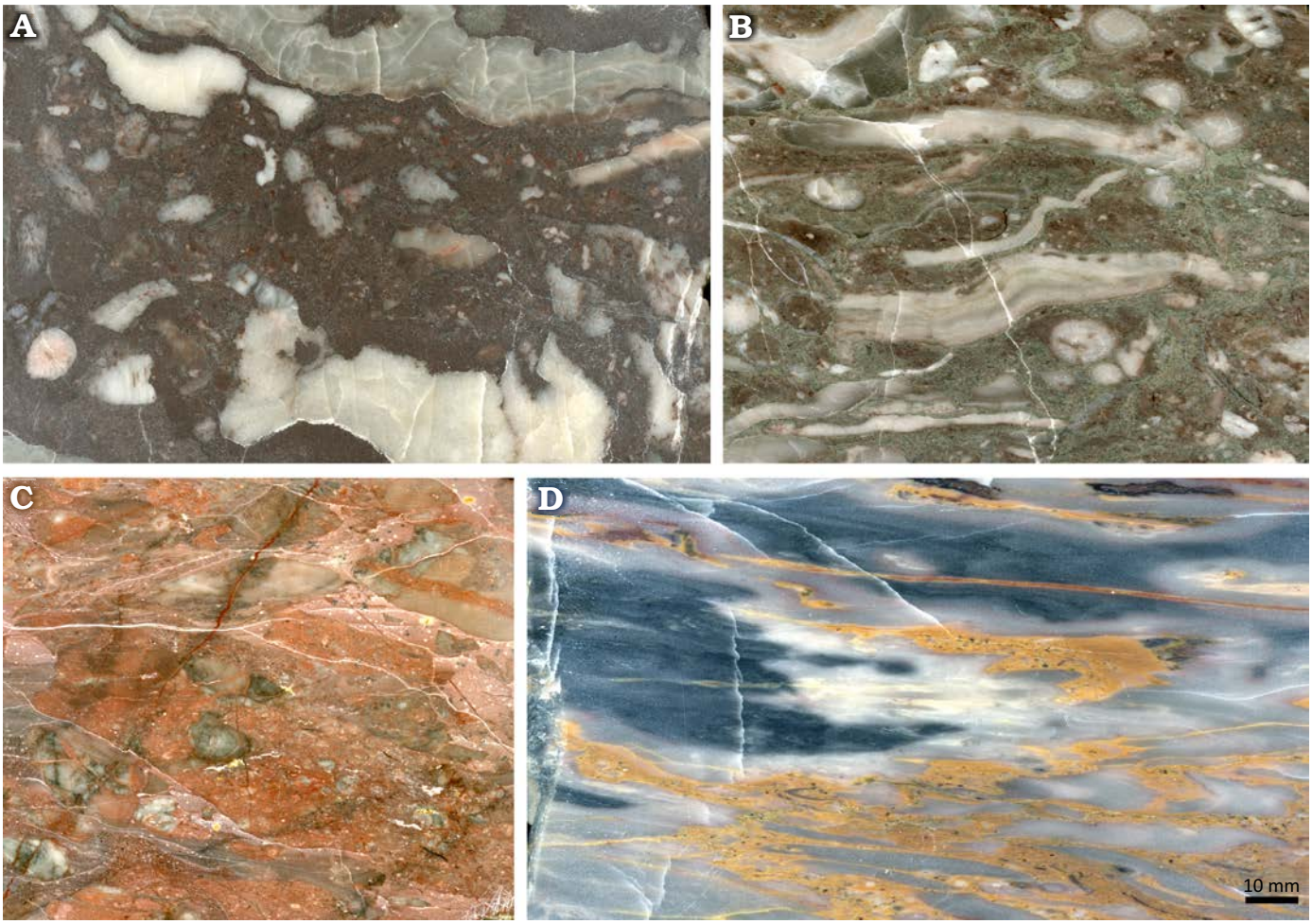

Fig. 4. Lithofacies of the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate limestone of the Bruche River valley, France. **A**. Russ Marble, red bioclastic limestone with abundant fragments of stromatoporoids and tabulate corals, from Russ II. **B**. Russ Marble, red-greenish stromatoporoid coverstone from Russ III. **C**. Pinkish bioclastic-crinoidal limestone, slightly recrystallised, from Schirmeck I. **D**. Slightly metamorphosed limestone with "ghosts" of stromatoporoids, Wakenbach. Polished slabs.

A second, smaller limestone body lies immediately south of the Barembach quarry. The facies is similar but the tabulate corals are less abundant and the stromatoporoid are bigger (up to 10 cm in diameter).

Both outcrops yield a coral assemblage almost identical to that from Russ: "*Fasciphyllum*" sp., *Acathophyllum* cf. *heterophyllum* (Fig. 6H), *Grypophyllum* sp. (Fig. 6J) and *Hillaepora* sp. Only *Grypophyllum* cf. *wedekindi* has been found in Barembach but not in Russ. Almost all fragments are coated with layers of the chaetetid sponge *Pachytheca stellimicans*.

Schirmeck and Rotonde de Schirmeck.—The section situated along the path immediately north of la Rotonde de Schirmeck (disused locomotive roundhouse, Fig. 3) exposes a limestone body and its contact with the surrounding sandstone and siltstone. The facies is a fine-grained limestone, grey or bluish-grey, with coarser-grained bioclastic horizons. In thin sections it appears as a wackestone with a microsparitic matrix made slightly fuzzy by recrystallisation (Fig. 5B). Bioclasts are mostly crinoid debris, fragments of tabulate corals and brachiopod shells. The surrounding siltstone and arkosic siltstone yield fragments of plants ("couches à Psilophytes" in Firtion 1957).

Three outcrops expose the limestone in the woody hills north of the Schirmeck town (Fig. 3). Schirmeck I ("gisement de la Place Clémenceau" in Firtion 1957) is a discontinuous section along a path, exposing at least two limestone units separated by several tens of metres of siliciclastic sediments. Several small disused quarries are opened in the massive limestone. The rock is a poorly stratified greyish limestone with an irregular bedding planes delimited by thin shaly seams. Masses of strongly veined and crystalline pinkish limestone suggest a slight metamorphism and shearing of the rock (Fig. 4C). It passes to thinly bedded argillaceous limestone with bioclastic horizons rich in crinoid but poor in other fossils. The contact with the surrounding greenish siltstone and sandstone is marked by limestone clasts.

Schirmeck II and III are spot outcrops in the valley of a small stream west of Schirmeck I. The first yielded coarse-grained crinoidal rudstone. The second is a conglomerate with centimetric fragments of volcanic rocks, micritic lime-

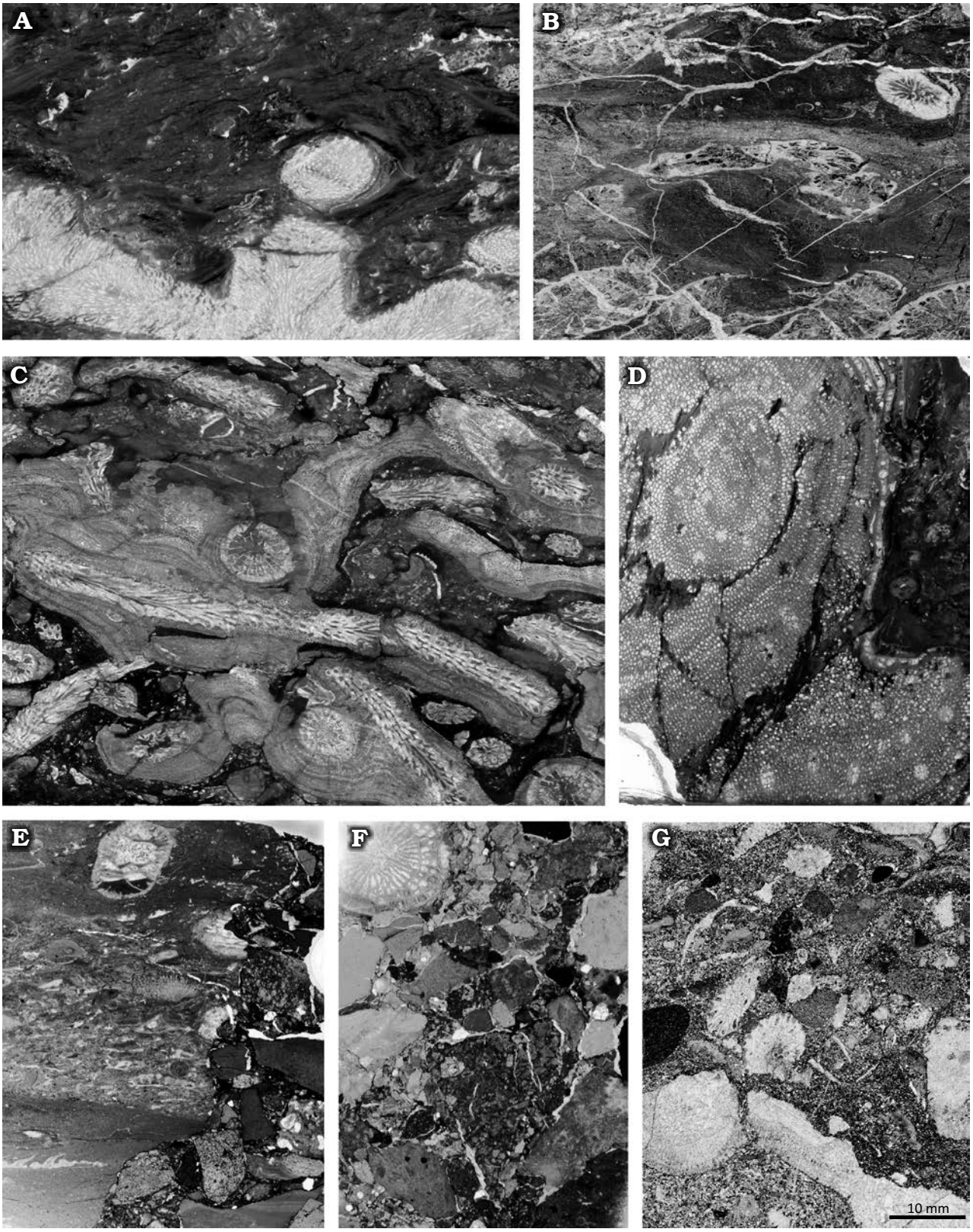

Fig. 5. Microfacies of the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate limestone of the Bruche River valley, France. **A**. Slightly metamorphosed packstone with ramose alveolitid tabulate corals (Schrimeck I, PAULg.SCH I.5). **B**. Wackestone with fasciculate rugose corals and stromatoporoid (Rotonde de Schirmeck, PAULg.ROT.7). **C**. Stromatoporoid-coral framestone (Russ, PAULg.RUS II.9). **D**. *Heliolites* sp. in bioclastic grainstone (Schirmeck, PAULg.SCH I.6). **E**. Margin between large clasts of limestone (bioclastic wackestone-packstone) and polygenic breccia (Schirmeck, PAULg.SCH III.2). **F**. Polygenic breccia (clasts of limestone, sandstone, weathered volcanoclastics and slates), note the solitary rugose coral on top left (Schirmeck, PAULg.SCH.III.2). **G**. Bioclastic sandy limestone with stromatoporoids and corals (Barembach, PAULg.BAR.I.2). Thin sections.

stone, dark sandstone and fragments of corals floating in an abundant sandy matrix (Fig. 5E, F).

The Rotonde de Schirmeck outcrop yields *Spasskyella* sp. (Fig. 7A, B), *Moravophyllum* sp. (Fig. 6A), fragments of "*Fasciphyllum*" sp. (Fig. 5B), *Calceola sandalina*, *Heliolites porosus*, and numerous fragments of indeterminate pachyporids. Firtion (1957) also reported *Acanthophyllum* ex. gr. *multiseptatum* (= *Dohmophyllum involutum*), *Favosites polymorphus* and *Alveolites suborbicularis* from this locality.

Schirmeck I yields *Moravophyllum* sp. (Fig. 6B), *Breviphyllum* sp. (Fig. 6C, D), *Tryplasma* sp. (Fig 6G), *Zonophyllum tabulatum* (Fig 6M), *Calceola sandalina* (Fig. 6I), *Mesophyllum* gr. *lissigense* (Fig. 6K), *Dohmophyllum helianthoides* (Fig. 6F), *Grypophyllum* cf. *wedekindi* (Fig. 6E), *Heliolites porosus* (Fig. 5D). Firtion (1957) also reported *Spongophylloides* ex. gr. *tomasae* (= *Dohmophyllum* sp.), cf. *Hemicosmophyllum*, and *Trematophyllum schulzi* (both = *Acanthophyllum* cf. *heterophyllum*).

Schirmeck II and III yield *Stringophyllum* cf. *wadilinum* (Fig. 6L), *Breviphyllum* sp. and fragments of *Hillaepora* sp.

The railway trench downstream of Schirmeck is not accessible nowadays (partly hidden by a wall, partly covered with a wire mesh). Firtion (1957) reported *Calceola sandalina*, *Cystiphyllum vesiculosum*, indet. *Streptelasmatidae*, *Thamnophyllum murchisoni* (putative *Grypophyllum* sp.), *Ceratophyllum dianthus* (= *Acanthophyllum* cf. *heterophyllum*), *Amplexus* sp. (= *Spasskiella* sp.), *Favosites goldfussi*, *Chaetetes inflatus*, *Heliolites porosus* and *Heliolites interstinctus*.

Wakenbach.—The Wakenbach disused quarry (Fig. 3) exposes a marmoreal limestone, passing to a true marble in some parts. The rock is, therefore, a banded marble, brownish to pinkish grey with centimetre-thick lenses of white calcite that probably corresponds to ghosts of stromatoporoids and tabulate coral colonies (Fig. 4D). Darker parts probably correspond to the remaining matrix. At the entrance of the quarry, the limestone is less recrystallized and rugose and tabulate corals are recognisable.

In the less metamorphosed samples, only "*Fascipyllum*" sp. and chaetetid sponges are recognisable.

Similar metamorphic limestone lenses occur westwards, near La Chapelle and Fouday, c. 10 km SW of Schirmeck (Jaeckel 1888; Firtion 1957) but the recrystallization is there so important that all organic structures are entirely erased. Nevertheless, the marbles are considered to have the same origin than those of the Bruche River valley.

Systematic paleontology

The material collected in the Bruche River valley by Fridolin Firtion in the 1950–60s seems to be partly lost. The thin sections of the tabulate corals are nowadays curated in the Collections of the Université de Strasbourg (Kévin Janneau, personal communication 2021). The rest of the material, including the thin sections of the rugose corals has not been traced, neither at the Université de Strasbourg nor in the Service géologique regional d'Alsace. The present material, collected by the author in 2019 and 2022, is curated in the Collection de Paléontologie animale et humaine at the Université de Liège, Belgium. The collection is composed of rock samples, slabs and thin sections.

Here are provided the description and discussion of some species of particular interest. Not all the corals are described as some species are well known or the material is too limited to provide significant details.

Class Anthozoa Ehrenberg, 1834

Order Stauriida Verril, 1865

Suborder Streptelasmatina Wedekind, 1927

Familly Streptelasmatidae Nicholson in Nicholson and Lydekker, 1889

Genus *Breviphyllum* Stumm, 1949

Type species: *Amplexus lonensis* Stumm, 1937, from the Emsian, Lower Devonian, of Nevada, USA.

Remarks.—Stumm (1949) introduced the generic name *Breviphyllum* for siphonophrentid corals with dissepiments. As pointed out by Merriam (1974), the type-specimen of the type species displays no dissepiments, therefore, *Breviphyllum* should be considered as a junior synonym of *Breviphrentis* Stumm, 1949 (Oliver 1992; Pedder 2002). However, the specimens figured by Stumm (1937: pl. 54: 3, 5), determined as *Amplexus nevadensis* and *Amplexus magnus*, display scarce dissepiments. The latter two are probably not congeneric with the type species *Breviphyllum lonensis*. Pedder (2002) demonstrated that true dissepiments are present in the type material, therefore the name *Breviphyllum* is correct. Pedder (2002) introduced two new genera *Weyerdites* Pedder, 2002, and *Bartineophyllum* Pedder, 2002, for breviphyllids with dissepiments (lonsdaleoid and interseptal, respectively) and long septa, that clearly differ from *Breviphyllum* by their more complex skeleton.

Breviphyllum sp.

Fig. 6C, D.

Material.—Three specimens (PAULg.SCH I.4, 8, and 14) from the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate, Schirmeck outcrop, France.

Description.—Cylindrical to scolecoid solitary coral up to 50 mm long and 13–14 mm in diameter, having 28–38 septa of each order. Major septa are short (half as long as the corallite radius) and thick near the wall, thinning towards the axis. Minor septa are either long (3/4 of the major septa in length) or withdrawn. Cardinal major septum as long as the other septa. Small cardinal fossula. Tabularium 9–12 mm-wide, free of septa. Dissepimentarium made of an incomplete row of concentric interseptal dissepiments (Fig. $5D_2$), vertically discontinuous. Dissepiments elongated and verti-

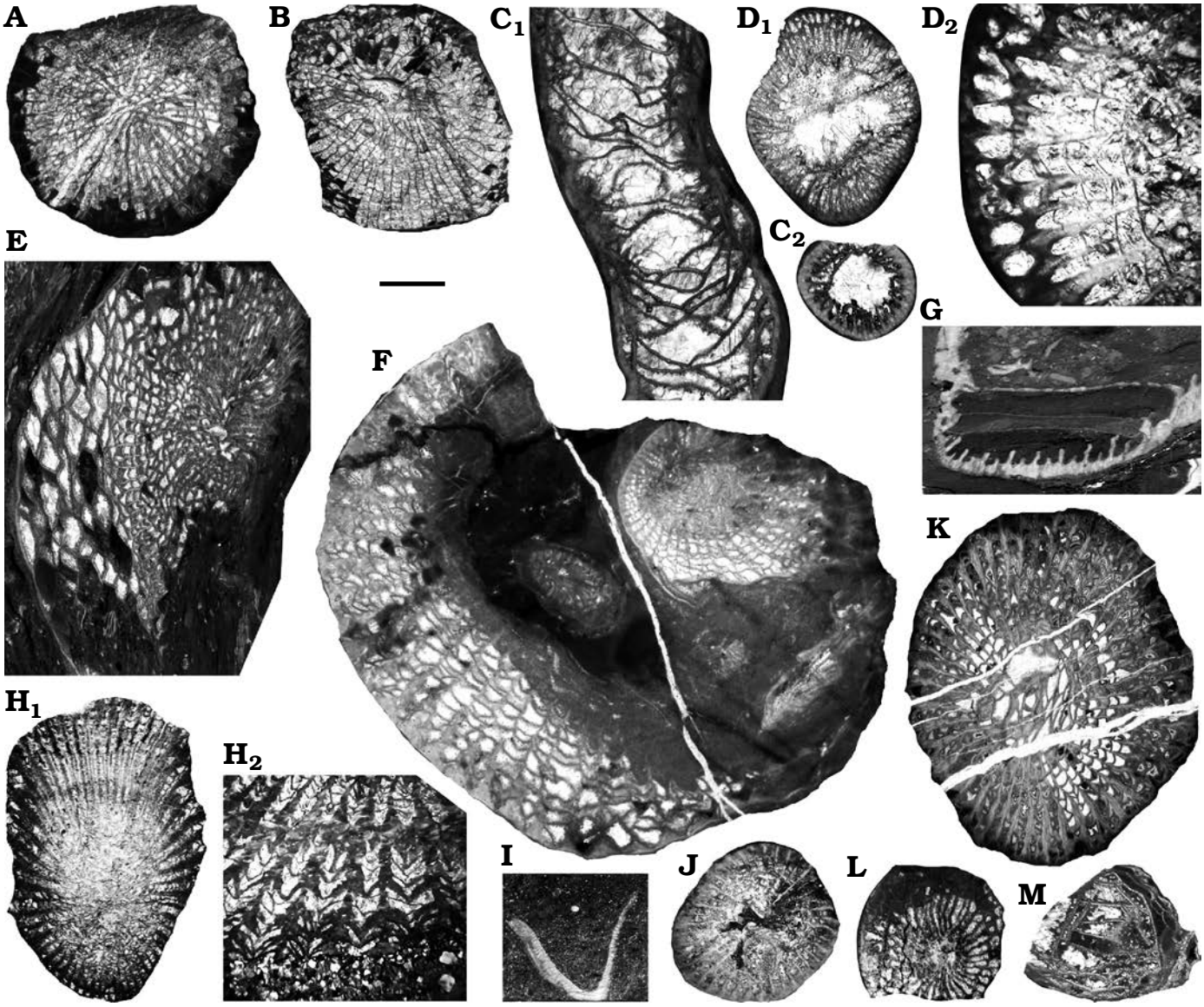

Fig. 6. Rugose corals from the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate of Schirmeck and Barembach outcrops, France. **A**, **B**. *Moravophyllum* sp. from Rotonde de Schirmeck, PAULg.ROT.2 (**A**) and PAULg.SCH I.5 (**B**) in transverse section (TS). **C**, **D**. *Breviphyllum* sp. from Schirmeck, PAULg.SCH I.8 (**C**) and PAULg.SCH I.14 (**D**), in longitudinal section (LS) (C_1, D_1, D_2) and TS (C_2), close-up view of the dissepimentarium (D_2). **E**. *Grypophyllum* cf. *wedekindi* Middleton, 1959, from Schirmeck, PAULg.SCH I.6, partly eroded corallite in TS. **F**. *Dohmophyllum difficile* (Wedekind, 1925) from Schirmeck, corallite showing a rejuvenescence, PAULg.SCH I.2 in TS. **G**. *Tryplasma* sp. from Schirmeck, PAULg.SCH I.20 in TS. **H**. *Acanthophyllum heterophyllum* (Milne-Edwards & Haime, 1851) from Barembach, PAULg. BAR II.14. in TS (H_1), close-up view of the dissepimentarium in TS (H_2). **I**. *Calceola sandalina* (Lamarck, 1799) from Schirmeck, PAULg.SCH I.12 in LS. **J**. *Grypophyllum* sp. from Barembach, PAULg.BAR II.6 in TS. **K**. *Mesophyllum* gr. *lissingense* (Schlüter, 1881) from Schirmeck, PAULg.SCH I.7 in TS. **L**. *Stringophyllum* cf. *wadilinum* Coen-Aubert, 1989, from Schirmeck, PAULg.SCH III.2. **M**. *Zonophyllum* sp. from Schirmeck, PAULg.SCH I.11 in TS. Scale bar: 5 mm ($A–D_1$, $E–H_1$, I–M); 1 mm (D_2, H_2).

cal. Tabulae irregular, complete or not, concave or convex. External wall thick, festooned.

Remarks.—The combined occurrence of short septa, wide tabularium and scarce dissepiments is unusual but known from North American specimens initially described as *Breviphyllum* (see Remarks above). The North American Emsian species *Breviphyllum lonense* (Stumm, 1937) is larger (40 mm in diameter and <40 septa) and displays longer minor septa. *Breviphrentis* cf. *superstes* Poty & Denayer in Denayer et al., 2012, with its diameter of 10–17 mm for 25–30 septa of each order is very similar to the present material but differs in having more regular tabulae and minor septa commonly contraclinant.

Suborder Cyathophyllina Nicholson in Nicholson and Lydekker, 1889

Family Cyathophyllidae Dana, 1846

Genus *Moravophyllum* Kettnerová, 1932

Type species: *Moravophyllum ptenophylloides* Kettnerová, 1932, from the lower Givetian, Middle Devonian, of Moravia, Czech Republic.

Diagnosis (after Kettnerová 1932).—Cylindrical solitary rugose coral with septa of two orders, variable in thickeness. The septa are radially arranged in the counter quadrants and pinnately disposed on both sides of the cardinal septum in the cardinal quadrants. Major septa long but leaving a free space in the axial part of the corallites. Minor septa reaching the edge of the tabularium. Wide tabularium made of complete and incomplete tabulae. Dissepimentarium made of globose dissepiments arranged in horizontal layers in its outer part and declined towards the tabularium in the inner part.

Moravophyllum sp.

Fig. 6A, B.

Material.—Two incomplete specimens (PAULg.SCH I.5 and PAULg.ROT.2) from the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate, Schirmeck and La Rotonde de Schirmeck outcrops, France.

Description.—Solitary rugose corals 17–18 mm in diameter having 26–28 septa of each order. Septa straight and thin in the tabularium, slightly thickened in the dissepimentarium. The major septa are long, joined in bundles, pinnately arranged in the cardinal quadrants, and more radially arranged in the counter quadrants, alar septa connected. Cardinal and counter septa similar to the other septa in one specimen but shorter in the other specimen. Minor septa long reaching the margin of the tabularium. Dissepimentarium made of 4–7 rows of small interseptal dissepiments, either concentric or angulo-concentric. Cadinal fossula slightly marked by the withdrawal of the cardinal septum. No longitudinal section is available to describe the tabulae.

Remarks.—*Moravophyllum ptenophylloides* Kettnerová, 1932, is larger, reaching 55 mm in diameter and 60 septa of each order. *Moravophyllum oliveri* Birenheide, 1987, has more than 40 septa at 45 mm in diameter. These two specimens probably belong to a distinct species yet to be named but the bad preservation of the present material precludes to a proper definition.

Moravophyllum sp. comes from the Schirmeck and Rotonde de Schirmeck outcrops. *Moravophyllum ptenophylloides* is known from the lower Givetian, Middle Devonian, of Moravia (Kettnerová 1932). A similar species has been described in the Givetian of Mauritania (*Moravophyllum* cf. *ptenophylloides*, Coen-Aubert 2017) and Yunnan (Jin 2005). *Moravophyllum oliveri* is from the upper Eifelian, Middle Givetian, of the Eifel Hills, Germany (Birenheide 1987; Schröder 1995, 1998).

Suborder Columnariina Soshkina, 1941

Familly Disphyllidae Hill, 1939

Genus *Spasskyella* Tsyganko, 1977

Type species: *Spasskyella pershinae* Tsyganko, 1977, from the Givetian, Middle Devonian, of the western side of the Polar Ural Mountains.

Diagnosis (after Tsyganko, 1977).—Fasciculate colony with cylindrical corallites displaying longitudinal rugae on the wall. Septa very short or not developed, minor and major septa indiscriminated. Base of septa triangular, included in the lamellar stereoplasm of the wall. Dissepimentarium unstable, made of one or two uncomplete rows of vertical dissepiments. Tabulae horizontal and flat.

Remarks.—These simple colonies have few characteristics for discussing the systematic attribution. The poor development of the septa and simple tabulae are commonly observed in *Pseudoamplexus* Weissermel, 1897, *Aphyllum* Soshkina, 1937, and *Tabularia* Soshkina, 1937. However, the latter are all solitary genera. The genus *Pycnostylus* Whiteaves, 1884, is a colonial form close to *Pseudoamplexus* and differs from *Spasskyella* Tsyganko, 1977, by its parricidal axial increase where four offsets form simultaneously, whereas *Spaskyella* displays non-parricidal lateral increase. *Synaptophyllum* Simpson, 1900, is relatively simple in morphology, but differs by its regularly spaced mesa-shaped tabulae and longer (and more stable) septa. *Cyathopaedium* Schlüter, 1889, has very irregular and sparse tabulae. Such a simple morphology is also observed in pseudocolonies of "*Amplexus*" *florescens* Počta, 1902, as figured by Berkowski (2006) but the latter, besides its gregarious habitus, differs by the more conical morphology of the corallites.

Tsyganko (1981) classified *Spasskyella* into the Disphyllidae based on the morphology of the septal trabeculae and cuneiform base of the septa included in the external wall. Based on the same argument, he included the species figured by Oliver (1976) *Disphyllum*? *stummi* (Oliver, 1971) and *Disphyllum*? *rectiseptatum* (Röminger, 1876) in *Spasskyella*. However, in those two species, the tabulae are commonly divided and convex. Moreover, the dissepimentarium is well developed (up to three rows in *D*.? *stummi*) and made of globose dissepiments (cf. Oliver 1976: pls. 30 and 44). Hence, the two American species are here excluded from *Spasskyella*.

The colonies doubtfully attributed to *Synaptophyllum* by Rodríguez-García (1978) present horizontal tabulae and not the mesa-shaped tabulae that are characteristic of the genus. Though ?*Synaptophyllum oliveri* Rodríguez-García, 1978, displays rather long septa, they could be included in *Spaskyella* after revision of the type material.

Spasskyella sp.

Fig. 8A, B.

Material.—One fragment of colony and numerous isolated corallites (PAULg.ROT.1 and 6) form the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate, La Rotonde de Schirmeck outcrop, France.

Description.—Small phaceloid colony with relatively densely-packed cylindrical corallites 5 to 5.5 mm in diameter, without any connecting structure. Septa developed in less than 10% of the corallites. Where present, there are up to 20 short septa, less than 0.5 mm long, but rarely on both sides of the corallite. Distinction between minor and major septa not possible. Where not developed, small triangular

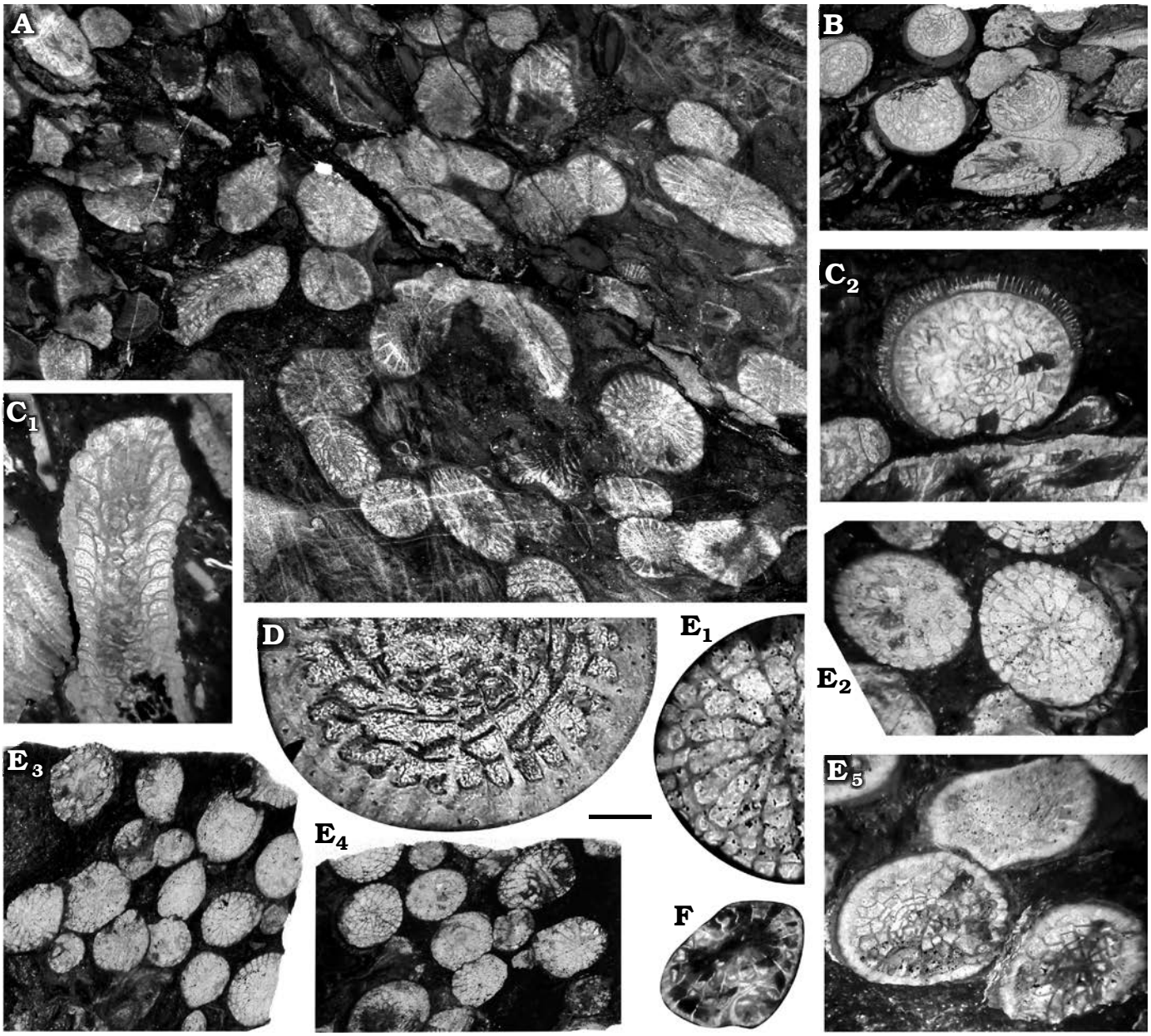

Fig. 7. Rugose corals from the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate of the Russ outcrops, France. **A**–**D**. "*Fasciphyllum*" *varium* Schlüter, 1889. **A**. PAULg.RUS I.2 in transverse section (TS). **B**. PAULg.RUS III.2 in TS. **C**. PAULg.RUS III.12, close-up view of a corallite coated with *Pachytheca stellimicans* (Schlüter, 1885), in longitudinal section (LS) (C_1) and in TS (C_2). **D**. PAULg.RUS III.5, close-up view showing the thick wall and development of septa in TS. **E**, **F**. "*Fasciphyllum*" sp., close-up view showing dissepiments in TS. **E**. PAULg.RUS III.6, close-up of a corallite (E_1), general view of colony (E_3, E_4), close-ups (E_2, E_5). **F**. PAULg.RUS III.12, close-up view of a corallite with an offset. Scale bar: 5 mm (A–C, E_3, E_4); 1 mm (D, E_1); 2 mm (E_2, E_5, F).

thickening on the inner edge of the wall might represent the base of the septa. External wall 0.2–0.5 mm thick, straight and smooth. One incomplete row of vertical vesicular dissepiment observed. In longitudinal section, tabulae flat or slightly concave, parallel to irregularly arranged, separated by 0.3 to 1 mm. Increase lateral with one or two offsets.

Remarks.—Though the available material is limited, the specimens from Rotonde de Schirmeck differ from the type-species and only other described species of *Spasskyella* by the size of the corallites (7.5 mm in diameter in the Russian species). The French specimens are closer in size to the possible *Spaskyella oliveri* Rodríguez-García, 1978, but the latter has longer septa.

Besides the type-species described from the Givetian strata of the Urals Mountains, and a possible occurrence in the Emsian of Ossa Morena, the French occurrence is the second report of the genus in NW Europe.

Suborder Ptenophyllina Wedekind, 1927

Family Fasciphyllidae Soshkina, 1954

Fasciphyllum Schlüter, 1885

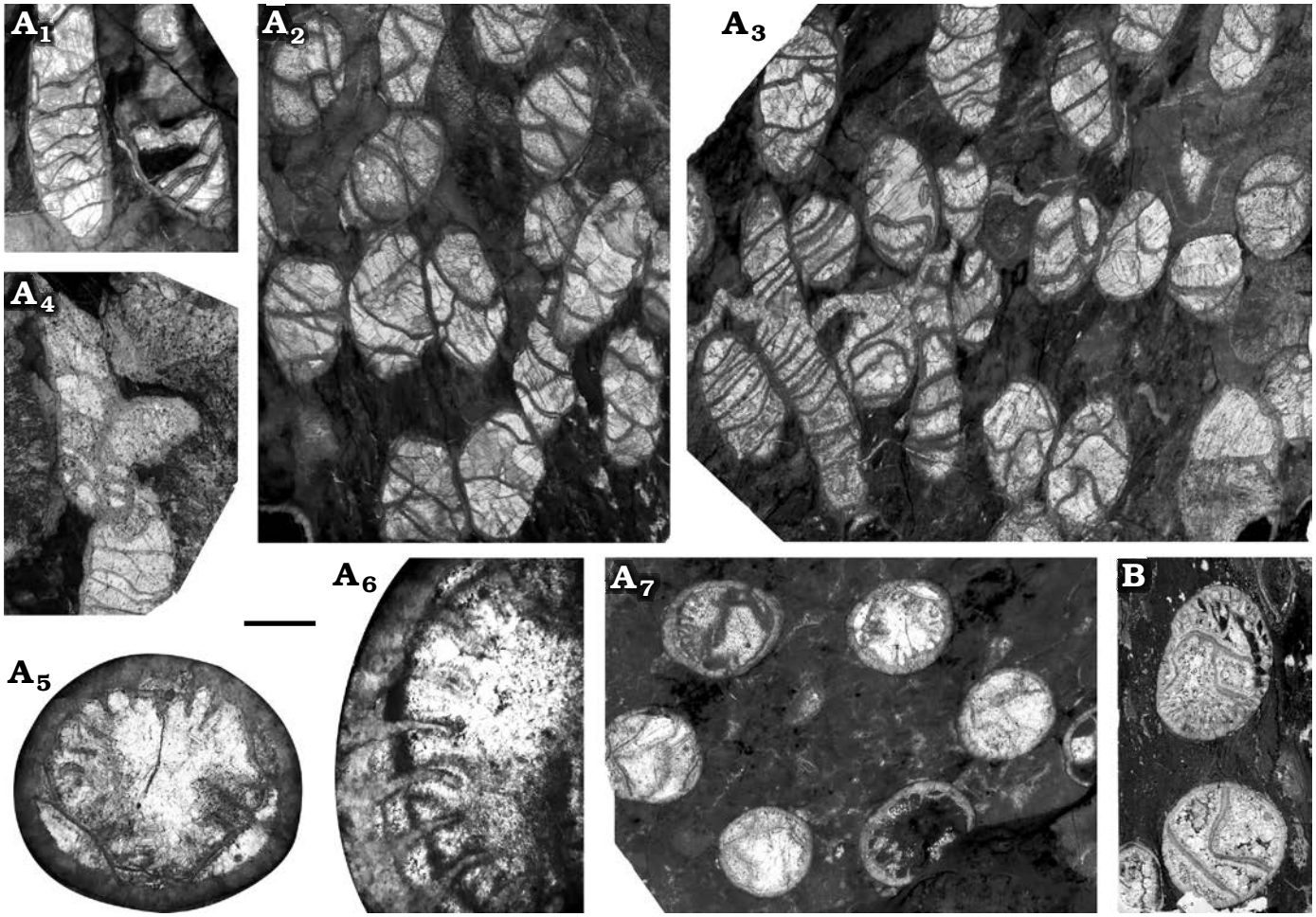

Fig. 8. Rugose corals *Spasskyella* sp. from the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate of Rotonde de Schirmeck outcrops, France. **A**. PAULg.ROT.1 in longitudinal section (LS) (A_1) and in transverse section (TS) (A_2, A_3, A_7), corallite showing two offsets in LS (A_4), close-up views showing the variable development of septa in TS (A_5, A_6). **B**. PAULg.ROT.6 in TS. Scale bar: 5 mm (A_1–A_3, A_7, B); 2 mm (A_5); 1 mm (A_6).

Type species: *Fascicularia conglomeratum* Schlüter, 1881, from the lower Givetian, Middle Devonian, Loogh Formation of the Eifel Hills, Germany.

Diagnosis (after Schlüter 1885).—Phaceloid colonies with cylindrical corallites. Septa dilated in periphery to form prominent stereozone. Major septa reaching the axis, minor septa short. Tabulae widely spaced, complete, flat or sagging. One row of vertically elongated dissepiments. Septal trabeculae slender.

Remarks.—There is a consensus on the synonymy of the genera *Fasciphyllum* Schlüter, 1885, and *Battersbya* Milne-Edwards & Haime, 1851. However, Schröder and Lütte (1999) and McLean (2018) accept *Batterbya*, based on the lectotype of *Battersbya inaequalis* Milne-Edwards & Haime, 1851, as valid, whereas Coen-Aubert (1992), and Zhen and Jell (1996) prefer to use the name *Fasciphyllum*, based on *Fasciphyllum conglomerata* Schlüter, 1881, as the type material of the latter is better preserved and more precisely constrained stratigraphically than the British species. If it is an agreement on *F. conglomeratum* being a junior synonym of *B. inaequalis*, the species *F. varium* is very different (larger corallites, dissepimentarium more complex, stereozone less developed, mode of increase) as documented by Schröder and Lütte (1999). Hence, this species is probably not congeneric with *B. inaequalis* and a new genus name would be required. Meanwhile, we use here the name "*Fasciphyllum*" *varium* for the present material.

"*Fasciphyllum*" *varium* Schlüter, 1889

Fig. 7A–D.

Material.—Nine fragments (PAULg.RUS I.2, II.8, III.1, 2, 5, 7, 11, PAULg.BAR II.4, 5, and PAULg.WAK.1) of colonies from the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate, Russ I, II, and III outcrops, two from Barembach and one from Wakenbach, France.

Description.—Fasciculate colonies with small cylindrical corallites growing parallel to each other, some colonies display polygonal corallites where offsets remain attached to parent corallites. Increase lateral mostly non-parricidal, though axial division is suspected in one specimen. Corallites 4.5–6 mm in diameter (tabularium 3.5–4 mm), having 16–18 septa of both orders. Major septa long, reaching the axis, some of them connecting, or slightly withdrawn, leaving a free space <1 mm wide in the axial part of the corallite.

Major septa straight and smooth, or slightly tortuous in the axial part. Minor septa short, not reaching the margin of the tabularium, most commonly reduced to septal crests on the wall. Base of septa thickened with the wall. In rare, well-preserved specimens, a thin dark median line is visible in the septa. Wall up to 0.4 mm thick. Dissepimentarium very narrow, made of one, commonly incomplete row of concentric interseptal dissepiments, rarely a second incomplete row in large corallites, but missing in the small ones. In longitudinal section, dissepiments globular declined towards the axis at 40–50°, the second row being formed of larger dissepiments declined at 70°. Tabulae flat or slightly concave, mostly complete, densely packed.

Remarks.—Despite the poor preservation of the material, the characteristics of "*F.*" *varium* are recognisable, notably the long and thin major septa, short minor septa, the dissepiments variable in size and shape, and the sagging tabulae.

Geographic and stratigraphic range.—In the Northern Vosges, the species is present in the Russ Marble in Russ, Barembach and Wakenbach. The species is abundant in the Eifelian of Belgium and the Eifel Hills, Germany (Schröder and Lütte 1999; Denayer 2023) and possibly in the Givetian of Moravia (*Battersbyia* cf. *anisactis* in Galle 1981, with several rows of dissepiments)

"*Fasciphyllum*" sp.

Fig. 7E, F.

Material.—Three fragments (PAULg.RUS III.4, 6, 12) of small colonies from the Middle Devonian (upper Eifelian–?lower Givetian) Russ Conglomerate, Russ III outcrop, France.

Description.—Small fasciculate colonies with cylindrical corallites growing parallel to each other, 4–4.5 mm in diameter (3.5–4 mm for the tabularium). Increase lateral non-parricidal. On average, 15–16 septa of each order. Major septa long but withdrawn from the axis, straight and smooth. Minor septa short, reaching the margin of the tabularium. Wall 0.4 mm thick. Dissepimentarium made of two rows of concentric and crossed interseptal dissepiments, the inner row being usually thickened. In longitudinal section, dissepiments variable in shape and size, declined towards the axis at 40–60°, the inner row being more irregular. Tabulae complete and flat.

Remarks.—Three colonies described herein differ from "*Fasciphyllum*" *varium* by their smaller diameter their number of septa slightly lower, but, above all, their dissepimentarium more developed and more complex.

The species is only known from Russ in the northern Vosges.

Discussion

Historically, the Russ Marble is supposed to be Givetian, Middle Devonian, after the occurrence of the brachiopod *Stringocephalus burtini* reported by Jaekel (1888) and consequently repeated in the literature (Wagner 1923; Jung 1928; Dubois 1946). Meanwhile, Benecke and Bücking (1898) reported steinkern of *Calceola sandalina* in Champenay (upstream part of the Bruche River valley), in siliciclastic sediments that include the limestone bodies, making it "Couvinian" (i.e., uppermost Emsian to lowermost Givetian in modern terms). Firtion (1957: pl. 10: 8) illustrated a putative *Stringocephalus burtini* from Jaekel's collection but this specimen is hardly identifiable. Firtion (1957) noticed the same brachiopod in the Russ Marble, including in the Russ church where the main altar is carved with this ornamental stone. Despite careful research, it was not possible to find a single brachiopod shell in the church marbles in 2022.

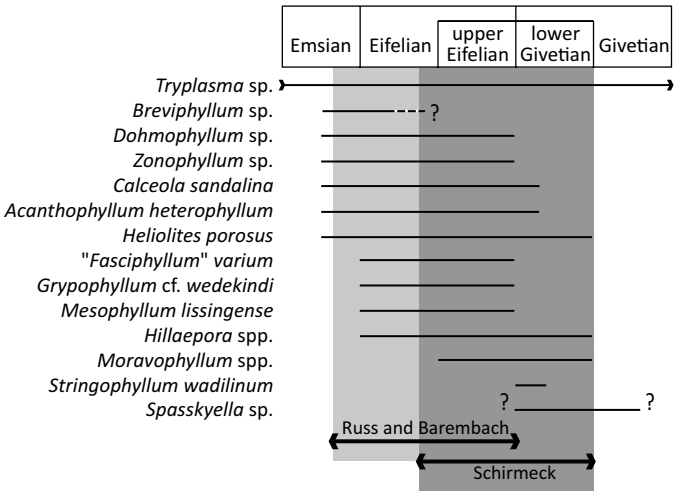

Fig. 9. Stratigraphic range of the rugose and tabulate corals collected from the Russ, Barembach, and Schirmeck outcrops in the Bruche River valley.

The Givetian age extrapolated from the occurrence of *Stringocephalus burtini* and other brachiopods is consequently not robust. There are few datation elements available from the field. The search for conodonts in the limestone was not successful as the treated samples were barren. Similarly, the palynological samples taken from the surrounding siltstone yielded no useful element.

Based on the coral fauna, there are clearly two distinct assemblages (Fig. 9): (i) the assemblage dominated by "*Fasciphyllum*" *varium* and *Hillaepora* sp., from the Russ, Barembach, and Wakenbach localities (i.e., southern part of the Bruche Massif), and (ii) the assemblage with *Spasskyella* sp., *Moravophyllum* sp., and *Heliolites porosus* from Schirmeck and La Rotonde de Schirmeck localities (i.e., northern part of the Bruche Massif).

The first contains "*F.*" *varium*, known from the Eifelian of Belgium and Germany (Costatus Conodont Zone). *Hillaepora* spp. are not known above the lower Givetian (Mironova 1960). *Acanthophyllum heterophyllum* is recorded from the upper Emsian to lowermost Givetian in Belgium, Germany, Poland, Mauritania, and Morocco (Coen-Aubert 2017). *Grypophyllum* is a genus ranging throughout the Middle Devo-

nian and, without a proper specific attribution, it is not stratigraphically useful. This assemblage is most probably upper Eifelian and possibly lower Givetian.

The second assemblage yields *Moravophyllum* sp. This genus is uncommon in the fossil record and the species *Moravophyllum ptenophylloides* is from the lower Givetian of Moravia (Kettnerová 1932), whereas *Moravophyllum oliveri* is described in the upper Eifelian of Germany (Birenheide 1987). Two more occurrences of this genus are known: *Moravophyllum* cf. *ptenophylloides* from the Givetian of Mauritania (Coen-Aubert 2017) and *Moravophyllum* cf. *oliveri* from the Eifelian of the Eifel Hills (Schröder 1995). *Stringophyllum* and *Dohmophyllum* are two genera containing several species ranging from the upper Eifelian to the lower Givetian in Europe (Birenheide 1963), and also in the Lower Devonian in Canada (Pedder 1971) and Australia (Yu and Jell 1990). *Calceola sandalina* is known from the uppermost Emsian to the lowermost Givetian. *Breviphyllum* sp. occurs sporadically outside of the Emsian of North America, it is not taken into account here as its stratigraphic extension is not known. Similarly, *Spasskyella* sp. being here first described outside of the Givetian of the Urals Mountains, its stratigraphic value is yet to be determined. The genera *Zonophyllum*, *Mesophyllum*, and *Tryplasma* are long-ranging from the Lower and Middle Devonian. This second assemblage is also occurring in upper Eifelian–lower Givetian worldwide.

The differences between the two assemblages are probably related to the variation of facies (reefal/non-reefal) but also to a difference in age. The typical Russ Marble, with its abundant "*F.*" *varium,* is most probably Eifelian whereas the fine-grained limestone of Schirmeck is most probably younger, latest Eifelian to early Givetian in age. The absence of typical Givetian genera such as *Sociophyllum, Disphyllum*, and *Columnaria* also pleads for an age no younger than early (or earliest) Givetian (Fig. 2).

In the Netzenbach valley north of Schirmeck, Lillié and Blanalt (1970) described a conglomerate with limestone pebbles of Late Devonian or Carboniferous age (Kleinenberg Conglomerate). It is probably from this locality that comes the fragment of colony attributed to *Hexagonaria quadrigemmina* by Firtion (1957: pl. VI: 1, 2). Based on the figured material, the latter is *Argutastraea* sp., a typically Givetian genus.

If the limestone clasts and olistoliths are Middle Devonian in age, the Russ Conglomerate should not be older than Givetian and as the overlying strata are dated from the Late Devonian (goniatites, conodonts, radiolarians), the age of the olistostrome is therefore constrained as pre-Frasnian (Fig. 2). The idea developed by Bonhomme and Prévôt (1968) and Fluck et al. (1991) of a post-Devonian olistostome should consequently be rejected.

Considering the above discussion, it is reasonable to think that the limestone clasts and olistoliths get younger northwards, which is coherent with the hypothesis of a northwards progression of the flysch along the margin of the Saxo-Thuringian Zone (Skrzypek et al. 2014).

Conclusions

The Russ Conglomerate of the Bruche Unit of Northern Vosges (France) is an olistostrome containing limestone olistoliths. Some of these limestones are entirely recrystallised by regional metamorphism but in some localities, the organic structures and fossils are preserved, though rather poorly. In Russ and Barembach, the olistoliths display reefal facies with stromatoporoids and corals in a sandy carbonate matrix. The rugose coral assemblage in these localities is dominated by "*Fasicphyllum*" *varium*, "*Fasicphyllum*" sp., *Grypophyllum* sp., and *Acanthophyllum* sp., and is of supposed Eifelian age. In Russ, the limestone was quarried in the 19th century as an ornamental stone known as Russ Marble. Near the Schirmeck town, several outcrops of limestone in non reefal facies yield a more diverse coral fauna with *Dohmophyllum*, *Stringophyllum*, *Breviphyllum*, *Zonophyllum*, *Mesophyllum*, *Tryplasma*, *Moravophyllum*, and the genus *Spasskyella* reported for the first time in Western Europe. This assemblage is possibly younger than the previous one, i.e., Givetian in age.

The Northern Vosges provides a unique insight into the Devonian coral fauna from the Saxo-Thuringian Zone which extends from France to Poland through Germany and the Bohemian Massif.

Acknowledgements

The author is grateful to Cyrille Prestianni (Université de Liège, Belgium) for his help in the field and to Francis Tourneur (Service géologique de Wallonie, Namur, Belgium) for discussions about the tabulate corals. Kévin Janneau (Université de Strasbourg, France) is thanked for the search of the Firtion collection in his institution. The reviewers Ross McLean (Forresters Beach, Australia) and Błazej Berkowski (Adam Mickiewicz University, Poznań, Poland) are thanked for their constructive comments.

References

Aghai Soltani, L., Bender, P., Braun, A., and Schmidt-Effing, R. 1996. Oberdevonische Radiolarien aus Kieselgesteinen des Breuschtales (Vallée de la Bruche, Nord-Vogesen, Frankreich). *Jahresbericht und Mitteilungen des oberrheinischen geologischen Vereins* 78: 183–208.

Benecke, E.W. and Bucking, H. 1898. *Calceola sandalina* im oberen Breuschtal. *Mitteilungen der Geologischen Landesanstalt von Elsaß-Lothringen* 4: 105–111.

Berkowski, B. 2006. Vent and mound rugose coral associations from the Middle Devonian of Hamar Laghdad (Anti-Atlas, Morocco). *Geobios* 39: 155–170.

Birenheide, R. 1963. *Cyathophyllum*- und *Dohmophyllum*-Arten (Rugosa) aus dem Mitteldevon des Eifel. *Senckenbergiana Lethaea* 44: 363–458.

Birenheide, R. 1987. Erster Nachweis der rugosen Korallengattung *Moravophyllum* aus dem Ober-Eifelium der Eifel. *Senckenbergiana Lethaea* 67: 459–466.

Blanalt, J.-G. 1969. *Contribution à l'étude du conglomérat givétien de Russ (vallée de la Bruche, Vosges). Essai de paléogéographie*. 172 pp. Thèse de la Faculté des Sciences de l'Université de Strasbourg, Institut Géologique, Strasbourg.

Blanalt, J.-G. and Doubinger, J. 1973. Contenu paléontologique du gisement frasnien de la carrière Wenger et Petit à Hersbach (Vallée de la Bruche, Vosges). *Sciences Géologiques, Bulletin* 26: 75–90.

Blanalt, J.-G. and Lillié, F. 1973. Données nouvelles sur la stratigraphie des terrains sédimentaires dévono-dinantiens de la vallée de la Bruche (Vosges septentrionales). *Sciences Géologiques, Bulletin* 26: 69–74.

Bonhomme, M. and Prévôt, L. 1968. Application de la méthode rubidium-strontium à l'étude de l'âge radiométrique de quelques dépôts dévono-dinantiens du massif de la Bruche (Vosges du Nord). *Bulletin du Service de la carte géologique d'Alsace et de Lorraine* 21: 219–247.

Bücking, H. 1918. Beiträge zur Geologie des oberen Breuschtals in den Vogesen. *Mitteilungen der Geologischen Landesanstalt von Elsaß-Lothringen* 12: 1–168.

Coen-Aubert, M. 1989. Description de quelques Rugueux coloniaux du Couvinien supérieur de Wellin (bord sud du Bassin de Dinant, Belgique). *Bulletin de l'Institut royal des Sciences naturelles de Belgiques, Sciences de la Terre* 59: 15–35.

Coen-Aubert, M. 1992. Rugueux coloniaux mésodévoniens du Fondry des Chiens à Nismes (Ardenne, Belgique). *Bulletin de l'Institut royal des Sciences naturelles de Belgiques, Sciences de la Terre* 62: 5–21.

Coen-Aubert, M. 2017. Givetian rugose corals from the Zemmour in Mauritania. *Geologica Belgica* 20: 161–180.

Corsin, P., Danze-Corsin, P., Millot, G., and Ruhland, M. 1960. Sur l'âge viséen inférieur des schistes de Schwarzbach (vallée de la Bruche) dans les Vosges du Nord. *Bulletin du Service de cartographie d'Alsace-Lorraine* 13: 163–164.

Dana, J.D. 1846. Genera of fossil corals of the family Cyathophyllidae. *American Journal of Science and Arts, Series 2* 1: 178–189.

Denayer, J. 2023. From mud to limestone: birth and growth of a giant reef in the Eifelian (Middle Devonian) of S Belgium. *Palaeogeography, Palaeoclimatology, Palaeoecology* 627: 111748.

Denayer, J., Poty, E., Marion, J.-M., and Mottequin, B. 2012. Lower and Middle Famennian (Upper Devonian) rugose corals from southern Belgium and northern France. *Geologica Belgica* 15: 273–283.

Dörr, W., Pique, A., Franke, W., and Kramm, U. 1992. Les galets granitiques du conglomerat de Russ (Devono-Dinantien des Vosges du Nord) sont les temoins d'un magmatisme acide ordovicien. La distension crustale et le rifting saxothuringien au Paleozoique inferieur. *Compte-rendu de l'Académie des Sciences, 2° série* 315: 587–594.

Dubois, G. 1946. Répartition des gisements certainement et vraisemblablement dinantiens dans la région de la Bruche (Vosges moyennes). *Comptes-rendus sommaires de la Société géologique de France* 12: 222–223.

Ehrenberg, C.G. 1834. Beitriige zur physiologischen Kenntniss der Corallenthiere im allgemeinen, und besonders des Rothen Meeres, nebst einem Versuche zur physiologischen Systematik derselben. *Königlichen Akademie der Wissenschaften physikalisch-matematische Klasse, Abhandlungen* 1: 225–380.

Eisbacher, G.H., Lüschen, E., and Wickert, F. 1989. Crustal-scale thrusting and extension in the Hercynian Schwarzwald and Vosges, Central Europe. *Tectonics* 8: 1–21.

Firtion, F. 1938. Sur les caractères faunistiques des calcaires givetiens de la région de Schirmeck. *Comptes Rendu de l'Académie des Sciences* 206: 615.

Firtion, F. 1945. Apports à la connaissance paléontologique du Dévono-dinantien de la région de Schirmeck. *Compte rendu Sommaire des Séances de la Société Géologique de France* 5: 1–57.

Firtion, F. 1957. Les éléments paléontologiques dévoniens du val de Bruche. *Annales Universitatis Saraviensis Scientia* 5–6: 97–184.

Fluck P., Piqué A., Schneider J.-L., and Whitechurch H. 1991. Les massifs anciens de France – II: Le socle vosgien. *Sciences Géologiques, Bulletin* 44: 207–235.

Franke, W., Cocks, L.R.M., and Torsvik, T.H. 2017. The Palaeozoic Variscan oceans revisited. *Gondwana Research* 48: 257–284.

Galle, A. 1981. Rugose corals on the slopes of Bohemian Massif in the Region South. *In*: J. Kalvoda (ed.), *Biostratigrafie Paleozoika na jihovychodni Morave*, 64–66. Moravské Naftové Doly, Hodonin.

Hill, D. 1939. The Devonian rugose corals of Lilydale and Loyola, Victoria. *Royal Society of Victoria, Proceedings* 51: 219–256.

Jaeckel. O. 1888. Über Mitteldevonische Schichten im Breuschtal. *Mitteilungen der Geologischen Landesanstalt von Elsaß-Lothringen* 1: 229–239.

Jin, S.Y. 2005. Devonian coral identification and genera-species description. *In*: S.Y. Jin, A. Shen, Z. Chen, J. Lu, M. Wei, Y. Wang, and F. Xie (eds.), *Mixed biostratigraphy of Devonian in Wenshan*, *Yunnan*, 78–138. Petroleum Industry Press, Hangzhou.

Jung, J. 1928. Contribution à la géologie des Vosges hercyniennes d'Alsace. *Mémoires du Service de la Carte Géologique d'Alsace-Lorraine* 2: 1–481.

Juteau, T. 1971. Nouvelles données cartographiques, pétrographiques et chimiques sur le massif dévono-dinantien du Rabodeau (Vosges septentrionales). Pétrogénèse d'une série spilite-kératophyre "hercynotype" complexe. *Sciences de la Terre* 16: 45–106.

Kettnerova, M. 1932. Paleontologicke studie z celechovickeho devonu, cast IV: Rugosa. *Prace geologicko-palaeontologickeho ustavu Karlovy university v Praze za rok* 1932: 1–97.

Kossmat, F. 1927. Gliederung des varistischen Gebirgsbaues. *Abhandlungen des Sächsischen Geologischen Landesamtes* 1: 1–39.

Kreche, M. and Behrmann, J.H. 2004. Tectonics of the Vosges (NE France) and the Schwarzwald (SW Germany): evidence from Devonian–Carboniferous active margin basins and their deformation. *Geotectonic Research* 95: 61–86.

Lamarck, J.B.P.A. 1799. Prodrome d'une nouvelle classification des coquilles. *Société d'Histoire naturelle de Paris, Mémoire* 1: 63–91.

Lillié, F. and Blanalt, J.-G. 1970. Les terrains dévono-dinantiens aux environs de Hersbach et de Wisches (vallée de la Bruche, Vosges du Nord). *Rapport du B.R.G.M.* n° 70 SGN 96 NES: 1–33.

McLean, R.E. 2018. Fasciphyllid and spongophyllid rugose corals from the Middle Devonian of Western Canada. *Palaeontographica Canadiana* 37: 1–117.

Merriam, C.W. 1974. Middle Devonian rugose corals of the Central Basin. *United States Geological Survey Professional Paper* 799: 1–53.

Middleton, G.V. 1959. Devonian tetracorals from South Devonshire, England. *Journal of Paleontology* 33: 138–160.

Milne-Edwards, H. and Haime, J. 1850–1855. *A Monograph of the British Fossil Corals*. 1–71 (1850), 147–210 (1851), 211–244 (1853), 245–299 (1855). Palaeontographic Society Monograph, London.

Mironova, N.V. 1960. Two new genera of Tabulata [in Russian]. *Trudy Sibirskogo Naučno-issledovatel'skogo Instituta Geologii, Geofizikii i Mineralnogo Sibirâ* 8: 95–98.

Montigny, R., Schneider, C., Royer, J.-Y., and Thuizat, R. 1983. K-Ar dating of some plutonic rocks of the Vosges, France. *Terra Cognita* 3: 201.

Nicholson, H.A. and Lydekker, R. 1889. *A Manual of Palaeontology: 3rd Edition*, 885 pp. Blackwood & Sons, Edinburgh, London.

Oberlin, H.G. 1806. *Propositions géologiques, pour servir d'introduction à un ouvrage sur les éléments de la chorographie, avec l'exposé de leur plan, et leur application a la description géognostique, oeconomique et médicale du Ban de la Roche*. 261 pp. Imprimerie de Levrault, Strasbourg.

Oliver, W.A., Jr. 1971. The coral fauna and age of the Famine Limestone in Quebec. *In*: J.T. Dutro Jr. (ed.), Paleozoic Perspectives: A Paleontological Tribute to G. Arthur Cooper. *Smithsonian Contributions* 3: 193–201.

Oliver, W.A., Jr. 1976. Noncystimorph colonial rugose corals of the Onesquethaw and Lower Cazenovia Stages (Lower and Middle Devonian) in New York and adjacent areas. *Geological Survey Professional Paper* 869: 1–156.

Oliver, W.A., Jr. 1992. The Siphonophrentidae (Rugose Corals, Devonian) of Eastern North America. *Geological Survey Bulletin* 2024: 1–32.

Pedder, A.E.H. 1971. Lower Devonian corals and bryozoa from the Lick Hole Formation of New South Wales. *Palaeontology* 14: 371–386.

Pedder, A.E.H. 2002. New systematic and biostratigraphic data concerning the Breviphyllidae (Lower Devonian Rugosa) of Nevada. *Coral Research Bulletin* 7: 141–166.

Počta, P. 1902. Anthozoaires et Alcyonaires. *In*: J. Barrande (ed.), *Système*

silurien du centre de la Bohême, 1ère Partie: Recherches paléontologiques, 1–347. Musée de Bohême, Prague.

Rizki, A. and Baroz, F. 1988. Le volcanisme tholéïtique du massif de Schirmeck (Vosges septentrionales, France), témoin d'une zone de convergence de plaques au Paléozoïque supérieur. *Comptes-rendus de l'Académie des Sciences* 307: 511–516.

Rodríguez-García, S. 1978. Corales rugosos del Devónico de la sierra del Pedroso. *Estudios Geológicos* 34: 331–350.

Röminger, C. 1876. Lower Peninsula. Part II. Palaeontology: Fossil corals. *Geological Survey of Michigan* 3: 1–161.

Schlüter, C. 1881. Über einige Anthozoan des Devon. *Zeitschrift der Deutschen Geologischen Gesellschaft* 33: 75–108.

Schlüter, C. 1885. Über einige neue Anthozoen aus dem Devon. *Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande und Westfalens, Sitzungsberichte* 42: 144–152.

Schlüter, C. 1889. Anthozoen des rheunischen Mittel-Devon. *Abhadlungen zur geologiscjen Specialkarte von Preussen und den Thüringischen Staaten* 8: 1–207.

Schröder, S. 1995. Rugose Korallen aus der Freilingen-Formation der Dollendorfer Mulde (Ober Eifelium/Mitteldevon; Eifel/Rheinisches Schiefergebirge). *Senckenbergiana Lethaea* 75: 33–75.

Schröder, S. 1998. Rugose Korallen und Stratigraphie des oberen Eifelium und untere Givetium der Dollendorfer Mulde/Eifel (Mittel-Devon; Rheinisches Schifergebirge). *Courier Forschunginstitut Senckenberg* 208: 1–135.

Schröder, S. and Lütte, B.P. 1999. On the taxonomic position of "*Fasciphyllum varium* Schlüter 1889" (Rugosa/Middle Devonian of the Eifel). *Senckenbergiana Lethaea* 79: 119–129.

Simpson, G.B. 1900. Preliminary descriptions of new genera of Paleozoic rugose corals. *Bulletin of the New York State Museum* 39: 199–222.

Skrzypek, E., Schulmann, K., Tabaud, A.-S., and Edel, J.-B. 2014. Palaeozoic evolution of the Variscan Vosges Mountains *In*: K. Schulmann, J.R. Martínez Catalán, J.M. Lardeaux, V. Janoušek, and G. Oggiano (eds.), The Variscan Orogeny: Extent, Timescale and the Formation of the European Crust. *Geological Society, London, Special Publications* 405: 45–75.

Soshkina, E.D. 1937. Corals of the Upper Silurian and Lower Devonian of the eastern and western slopes of the Urals [in Russian]. *Trudy Paleontologičeskogo Instituta* 6: 1–155.

Soshkina, E.D. 1941. Systematics of the Middle Devonian Rugosa of the Urals [in Russian]. *Akademiâ Nauk SSSR, Paleontologičeskij Institut, Trudy* 10: 1–54.

Soshkina, E.D. 1954. Devonian tetraradiate corals of the Russian Platform [in Russian]. *Akademiâ Nauk SSSR, Paleontologičeskij Institut, Trudy* 52: 1–76.

Stumm, E.C. 1937. The Lower Middle Devonian tetracorals of the Nevada Limestone. *Journal of Paleontology* 11: 423–443.

Stumm, E.C. 1949. Revision of the families and genera of the Devonian tetracorals. *Geological Society of America, Memoirs* 40: 1–128.

Tait, J., Schätz, M., Bachtadse, V., and Soffel, H. 2000. Paleomagnetism and Paleozoic paleogeography of Gondwana and European terranes. *In*: W. Franke, V. Haak, O. Oncken,, and D. Tanner (eds.), Orogenic Processes: Quantification and Modelling in the Variscan Belt. *Geological Society, London, Special Publication* 179: 21–34.

Tsyganko, V.S. 1977. *Spasskyella*, a new genus of Devonian rugose coral [in Russian]. *In*: Geologiâ i poleznye iskopaemye severo-vostoka Evropeyskih časti SSSR. *Ežegodnik Instituta geologii Komi filiala Akademii Nauk SSSR* 1976: 40–44.

Tsyganko, V.S. 1981. *Devonskie Rugozy Severa Urala*. 220 pp. Nauka, Leningrad.

Vélain, C. 1887. Le Carbonifère dans la région des Vosges. *Bulletin de la Société géologique de France, 3° série* 15: 703–719.

Verrill, A.E. 1865. Classification of polyps (Extract condensed from a Synopsis of the polypi of the North Pacific Exploring Expedition, under captains Ringgold and Rodger J, U.S.N.). *Essex Institute, Proceedings* 4: 145–149.

Wagner, W. 1923. Gliederung ung Lanerung des Devon sim Breuscht. *Mitteilungen der Geologischen Landesanstalt von Elsaß-Lothringen* 9: 67–152.

Wedekind, R. 1925. Das Mitteldevon del' Eifel, ll. Teil, Materialien zur Kenntnis des mittleren Mitteldevon. *Gesellschaft zur Befördung der Gesamten Naturwissenschaften zu Marburg, Schriften* 14: 1–85.

Wedekind, R. 1927. Die Zoantharia Rugosa von Gotland (Nordgotland). *Svergies Geologiska Undersökning, Serie C* 19: 1–94.

Weisermel, W. 1897. Die Gattung *Columnaria* und Beiträge zur Stammesgeschichte der Cyathophylliden und Zaphrentiden. *Zeitschrift der Deutschen Geologischen Gesellschaft* 49: 865–888.

Whiteaves, J.F. 1884. On some new, imperfectly characterized or previously unrecorded species of fossils from the Guelph Formation of Ontario. *Canada Geological Survey. Palaeozoic Fossils* 3: 1–43.

Wickert, F. and Eisbacher, G.H. 1988. Two sided Variscan thrust tectonics in the Vosges Mountains, Northeastern France. *Geodinamica Acta* 2: 101–120.

Yu, C. and Jell, J.S. 1990. Early Devonian rugose coral fauna from the Shield Creek Formation, Broken River Embayment, north Queensland. *Memoirs of the Association of Australasian Palaeontologists* 10: 169–209.

Zhen, Y.Y. and Jell, J.S. 1996. Middle Devonian rugose corals from the Fanning River group, North Queensland, Australia. *Palaeontographica Abteiling A* 242: 15–98.