

Brachiopod faunas from the basinal facies of southeastern Thuringia (Germany) before and after the Hangenberg Crisis (Devonian–Carboniferous boundary)

Bernard Mottequin, Konrad Bartsch, Eric Simon, and Dieter Weyer

ABSTRACT

Upper Famennian–Tournaisian (Hastarian) brachiopods from the deep-water, mixed siliciclastic–carbonate Gleitsch Formation (Breternitz and Pfaffenberg members) of southeastern Thuringia (mainly from the Saalfeld area, Germany) are described systematically. A new Tournaisian rhynchonellide genus (*Thuringorhynchus* gen. nov.) and four new Tournaisian species are described (*Productina saalfeldensis* sp. nov., *Thuringorhynchus pseudoequitans* gen. et sp. nov., *Cleiothyridina pfaffenbergensis* sp. nov., and *Crassumbo germanicus* sp. nov.). Moreover, the lectotype of “*Lingularia*” *straeleni* (Demanet, 1934), from the Tournaisian of Belgium, is selected. Prior the Hangenberg Crisis, the brachiopod assemblage (10 species) of the Breternitz Member (upper and uppermost Famennian) is strongly dominated by species belonging to smooth to poorly ornamented rhynchonellide genera (*Hadyrhyncha*, *Novaplatirostrum*, *Rozmanaria*, and rozmanariid? gen. indet.) notably reported from Laurussia and the northern margin of Gondwana. The onset of the Hangenberg Crisis is marked by an anoxic black shale horizon at the top of the Breternitz Member followed by the siltstones and turbiditic sandstones of the Obernitz Member; both horizons did not yield brachiopods.

A completely changed, more diverse brachiopod assemblage (15 species) existed in the Pfaffenberg Member (Tournaisian, lower Hastarian), which also included a basal 20 cm “topmost Famennian” (according to the current, soon abandoned definition of the Carboniferous base using *Siphonodella sulcata* as criterion), but clearly dated as upper *Protognathodus kockeli* Zone). Small-sized productidines (*Productina*) and spiriferides (*Crassumbo*, *Texathyris*?) dominate; a probable complete turnover is recorded among the Rhynchonellida (*Thuringorhynchus*). The rapid recovery after the drastic Hangenberg extinction event includes species belonging to pre-existing genera and to new ones.

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INTRODUCTION

Worldwide, the mostly rare Famennian and basal Tournaisian Brachiopoda of aphotic zones (cephalopod limestones, “cypridinic” = entomozoid shales) are not well known and often remained even uncollected. Primary studies started in Germany with Count Georg Münster (1776–1844). After his outstanding ammonoid research (in 1832–1839), he published a monograph (Münster, 1840) of the complete faunal content in Upper Devonian limestones of Upper Franconia (mainly localities Schübelhammer, Gattendorf). His data (eight species from Schübelhammer and Geuser) are still unrevised. Nowadays, such a task would be extremely difficult due to the loss of his collections (excepting figured specimens) preserved in the Bayerische Staatssammlung Paläontologie at the university of München during the war 1944–1945 and with no chance to recollect in the gone quarry parts. Only one of his species, *Terebratula subun-*

data Münster, 1840 (homonym of the Cretaceous *Terebratula subundata* J. Sowerby, 1813; see below), is re-determined here as *Rozmanaria equitans* (Schmidt, 1924), using the holotype in München.

Münster (1840, p. 115, 120) had discussed the age of his “Uebergangskalk” (transitional limestone) with Roderick Impey Murchison (1792–1871) and Adam Sedgwick (1785–1873) in 1839 (during their visit in Bayreuth city). He opposed the suggestion of the British geologists (Devonian age according to the British sequence, just proposed in 1839) and speculated about a position between the Cambrian and “Silurian” systems. Today, Münster’s limestone localities are reassigned as Ludlow (Orthoceratenkalk of Elbersreuth) and to different ammonoid “stages” of the Famennian (*Cheiloceras–Wocklumeria*).

Immediately after Münster, similar palaeontological studies of the now classical Bohlen section near Saalfeld in Thuringia (Figures 1, 2.1) were

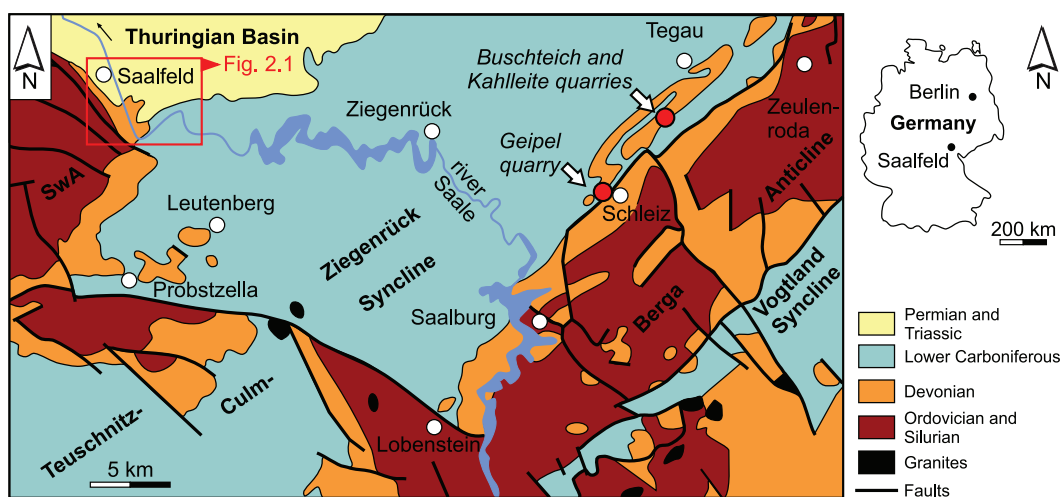


FIGURE 1. Schematic geological map (modified from Weber, 1955) of SE Thuringia (Thuringian Slate Mountains) – localities with top Famennian and/or basal Tournaisian sections on the SE flank of Schwarzburg Anticline (SwA), southeast of Saalfeld, and on the NW flank of Berga Anticline, west and north of Schleiz.

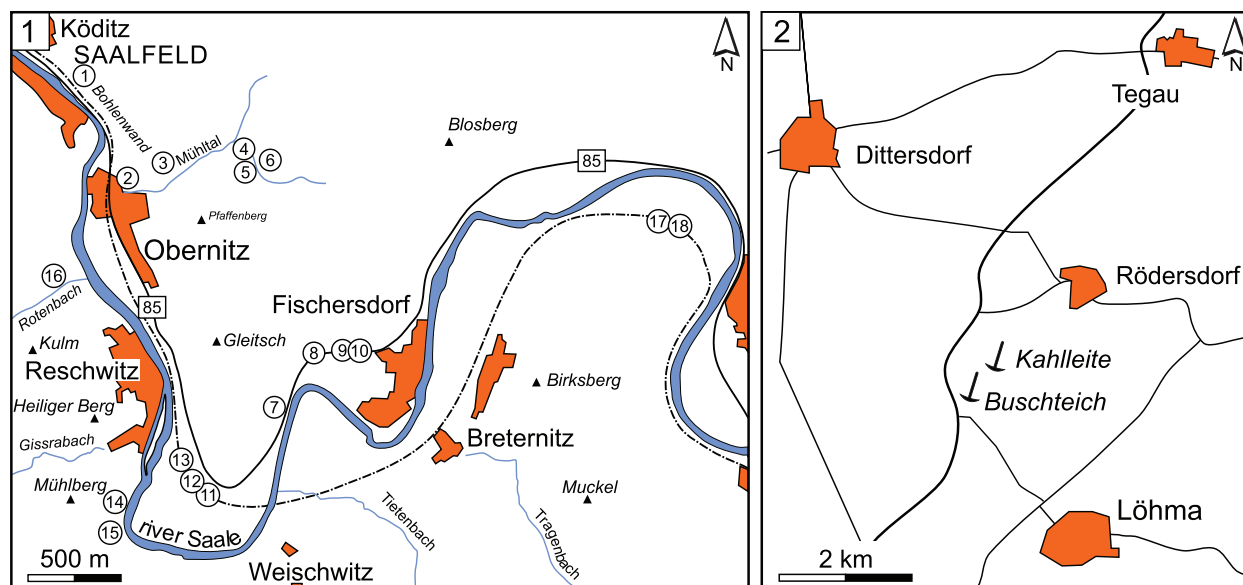


FIGURE 2. Topographic maps of Thuringian localities with fossiliferous top Famennian and/or basal Tournaisian sections. **1,** southeastern environments of Saalfeld, localities 1-18 (compare Table 1) (modified from Bartzsch and Weyer, 2012). **2,** Buschteich and Kahlleite sections SSW of Tegau (NNE of Schleiz).

published in 1848 and 1856 by Reinhard Richter (1813–1884). They include 14 “Upper Devonian” species of Brachiopoda (determined after Münster 1840, or in open nomenclature; only one newly named: *Terebratula silicula* Richter, 1856, obviously from the *Cheiloceras*-“Stufe”, Plattenbruch-Member of Bohlen Formation). After death, his collection was acquired by the former Prussian Geological Survey in Berlin (now Berlin department of the Bundesanstalt für Geologie und Rohstoffe, Hannover) – the figured specimens escaped the destruction of the war years 1943–1945, but all supplementary materials were lost after a bombing attack destroying the complete regional Devonian collections of the Harz, Thuringian and Lower Silesian Mountains. More precise age data for the unzoned “Upper Devonian” of Richter (1848, 1856) are generally possible, due to his own stratigraphic notes of 1848 (p. 3, plate 1: bed “g” = Breternitz Member of the Gleitsch Formation; Figure 3), due to the later revisions of Schmidt (1923), Schindewolf (1924, 1952), Pfeiffer (1954) and the well-stratified rich new macro- and micro-faunal collections of Bartzsch and Weyer during the years 1963–1992, partly published (Bartzsch and Weyer, 1982, 2012).

The “Upper Devonian” of the nineteenth century up to Schindewolf [1923, after the proposal of a still upper Devonian *Gattendorfia*-“Stufe” in Schindewolf (1920)] included all the cephalopod limestones below the drastic change towards the

siliciclastic Culm facies (Liegende Alaunschiefer, now sensu Korn (2006), Kahlenberg-Subformation in the Rhenish Mountains, Rußschiefer Formatio) in Thuringia; Figure 3). This changed with Schmidt (1924) who elaborated the Carboniferous faunal characters of the Hangenberg Limestone = *Gattendorfia*-“Stufe”. His new system boundary then became a standard, especially after applying the decision of the second Heerlen Carboniferous Congress in 1935 (Paeckelmann and Schindewolf, 1937), where the Oberrödinghausen sequence (Hönnetal railway cut) was accepted as an international reference section.

Richter and Richter (1951), Schindewolf (1952) and Pfeiffer (1954) affirmed the presence of Lower Tournaisian equivalents of the Rhenish Hangenberg Limestone in Thuringia (now the Pfaffenberg Member of the Gleitsch Formation; Figure 3). Several fossils in Richter (1848, 1856), listed in Bartzsch and Weyer (1982, p. 4), come from Lower Hastarian beds, notably *Delthyris* sp. (1848, p. 45, plate 6, figure 210) (= *Crassumbo germanicus* sp. nov.), *Leptaena?* sp. (1856, p. 130, plate 2, figures 76-79) (= *Productina saalfeldensis* sp. nov.). The presence of Lower Hastarian beds was proved also for the Upper Franconian locality Schübelhammer after a revision of the Rugosa coral *Hebucophyllum priscum* (Münster, 1840) (Weyer, 1994, p. 187).

Further publications dealing with selected German Brachiopoda from the aphotic facies

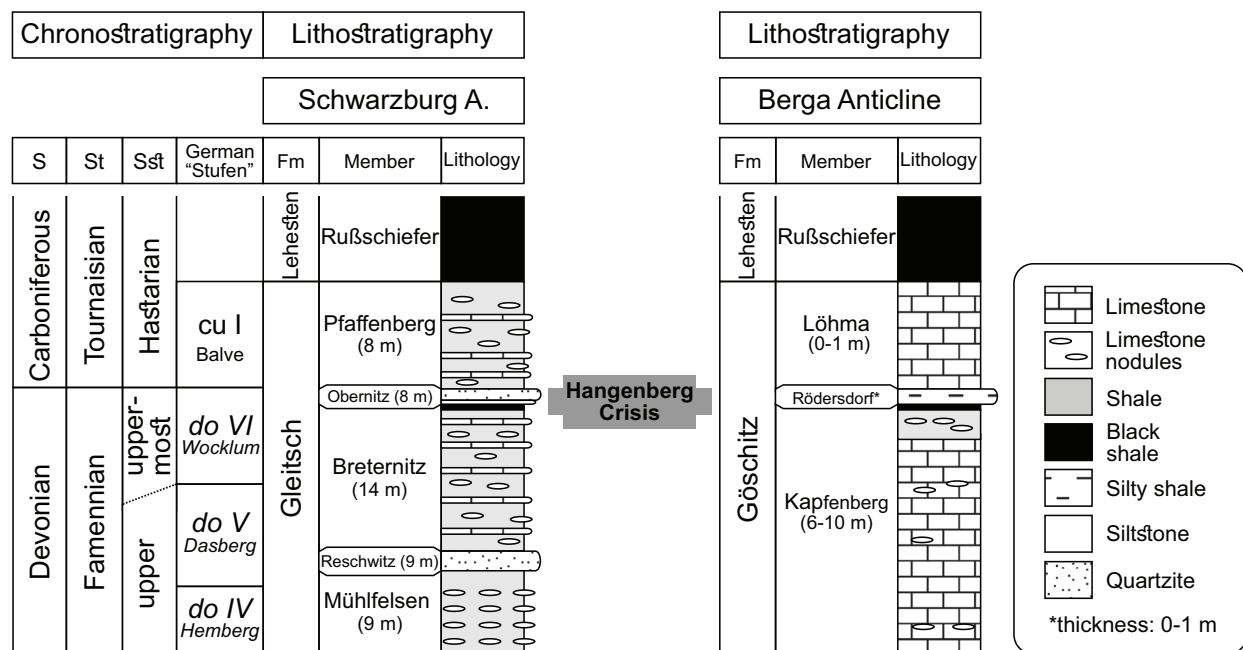


FIGURE 3. Upper Famennian and basal Tournaisian lithostratigraphy (with indication of thickness for each member) in the Thuringian Slate Mountains (modified from Bartzsch et al., 1999, 2001, 2008). A., Anticline; Fm, Formation; S, system; St, stage; Sst, substage.

around the Devonian–Carboniferous boundary are Tietze (1870), Paeckelmann (1913, 1930, 1931), Schmidt (1924), Grüneberg (1925), Gallwitz (1932), Weyer (1972, 1979), Bartzsch and Weyer (1986), Becker (1988, 1996), Bartzsch et al. (1998), Sartenaer (1997), Afanasjeva (2002) and Müller (2004). Comparatively few similar studies about such rare aphotic Famennian–Hastarian Brachiopoda were published in other countries: Poland (Biernat, 1983, 1988; Biernat and Racki, 1986a, 1986b; Sartenaer, 1998a; Halamski and Baliński, 2009), Czech Republic (Havlíček, 1979), Russia (Rozman, 1962), Algeria (Mottequin et al., 2015a), Morocco (Sartenaer, 1998a, 1998b, 1999, 2000) and China (Sartenaer and Xu, 1990).

In this paper, we studied new and well-dated collections from Saalfeld (Breternitz and Pfaffenberg members of the Gleitsch Formation; Figure 3) and other localities in Thuringia – more than 2000 specimens – represent the worldwide richest brachiopod assemblages of the aphotic cephalopod facies around the Devonian–Carboniferous boundary.

Based on material patiently collected between 1963–1992 by two of the authors (KB and DW), the goals of the present study are (1) to describe the upper and uppermost Famennian and the lower Tournaisian (Hastarian) brachiopod faunas from the Saalfeld area (Thuringia), (2) to discuss their palaeoecology and (3) to specify the conse-

quences of the Hangenberg Crisis (Kaiser et al., 2011, 2016) on these benthic suspension-feeders in this region.

GEOLOGICAL SETTING

Devonian–Carboniferous Boundary Beds of Thuringian Localities

Such fossiliferous strata occur as suitable outcrops only in very few places of SE Thuringia (Figure 1). Two of them are stable small ancient quarries, accessible since more than 90 years. Two others disappeared, but their collections are still available. One group of localities – the best – is situated around the Bohlen southeast of Saalfeld, at the NE end of the SE flank of the Schwarzburg Anticline (Figures 1, 2.1), Western Thuringian Slate Mountains (“Schiefergebirge”) and presents the more basal facies of “cypridinic” (entomozoid) shales with nodular limestone layers. Three other localities – at the NW flank of the Berga Anticline (Figures 1, 2.2), Eastern Thuringian Slate Mountains – represent the shallower facies of cephalopod limestone.

Figure 3 illustrates the current local lithostratigraphy, as proposed by Bartzsch et al. (1999, 2001, 2008). This scheme replaced older names from the Saalfeld region, long time in use since Liebe and Zimmermann (1888) and Zimmermann (1914) in the geological mapping period by the

TABLE 1. Localities SE of Saalfeld (as numbered in Figure 2) exposing the Breternitz Member (B), *Clymenia/Wocklumeria* Genozone, and the Pfaffenberg Member (P), *Gattendorfia* Genozone.

No.	Locality	Member	No.	Locality	Member
1	Obernitz, Bohlen–North (Vorderbohlen)	B	10	Fischersdorf–East	B, P
2	Obernitz, Schlosspark	B	11	railway cut Gleitsch–SE (km 144,4–144,5)	B
3	Obernitz, Bohlen, southern slope (right bank of lower Mühlthal)	P	12	railway cut Gleitsch–SE (km 144,43)	P
4	Obernitz, Bornleite, left upper Mühlthal	B	13	railway cut Gleitsch–NW (km 144,23)	B
5	Obernitz, Pfaffenberg–SW	P	14	Reschwitz, Mühlfelsen–North	B
6	Obernitz, Pfaffenberg–NE	P	15	Reschwitz, Mühlfelsen–South	B
7	Fischersdorf, Gositzfelsen	B, P	16	Reschwitz, road cut Hoher Schuss	B
8	Fischersdorf–West	B, P	17	Breternitz–West/Middle	B
9	Fischersdorf–Middle	B	18	Breternitz–East	B

Prussian Geological Survey, up to Meyer (1920) and Pfeiffer (1954), but no longer in accordance to rules and terminology of the International Stratigraphic Guide (Hedberg, 1976). The acronyms do IV to do VI refer to successive Famennian cephalopod zones (Wedekind, 1908) with ‘do’ meaning Upper Devonian.

Nearly all the brachiopods of this study come from the Saalfeld region. The few additional, often not well-preserved specimens from the other Thuringian localities are only a supplement to underline the regional distribution of such faunas, which we know also from small collections in the northern Rhenish Mountains (Sauerland). These additional, mostly identical materials, found in literature, in older museum stores and in the field, are already mentioned here sometimes, but will be described in a separate publication. Present isolated data in other countries (especially Poland, but also Czech Republic, Russia, Morocco) promise perspectives for future studies of such often neglected brachiopod assemblages in the aphotic cephalopod facies.

Bohlen area. Bohlen is the name of the steep wall at the western slope of the mount Roter Berg east of Saalfeld, eroded by the Saale river at its right bank (the term Bohlenwand is used in Figure 2.1). There and nearby in an area of 2–3 km exist many, mostly small outcrops (listed in Table 1 and indicated in Figure 2.1) of the Breternitz and Pfaffenberg Members, which yielded nearly all the brachiopods (Figures 4, 5). Details of sequence, fossil content, biozones and age can be found in Bartzsch and Weyer (1982, 2012) and Kononova and Weyer (2013). Macrofossils are rather rare, and to collect them is very time-consuming. Besides Brachiopoda, there occur Ammonoidea, Trilobita, Bivalvia, Gastropoda, Crinoida and

Anthozoa. Microfaunas are rich in Ostracoda (Thuringian = psychrospheric ecotype and Entomozoidae), but poorer in Conodonts and Foraminifera; they also include a few Chondrichthyes.

Possible biozonation for the Breternitz Member is shown in Kononova and Weyer (2013, figure 7) (Figure 4). Ammonoids start in the *Clymenia laevigata* Zone (lower *Clymenia*-“Stufe”) and finish with the *Wocklumeria sphaeroides* Zone (uppermost *Wocklumeria*-“Stufe”) just before the global Hangenberg Crisis. Remarkably six zones of psychrosphaeric ostracods had been discriminated by Blumenstengel (1997) but up to now this potential was never verified in any other region. Some corrections are necessary for the conodont zonation of Kononova and Weyer (2013). There the species *Bispathodus spinulicostatus* (Branson, 1934) was neglected and included into *Bispathodus ziegléri* (Rhodes et al., 1969) (see revision in Hartenfels and Becker, 2016), but the earlier appearance of *Bispathodus ultimus ultimus* (Bischoff, 1957) already in the upper *Clymenia*-“Stufe” can be verified for bed 17.2. (illustrated in a forthcoming paper), thus disqualifying this subspecies as an index fossil of the *Wocklumeria*-“Stufe” or Strunian or Uppermost Famennian. The ammonoid and conodont zonation of the Pfaffenberg Member is shown in Figure 5 (based on Bartzsch and Weyer, 1982).

Besides the usual index fossils (ammonoids, conodonts), several accompanying groups have been studied, both from the top Famennian and the basal Tournaisian: anthozoans (Weyer, 1971, 1981b, 1984, 2006), ostracods (Richter, 1869; Blumenstengel, 1959, 1965, 1979; Gründel, 1962; Becker and Blumenstengel, 1995) and trilobites (Hahn et al., 1995; Gawlick, 1996, 1997; Crônier et al., 1999; Lerosey-Aubril, 2006).

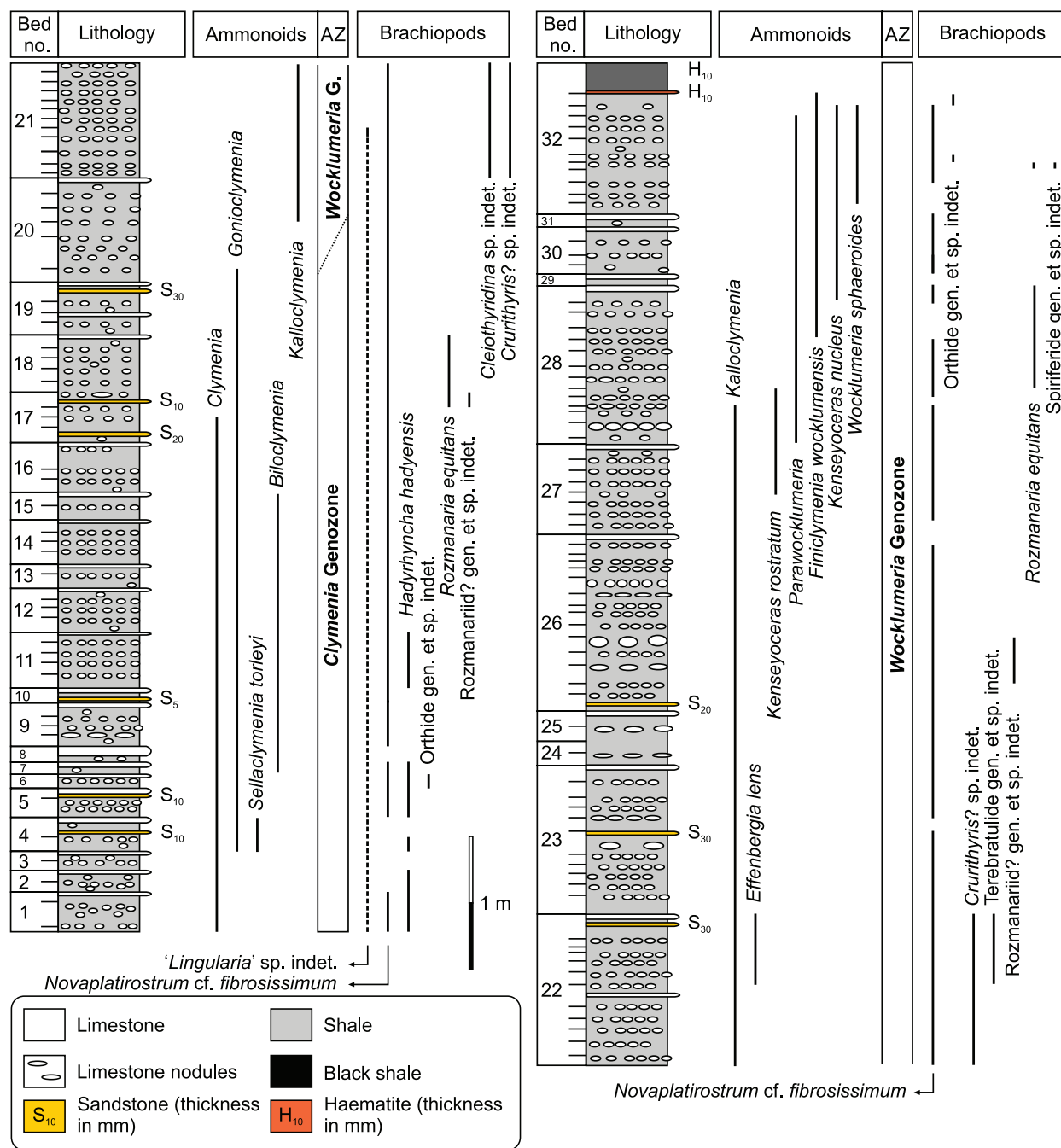


FIGURE 4. Lithostratigraphy and ammonoid zonation of the Breternitz Member near Saalfeld (Thuringia) and brachiopod distribution (modified from Bartsch and Weyer, 2012).

Probstzella. This outcrop on the NE slope of the road Probstzella–Marktgrößitz (2.5 km NW of the railway station Probstzella; Figure 1) offers a 16 m thick sequence of the nearly complete Breternitz Member (Bartsch and Weyer, 2012, figure 8a-b); only the last metre is missing. The section demonstrated the quite perfect lithological uniformity of sedimentary cycles along the SE flank of the Schwarzburg Anticline but was unsuitable for col-

lecting macrofossils. In 1991–1992 we found quite accidentally only one specimen of *Novaplatirostrum*.

Hirtenrangen in Steinach. A further, rather poor locality of the top Breternitz Member and the Pfaffenberg Member was studied by Gründel (1961, p. 71, figure 10), Hirtenrangen in the town of Steinach, near the southern end of the Schwarzburg Anticline [not represented in Figure 1; see

localisation in Gründel (1961)]. The dominating shales yielded only determinable entomozoid ostracods (Gründel, 1961; Groos-Uffendorfer, 1993). Conodonts and “silicified” (chloritized) ostracods of the Thuringian ecotype could not be prepared, as the few limestone nodules are completely weathered. Gründel (1961, p.71, table 1) mentioned rare brachiopods; we suppose that these had been only undeterminable fragments.

Buschteich quarry. The ancient Buschteich quarry, abandoned long ago already at the end of the nineteenth century, is situated 1.5 km NE of the village of Löhma (6 km NNE of the town of Schleiz) (Figures 1, 2.2), just east of the road Schleiz–Auma (part of the German South–North main road no. 2 München–Berlin). The name was derived from a nearby former pond “Großer Buschteich” (ca. 500 m SSW just at the western side of the same road), which vanished around 1955 losing its water due to underground karst of Tertiary times. The locality lies on the SE flank of the Ziegenrück Syncline, immediate near the NW margin of the Berga Anticline (Figure 1), in a special Pörmitz Fold Zone (Gräbe, 1962). This small tectonic unit had suffered from strong compressions during the Variscan orogenesis in late Visean times, locally near to alpine nappe structures (Blumenstengel and Gräbe, 1969, figure 2).

The sequence includes the top of the volcanic Frasnian Göschwitz Formation, the extreme condensed Vogelsberg, Kahlleite and Göschwitz Formations (cephalopod limestones), the Tournaisian Rußschiefer Formation, the lower Visean Buschteich Formation (Arundian “Kohlenkalk” = turbiditic calcarenites) and the basal Hasenthal Formation (sandy/silty shales). The section is illustrated in Bartzsch et al. (2008, figure 7). A detailed mea-

surement and sampling (Bartzsch and Weyer during the year 1980) of the Kapfenberg Member (5.63 m, from the *annulata*-Event to the equivalent of the Rhenish Hangenberg Black Shale) and the Löhma Member (0.55 m, *Gattendorfia*-“Stufe”) remained unpublished, but was used in excursion guides (e.g., Bartzsch et al., 1993, p. 16). The complete Famennian and its conodont faunas were analyzed by Girard et al. (2016).

Special studies of the Devonian–Carboniferous boundary beds (Weyer, 1977, 1979, p. 100, plate 3; Bartzsch and Weyer, 1988, 1996, based on ammonoids and conodonts) recorded “*Kenseyoceras*” = *Prionoceras* n. sp. IV sensu Schindewolf (1937) = *Effenbergia lens* (Korn, 1992) in the last 25 cm thick nodular limestone bed below the 15 cm shales of the Hangenberg Event. This index fossil of the upper *Kalloclymenia subarmata* Zone proves a remarkable gap (absence of the upper half of the *Wocklumeria*-“Stufe”: *Parawocklumeria paradoxa* Zone). The younger Löhma Member starts also with a hiatus as the *Acutimitoceras prorsum* Zone (Stockum fauna) is missing. The oldest Carboniferous goniatites from the basal 10 cm are dated as *Acutimitoceras acutum* Zone within the *Gattendorfia subinvoluta* Zone: *Gattendorfia costata* Vöhringer, 1960, *Gattenpleura bartzschi* Weyer, 1976, *Acutimitoceras acutum acutum* (Schindewolf, 1923). The top 15 cm yielded *Pseudarietites westfalicus* Schmidt, 1924. Two conodonts determined as *Siphonodella duplicata* (Branson and Mehl, 1934) by Weyer (1977, plate 3, figures 8–9) now belong to *Siphonodella duplicata* morphotype 1 sensu Sandberg et al. (1978), renamed *Siphonodella (Eosiphonodella) bransoni* Ji, 1985.

Accompanying brachiopods are rare and not well preserved. Weyer (1979, plate 3) mentioned

FIGURE 5 (figure on previous page). Stratigraphy of the early Hastarian (Lower Tournaisian) Pfaffenberg Member near Saalfeld (Thuringia) – lithostratigraphy, ammonoid-conodont-trilobite biozones, brachiopod distribution. Lithological sequence (dominating shales with micritic limestone beds and nodules) after Bartzsch and Weyer (1982, figure 2, 2-3), mainly based on the type section in the ancient quarry Pfaffenberg-Northeast in the upper Mühlthal valley near Saalfeld-Obernitz. Ammonoid and conodont biostratigraphy after Bartzsch and Weyer (1982), slightly modified according to current terminology and zoological nomenclature, including some new records. Trilobite zonation after Gawlick (1995, 1996, 1997, 2002), using the phylogeny of *Liobolina* Richter and Richter, 1951 in the European basal facies – *Liobolina (Guilinaspis) crestaverdensis* Feist, 1992, *Liobolina (Liobolina) submonstrans* Richter and Richter, 1951, *Liobolina (Liobolina) nebulosa* Richter and Richter, 1951, and *Liobolina (Liobolina) saalfeldensis* Gawlick (in Hahn and Hahn, 2008). The black dot indicates the observed local first appearance of taxa, not necessarily the real first appearance in view of the rather rare ammonoid and conodont faunas. The hitherto mostly neglected remarkable gap in the ammonoid sequence and zonation of the German *Gattendorfia*-“Stufe” was already suspected in Bartzsch and Weyer (1982, figure 9) and is now reality (Korn and Weyer, 2003, p. 92, figure 12) – ammonoid faunas (with *Kahlacanites*) of this time interval occur in Morocco and Algeria (Ebbighausen et al., 2004; Bockwinkel and Ebbighausen, 2006). The range of the brachiopods *Anopliopsis glabra* and *Thuringochonetes thuringicus* is based on Afanasjeva (2002). Abbreviations: AZ, ammonoid zones; CZ, conodont zones; TZ, trilobite zones; br., *bransoni* Zone; cr., *crestaverdensis* Zone; subm., *submonstrans* Zone.

Rozmanaria equitans (Schmidt, 1924) from the *Wocklumeria*-“Stufe”. The few specimens from the Lower Hastarian are here determined for the first time.

Kahlleite quarry. This now abandoned quarry, 1 km SW of village Rödersdorf (Figures 1, 2.2), in the Pörmitz Fold Zone is very near to the Buschteich quarry, but presented sections in a different, not so strongly condensed facies development, deposited originally in much greater distances. The once excellent sections were quarried away slowly and disappeared; the present eastern wall of the quarry stopped with the end of activities in tectonically stronger disturbed beds.

The 9.80 m thick upper Famennian Kapfenberg Member of the Göschitz Formation (Figure 3) is illustrated in Bartsch et al. (2001 p. 108, 2008, p. 79) and in Gereke (2004, p. 10). It starts above the *annulata* Event (Wagnerbank with *Prionoceras* and *Platyclymenia*), reaches the *Clymenia*-“Stufe” [top of bed 22: *Costaclymenia kiliani* (Wedekind, 1914)] and the lower *Wocklumeria*-“Stufe” (bed 35: *Kalloclymenia*), and ends in the complete upper *Wocklumeria*-“Stufe” (beds 40-45: *Kenseyoceras rostratum* Selwood, 1960, *Kenseyoceras nucleus* (Schmidt, 1924), *Finiclymenia wocklumensis* (Lange, 1929), *Wocklumeria denckmanni* Wedekind, 1918) with the global Hangenberg Crisis (bed 46). Gereke (2004, figure 7) identified conodonts from the Late *trachytera* to the Middle *praesulcata* Zones.

The 1.80 m thick Löhma Member (*Gattendorfia*-“Stufe”) (Figure 3) is illustrated in Bartsch et al. (2001, p. 109, 2008, p. 80). The sometimes nodular cephalopod limestones yielded mainly ammonoid and conodont faunas. The oldest limestones (beds 1-3 in Bartsch et al., 2001, 2008) represent the *Acutimitoceras prorsum* Zone and *Protognathodus kockeli* Zone, followed (in bed 4) by the *Acutimitoceras acutum* Zone and the *Siphonodella* (*Eosiphonodella*) *sulcata* Zone. The *Pseudarietites westfalicus* Zone is proved for beds 19-23. Beds 24-27 can be dated as *Paragattendorfia patens* Zone (using the graphic correlations of Korn and Weyer, 2003).

Very few brachiopods were collected and are here determined for the first time. They demonstrate only the extended regional distribution of the rich assemblage from Saalfeld at least in Germany.

Geipel quarry. The quarry now disused is located on the western margin of Schleiz (Figure 1). The reported 4.40 m of dark-grey shales with limestone nodules at the bottom and margin of the entrance path nearly disappeared after gravelling with bro-

ken stones. Schindewolf (1921, p. 173) listed an ammonoid fauna, erroneously dated as *Gattendorfia*-“Stufe”, later revised as lower *Wocklumeria*-“Stufe” (Schindewolf, 1937, p. 44). Richter and Richter (1926, p. 285) determined the trilobites of the Schindewolf collection. Records of *Parawocklumeria* and *Glatziella glaucopis* Renz, 1914 (Müller, 1956, p. 10; Weyer, 1981a, p. 3) indicate middle parts of the *Wocklumeria*-“Stufe” (Subzone of *Kamptoclymenia endogona* sensu Schindewolf, 1937). Without revision of the old ammonoid faunal lists it is impossible to prove the real presence of the *Kalloclymenia subarmata* Zone (perhaps its upper part: *Effenbergia lens* Zone). Illustrations of some selected faunal elements were only given in Weyer (1965, 1972, 1981a).

Rare brachiopod specimens occur: *Rozmanaria equitans* (Schmidt 1924) (Weyer 1972, plate 2, figure 5), rozmanariid? gen. et sp. indet. [here revised, for *Rozmanaria equitans* (Schmidt 1924) of Weyer, 1972, plate 2, figure 4], *Novaplatisrostrum* cf. *fibrosissimum* (Tietze, 1870) [cited in Weyer (1981a, p. 5) as *Planovatisrostrum* cf. *richteri* (Oppenheimer, 1916), here revised].

MATERIAL AND METHODS

The bulk of the material, collected by Bartsch and Weyer between 1963–1992, is stored at the Museum für Naturkunde (Leibniz Institute) at the Humboldt-Universität in Berlin (MB.B.). Some older types (Richter, 1848, 1856; Schmidt, 1924) were borrowed from the Berlin Department of the Bundesanstalt für Geologie und Rohstoffe (Federal Institute for Geosciences and Natural Resources, Hannover), the former Prussian Geological Survey (BGR). Specimens curated at the Royal Belgian Institute of Natural Sciences (RBINS) collections, Brussels, are also illustrated.

Shells selected for scanning electron microscopy were observed using a low vacuum SEM, an ESEM FEI Quanta 200, but generally not coated with gold (except otherwise stated). Qualitative elemental composition of unidentified epizoans (see below) was determined through energy dispersive X-ray analysis (EDS) using the same SEM apparatus. The larger specimens were coated with ammonium chloride sublimate before being photographed.

SYSTEMATIC PALAEOONTOLOGY

The supraspecific classifications follow Holmer and Popov (2000) for Class Lingulata, Rachebœuf (2000, 2007) for Suborder Chonetid-

ina, Brunton et al. (2000) for Suborder Productidina, Williams and Harper (2000) for Order Orthida, Savage et al. (2002) and Savage (2007) for Order Rhynchonellida, Alvarez and Rong (2002) for Order Athyridida, Carter et al. (2006) for Order Spiriferida, and Lee et al. (2006) for Order Terebratulida. Grunt and Weyer (2016) recently discussed the authorship of the order Athyridida (Dagys, 1974 vs. Boucot et al., 1964) which was first introduced as such by Dagys (1974), but the latter did not attribute this authorship to himself but to Boucot et al. (1964). Grunt and Weyer's (2016) reassignment to Dagys (1974) should necessitate a revision of the super-levels of the classification, which is well beyond the scope of this paper.

Most of the synonymy lists refer only to the material from Thuringia. The representatives of the Suborder Chonetidina studied by Afanasjeva (2002) are only briefly discussed and not illustrated herein.

Phylum BRACHIOPODA Duméril, 1805
Subphylum LINGULIFORMEA Williams et al., 1996

Class LINGULATA Gorjansky and Popov, 1985

Order LINGULIDA Waagen, 1885

Superfamily LINGULOIDEA Menke, 1828

Family LINGULIDAE Menke, 1828

Genus LINGULARIA Biernat and Emig, 1993

Type species. *Lingularia similis* Biernat and Emig, 1993; from the Jurassic (Toarcian–Aalenian) of Spitsbergen.

“Lingularia” sp. indet.

Figure 4, Figure 5, Figure 6.1-6

Material. Breternitz Member: Obernitz–Vorderbohlen (do V): one undifferentiated valve; Gleitsch railway cut, section A, NE-side (bed 21.5): one undifferentiated valve. Pfaffenberg Member: Pfaffenberg–NE (beds: 5β, 5δ, 6γ-δ, 8α-β, 9α-γ): 24 undifferentiated valves.

Remarks. Due to their poor preservation, all the representatives of the family Lingulidae, both Famennian (Figure 6.1-4) and Tournaisian (Figure 6.5-6), are grouped under this unprecise identification. The available material is small-sized (up to 6 mm in length within the Breternitz Member vs. 4.5 mm within the Pfaffenberg Member). The lack of knowledge of the internal characters precludes a detailed identification and comparison with previously described species.

Numerous lingulid species were described in Mississippian and Pennsylvanian succession of Western Europe (see partial review in Graham, 1970). Among them, it appears that those from the

Tournaisian still remain poorly documented (e.g., Demanet, 1934; Winkler Prins and Martínez Chacón, 1999) contrary to their counterparts from the rest of the Carboniferous (e.g., Demanet in Renier et al., 1938; Dorsman, 1945; Vangerow, 1959; Graham, 1970). From the generic viewpoint, Biernat and Emig (1993) assigned several Carboniferous species such as *Lingula mytiloides* Sowerby, 1813 in 1812–1815 to their new genus *Lingularia*, which was recently revised by Bitner and Emig (2016). The latter erected the genus *Eolingularia* to include the Carboniferous species previously included in *Lingularia*, but Bitner and Emig (2016) failed to describe Carboniferous material to confirm the extension of *Eolingularia* and thus the presence of this genus in the Mississippian should still be demonstrated. Nevertheless, we refer temporarily the Thuringian material to *“Lingularia”* pending better material and a thorough revision of the internal morphology (generally unknown due to insufficient preservation) of the West European Mississippian and Pennsylvanian representatives of the Family Lingulidae. In order to facilitate such a revision, and although the goal of this paper is not the revision of the Tournaisian lingulids, it is helpful to re-illustrate the type material of *“Lingularia” straeleni* (Demanet, 1934) (Figure 6.7-22), which was originally described from the Tournaisian of southern Belgium. The exact age (Hastarian or Ivorian) of Demanet's species is currently not known with certainty due to discrepancies between the evasive labels accompanying the specimens and the data published in the literature (Demanet, 1934, 1958; Mortelmans, 1969). The specimens illustrated by Demanet (1934) were considered by him as paratypes and he did not select a holotype. For nomenclatorial purposes, the specimen RBINS a5802 (Demanet, 1934, plate 1, figure 5; Figure 6.14-17) is selected as the lectotype whereas the specimens RBINS a5801 (Demanet, 1934, plate 1, figure 4; Figure 6.7-13) and a5803 (Demanet, 1934, text-figure 1; Figure 6.18-22) are paralectotypes. Graham (1970) reported Demanet's species in the Visean–Bashkirian succession of Scotland, but it is not certain that the Scottish material is conspecific with the former species. Note that the species from Tournai was considered as a synonym (Vangerow, 1959) or a probable one (Biernat and Emig, 1993) of *“Lingularia” mytiloides*, but the internal morphology of the Tournaisian species remains unknown.

Occurrence. Gleitsch Formation, Breternitz (do V and do VI) and Pfaffenberg members (Figures 4, 5).

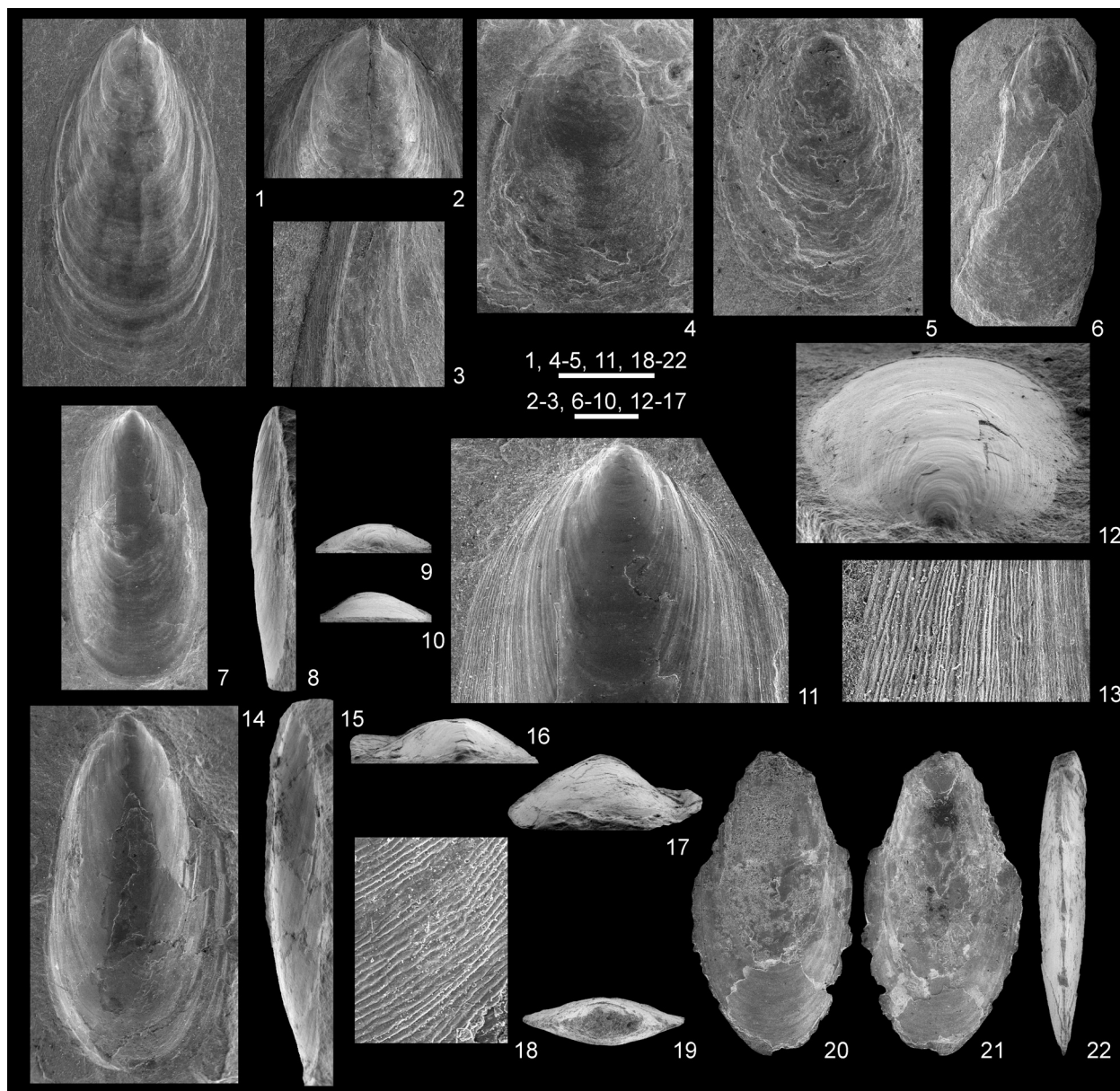


FIGURE 6. 1-4, *Lingularia* sp. indet. from the Breternitz Member. 1-3, possible ventral valve (MB.B.9817) in orthogonal view and details of the posterior region and of the ornamentation (Obernitz–Vorderbohlen, do V). 4, undifferentiated valve (MB.B.9818) in orthogonal view (railway cut Gleitsch-A-NE, bed 21.5, lower do VI). 5-6, *Lingularia* sp. indet. from the Pfaffenberg Member (Pfaffenberg–NE). 5, undifferentiated valve (MB.B.9819) in orthogonal view (bed 8β). 6, undifferentiated valve (MB.B.9820) in orthogonal view (bed 6 γ). 7-22, *Lingularia straeleni* Demanet, 1934, Tournaisian (precise stratigraphic level unknown) from the Tournai region, southern Belgium. 7-13, undifferentiated valve (RBINS a5801) in orthogonal, lateral, posterior, and anterior views, detail of the posterior region, oblique posterior view, and details of the ornamentation (precise origin unknown). 14-17, flattened, undifferentiated valve (lectotype, RBINS a5802) in orthogonal, lateral, posterior, and anterior views (precise origin unknown). 18-22, articulated specimen (RBINS a5803), almost complete, detail of ornamentation and posterior, “ventral”, “dorsal” and lateral views (Antoing, Orient quarry). Scale bars: 1, 5-6, 11-12 (1 mm), 2 (400 μm), 3 and 18 (200 μm), 4, 7-10, 14-17 and 19-22 (2 mm), 13 (250 μm). All SEM.

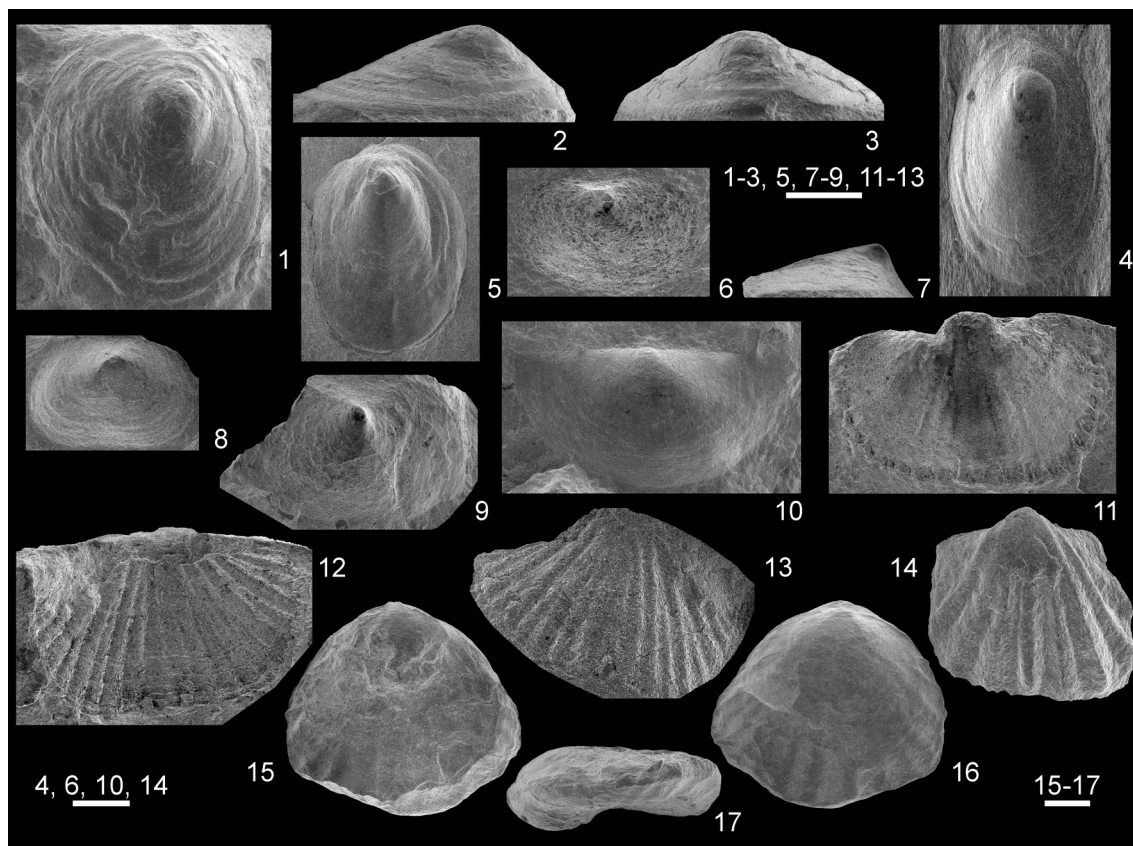


FIGURE 7. 1-5, *Oehlertella?* sp. from the Pfaffenberg Member (Pfaffenberg–NE). 1-3, almost complete dorsal valve (MB.B.9821) in dorsal, lateral and posterior views (bed 3). 4, complete dorsal valve (MB.B.9822) (bed 6γ). 5, almost complete dorsal valve (MB.B.9823) (bed 6γ). 6-9, Acrotretide? gen. et sp. indet. from the Pfaffenberg Member (Pfaffenberg–NE and SW). 6, decorticated ventral (?) valve (MB.B.9824) (bed 8β NE). 7, ventral (?) valve (MB.B.9825) (bed 4 SW). 8-9, ventral (?) valve (MB.B.9826) in lateral and ventral views (bed 8α NE). 10, *Tornquistia?* sp. from the Pfaffenberg Member (Pfaffenberg–SW, bed 8α), ventral valve (MB.B.9827). 11-14, Orthide gen. et sp. indet. from the Breternitz Member. 11-13, internal mould of a ventral valve (MB.B.9828), external mould and plasticine mould (Fischersdorf–Gositzfelsen, bed 6). 14, ventral valve (MB.B.9829) (Fischersdorf–West, bed 32.11). 15-17, Rhynchonellide gen. et sp. indet. from the Pfaffenberg Member (Pfaffenberg–NE, bed 1) crushed articulated specimen (MB.B.9830) in ventral, dorsal and lateral views. Scale bars: 1 mm, except 4 and 14 (500 μm). All SEM.

Superfamily DISCINOIDEA Gray, 1840

Family DISCINIDAE Gray, 1840

Genus OEHLERTELLA Hall and Clarke, 1890

Type species. *Discina pleurites* Meek, 1875; from the Cuyahoga Formation, Tournaisian, Ohio, USA.

Oehlertella? sp. indet.

Figure 5, Figure 7.1-5

Material. Pfaffenberg–NE (beds 1, 3, 6γ): three dorsal valves, including two juveniles.

Remarks. These poorly preserved dorsal valves are small-sized (up to ca. 3 mm in width), convex, subcircular to elliptic in outline, with their apex located in the posterior third of the valve. The relatively submarginal position of the apex suggests a

tentative assignment to *Oehlertella* Hall and Clarke (1890) rather than to *Orbiculoidea* d'Orbigny, 1847 in which the dorsal apex is located subcentrally according to Mergl (2006). Of course, ventral valves are required to reach a more confident identification.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*sulcata–jii* conodont zones) (Figure 5).

Order ACROTRETIDA Kuhn, 1949

Acrotretide? gen. et sp. indet.

Figure 5, Figure 7.6-9

Material. Pfaffenberg–NE (beds 6 β, 8α-β): three (ventral?) valves; Pfaffenberg–SW (bed 4): one (ventral?) valve.

Remarks. These poorly preserved, small (ventral?) valves (up to 4.9 mm in width) are subconical and characterized by a transversely oval outline with a straight and wide posterior margin and procline pseudointerarea. The ornamentation consists of poorly preserved growth lines. Their morphology is reminiscent of that of representatives of some acrotretide genera. According to Holmer and Popov (2000), the Order Acrotretida is known with certainty until the Middle Devonian. Additional material is required to reach a better identification.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*jii-sandbergi* conodont zones) (Figure 5).

Subphylum RHYNCHONELLIFORMEA

Williams et al., 1996

Class STROPHOMENATA Williams et al., 1996

Order PRODUCTIDA Sarycheva and Sokolskaya, 1959

Suborder CHONETIDINA Muir-Wood, 1955

Superfamily CHONETOIDEA Bronn, 1862

Family ANOPLIIDAE Muir-Wood, 1962

Subfamily ANOPLIINAE Muir-Wood, 1962

Genus ANOPLIOPSIS Girty, 1938

Type species. *Chonetina subcarinata* Girty, 1926; from the Fort Payne Chert and Ridgetop Shale (Lower Mississippian) of western Tennessee, USA.

Anopliopsis glabra (Afanasjeva, 2002)
Figure 5

* 2002 *Palaeoanopliopsis glabra* sp. nov. Afanasjeva, p. 58, plate 4, figures 17-23.

2007 *P.* (= *Palaeoanopliopsis*) *glabra*; Rachebœuf, p. 2631.

Description. See Afanasjeva (2002).

Remarks. The genus *Palaeoanopliopsis* Afanasjeva, 2002 was considered as a junior subjective synonym of *Anopliopsis* Girty, 1938 by Rachebœuf (2007).

Occurrence. Gleitsch Formation, Pfaffenberg Member (*sulcata* conodont Zone) (Figure 5). The species is also reported in the Rhenish Slate Mountains (Afanasjeva, 2002).

Genus TORNQUISTIA Paeckelmann, 1930

Type species. *Leptaena (Chonetes) polita* M'Coy, 1852; from the Visean of Lowick, Northumberland, England.

Tornquistia? sp. indet.
Figure 5, Figure 7.10

Material. Pfaffenberg–SW (bed 8a): one single ventral valve.

Remarks. This identification is made for a minute (ca. 5 mm in width), convex and transverse ventral valve, which is covered by numerous growth lines.

The right side of the hinge line displays a single orthomorph oblique (80°) spine whereas the left side shows a pit corresponding to the base of a spine. The external features such as the absence of radial ornamentation and the type of spine strongly suggest an assignment to Paeckelmann's genus, but the lack of data related to the internal morphology precludes a definitive generic identification.

Tornquistia was largely reported in the Carboniferous of Western Europe (e.g., Paeckelmann, 1930; Muir-Wood, 1962; Brand, 1970; Martínez Chacón, 1979), mostly in Visean–Serpukhovian strata. Numerous *Tornquistia* species were described in the literature. According to Rachebœuf (in Wongwanich et al., 2004), most of them are still poorly known and a detailed revision of Girty's genus is urgently required.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*sandbergi* conodont Zone) (Figure 5).

Family RUGOSOCHONETIDAE Muir-Wood, 1962
Subfamily RUGOSOCHONETINAE Muir-Wood,
1962

Genus THURINGOCHONETES Afanasjeva, 2002

Type species. *Thuringochonetes thuringicus* Afanasjeva, 2002; from the Gleitsch Formation (Pfaffenberg Member; Hastarian) of Thuringia, Germany.

Thuringochonetes thuringicus Afanasjeva, 2002
Figure 5

* 2002 *Thuringochonetes thuringicus* sp. nov. Afanasjeva, p. 60, plate 4, figures 1-9.

2007 *T.* (= *Thuringochonetes*) *thuringicus* Afanasjeva, 2002; Rachebœuf, p. 2634, figure 1749,3 (= copy of Afanasjeva 2002).

Description. See Afanasjeva (2002).

Remarks. Rachebœuf (2007) transferred Afanasjeva's genus from the family Strophochonetidae to the family Rugosochonetidae.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*kockeli-quadruplicata* conodont zones) (Figure 5). Afanasjeva (2002) also reported the species in the Hastarian of the Rhenish Slate Mountains.

Suborder PRODUCTIDINA Waagen, 1883
Superfamily PRODUCTOIDEA Gray, 1840
Family PRODUCTELLIDAE Schuchert, 1929
Subfamily PRODUCTININAE Muir-Wood and
Cooper, 1960
Genus PRODUCTINA Sutton, 1938

Type species. *Productus sampsoni* Weller, 1909; from the Chouteau Limestone (Kinderhookian), Pettis County, Missouri.

Productina saalfeldensis sp. nov.

Figure 5, Figure 8

zoobank.org/CF516DFF-EE32-4937-A4AC-597C54D0BC24

- 1856 ?*Leptaena* spec.; Richter, p. 130, plate 2, figures 76-79.
- p 1931 *Productus* (*Thomasina*) *margaritaceus* Phillips; Paeckelmann, p. 184, plate 17, figure 10 (only the specimen from Aprike-Riemke).
- 1954 *Productus* sp.; Pfeiffer, p. 69.
- v 1979 *Productina* sp.; Weyer, p. 100, plate 5, figure 17.
- v 1982 *Productina* sp.; Bartsch and Weyer, text-figure 11.1, plate 6, figures 9, 10 (copy of Weyer, 1979).
- v 1986 *Productina* sp.; Bartsch and Weyer, plate 1 (right column), figure 2.
- v 1995 *Productina* sp.; Pfeiffer et al., plate 4.3.5-II, figure 17 (copy of Weyer, 1979).
- v 2015 *Productina* sp.; Bartsch et al., figure 14.2 (Brachiopoda) (copy of Bartsch and Weyer, 1986).

Etymology. From the town of Saalfeld (Thuringia, Germany), which is close to the type locality.

Holotype. An articulated specimen (MB.B.9835), with dorsal valve partly concealed by shaly matrix (Figure 8.15-19) from the locality Pfaffenberg–SW (bed 5γ) (Figures 2.1, 5).

Additional material. Fischersdorf-East (bed 7): five ventral valves; Fischersdorf-Gositzfelsen (bed 6δ): two ventral valves; Pfaffenberg-NE (beds 2-4, 5 α-δ, 6α-β, 6δ, 7, 8α-β, 9α-γ, 10α, 10γ): two articulated specimens, 284 ventral and eight dorsal valves, three ventral and three dorsal interiors; Pfaffenberg-SW (beds 2-4, 5 α-δ, 6α, 6γ-δ, 7, 8α-β, 9α-γ): four articulated specimens, 404 ventral and three dorsal valves, 14 ventral and 16 dorsal interiors.

ors. Kahleite quarry-E-1 (beds 7.1-2): two ventral and one dorsal valves.

Type locality. Pfaffenberg–SW (Figure 2.1).

Type stratum. Gleitsch Formation, Pfaffenberg Member (Tournaisian, Hastarian) (Figures 3, 5).

Diagnosis. Shell small-sized (up to ca. 11.5 mm in width), strongly concavo-convex, semi-circular to semi-elliptic in outline with a strong ventral umbo, wider than long, widest slightly anteriorly to hinge line; anterior commissure rectimarginate to undulose (ventrally oriented); 6–10 regular, rounded ribs per 2 mm at front; spines posteriorly confined (one or two on both sides of the ventral umbo); growth lines irregularly spaced on ventral valve, more prominent (rugae) on dorsal valve (microlines observed); brachial ridges very low, lobate, anteriorly directed.

Description. Shell small-sized (up to ca. 11.5 mm in width), semi-circular to semi-elliptic in outline, wider than long, strongly concavo-convex, widest slightly anteriorly to hinge line; anterior commissure rectimarginate to undulose (ventrally oriented); ears inclined to become flat. Ventral valve regularly convex in posterior profile view as is the case in lateral one but with an accentuation in the posterior part; umbo large, markedly prominent; ginglymus not observed. Dorsal valve is markedly concave, with flattened posterolateral extremities (rarely observed), semi-circular to semi-elliptic in outline.

Shell covered by rounded ribs increasing by bifurcations and intercalations in ventral valve (6–10 ribs per 2 mm at front); spines posteriorly confined (one or two on both sides of the ventral umbo); growth lines irregularly spaced on ventral valve, more prominent (rugae) on dorsal valve (microlines observed).

Ventral interior (Figure 8.35-36) devoid of septum; endospines numerous; teeth not observed.

FIGURE 8 (on next page). *Productina saalfeldensis* sp. nov. from the Pfaffenberg Member (Pfaffenberg–NE and SW). **1-3**, incomplete ventral valve (MB.B.9831) in ventral, lateral, and posterior views (bed 5α SW). **4-5**, distorted ventral valve (MB.B.9832) in posterior and ventral views (bed 5β SW). **6-8**, ventral valve (MB.B.9833) in ventral, lateral and posterior views (bed 5γ SW). **9-14**, slightly distorted articulated specimen (MB.B.9834) in ventral, dorsal, oblique postero-dorsal, lateral, posterior and anterior views (bed 4 SW). **15-19**, almost complete articulated specimen (holotype, MB.B.9835) with dorsal valve concealed with shaly matrix in ventral, dorsal, lateral, posterior and anterior views (bed 5γ SW). **20**, incomplete dorsal external mould (MB.B.9836) (6δ NE). **21-24**, incomplete and slightly distorted ventral valve (MB.B.9837) in ventral, lateral, posterior and anterior views (bed 4SW). **25-27**, almost complete ventral valve (MB.B.9838) in ventral, lateral and posterior views (bed 4 SW). **28-30**, slightly distorted ventral valve (MB.B.9839) in ventral, lateral and posterior views (bed 4 SW). **31-34**, ventral valve (MB.B.9840) with detail of lateral spine base, in ventral, lateral and posterior views (bed 5β SW). **35-36**, slightly distorted ventral internal mould (MB.B.9841) in ventral and oblique posterior views (bed 6δ NE). **37-38**, distorted dorsal internal mould (MB.B.9842) in oblique posterior view and detail of the dorsal muscle field and of the poorly preserved cardinal process (bed 5α SW). **39**, distorted dorsal internal mould (MB.B.9843) in dorsal view (bed 5α SW). **40-43**, distorted dorsal internal mould (MB.B.9844) in dorsal, oblique lateral, and oblique posterior views and close-up of the posterior region (bed 5α SW). Scale bars: 2 mm, except 31 (200 μm), 38 (500 μm), and 43 (1 mm). All SEM.

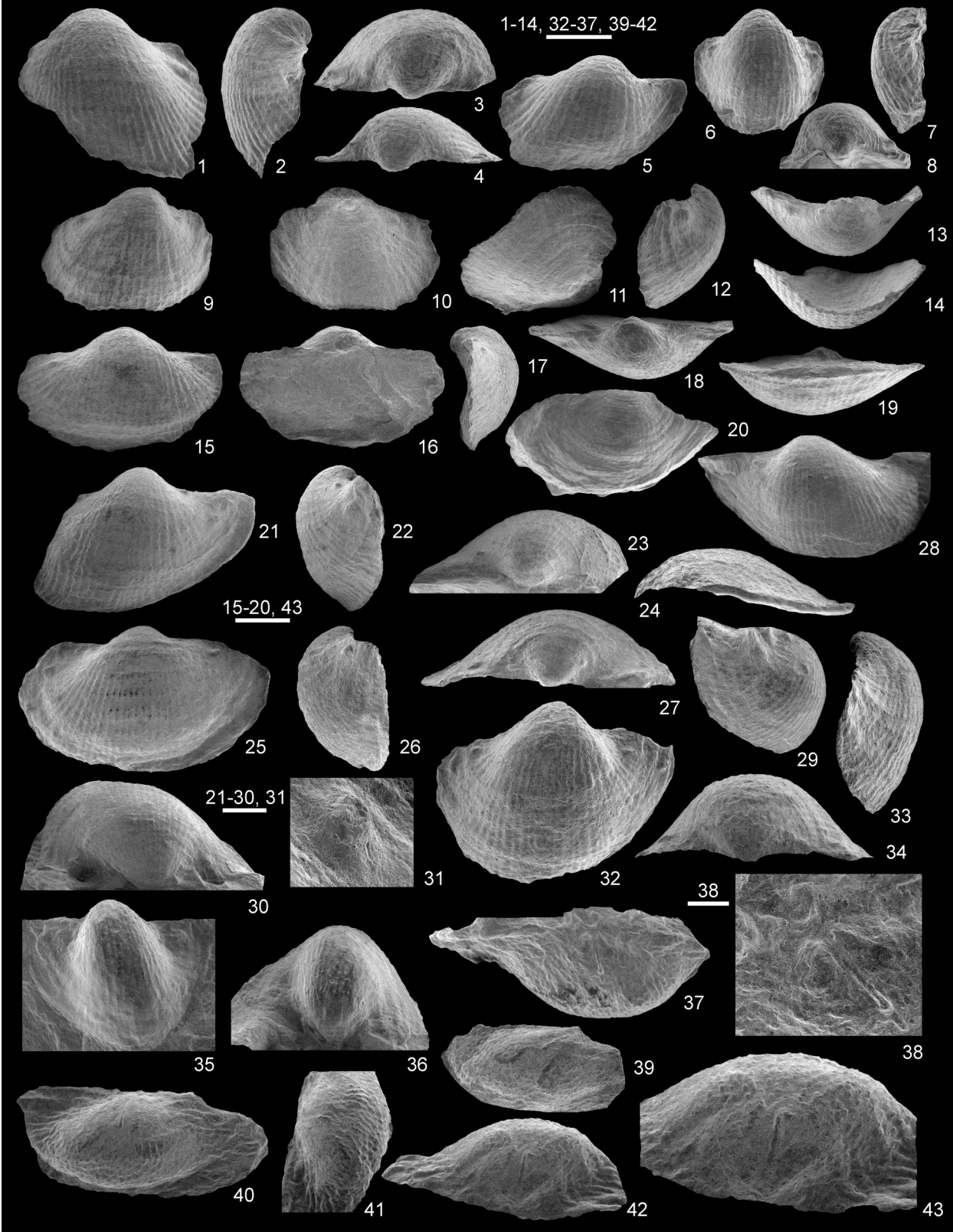


FIGURE 8 (caption on previous page).

Dorsal interior (Figure 8.37-43) with adductor scars rounded trigonal in outline, slightly raised, small, smooth; median septum confined to the posterior half of the valve; endospines numerous; cardinal process bilobed anteriorly (observed only in a single specimen); brachial ridges very low, lobate, anteriorly directed.

Remarks. The discrimination criteria between the productinine genera *Argentiproductus* Cooper and Muir-Wood, 1951, *Dorsirugatia* Lazarev (in Lazarev and Suur'suren, 1992), and *Productina* Sutton, 1938, were exposed by Muir-Wood and Cooper (1960), Brunton and Mundy (1993) and Brunton et al. (2000). Based on their respective discussion, the Thuringian new species is assigned to Sutton's genus as it displays a regular, fine ribbing, which is not interrupted by concentric lamellae. However, most of the specimens are less inflated and more developed in width than the type species *Productina sampsoni* (Weller, 1909) and its closely related species *P. parvula* (Winchell, 1863), both from North America. *Productina saalfeldensis* sp. nov. seems to be closer to *P. lodgepolensis* Rodriguez and Gutschick, 1968 from Montana, in terms of size and shell thickness, but can be distinguished by its thinner ribbing and the development of faint brachial ridges. *Productina saalfeldensis* sp. nov. is similarly sized than *P. globosa* Roberts, 1963, but its ornamentation is thinner and its outline is more developed in width. The other Australian *Productina* species described by Roberts (1976), namely *P. striata* and *P. morrissi* (see also discussion in Brunton and Mundy, 1993) are clearly larger than the Thuringian one. *Productina saalfeldensis* sp. nov. cannot be confused with *P. pectinoides* (Phillips, 1836) due to its much smaller size and its more transverse outline. With *Productus* (*Thomasina*) *decheni* Paeckelmann, 1931, a possible upper Famennian, small-sized *Productina* representative according to Brunton and Mundy (1993) although its internal features are still unknown, *P. saalfeldensis* sp. nov. shares its transverse outline and its small size, but has a thinner ribbing, and its spines are confined to the posterior part of the ventral valve.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*sulcata*–*quadruplicata* conodont zones) (Figure 5). Outside Thuringia, the species is also often recognized within the basal Hastarian Hangenberg Limestone in the Rhenish Slate Massif (see Paeckelmann, 1931, plate 17, figure 10; Bartzsch and Weyer, 1982, text-figure 11.1).

Class RHYNCHONELLATA Williams et al., 1996
Order ORTHIDA Schuchert and Cooper, 1932

Orthide gen. et sp. indet.

Figure 4, Figure 7.11-14

- ? 1840 *Orthis costata*; Münster, p. 79, plate 14, figure 18.
- v 1986 *Hypsomyonia pauciplicata* (Grüneberg, 1925); Bartzsch and Weyer, p. 149.
- v 1998 *Hypsomyonia pauciplicata* (Grüneberg, 1925); Bartzsch et al., p. 45.
- v 2008 *Hypsomyonia*; Bartzsch et al., p. 71.

Material. Fischersdorf–Gositzfelsen (bed 6): one ventral internal interior; Fischersdorf–West (beds 32.6, 32.11): one ventral valve, one dorsal valve, and one ventral interior.

Remarks. These minute (up to ca. 3.4 mm in width) strongly costellate shells display the following features (dorsal valve poorly preserved): rounded rectangular outline, convex ventral valve, flat dorsal valve, prominent ventral umbo, large ventral muscle field, small unsupported teeth, ca. 20 costae, numerous microlines irregularly thickened. The absence of dorsal interior, so important for generic identification of orthide genera, precludes a generic and specific identification, even if the external morphology suggests a parallel with the genus *Hypsomyonia* Cooper, 1955, known from the Frasnian of the USA (Cooper, 1955), Australia (Veevers, 1959) and maybe Belgium (Mottequin, 2008). According to Paeckelmann (1930, p. 156), the Upper Franconian (locality Schübelhammer) specimen with numerous ribs illustrated by Münster (1840, plate 14, figure 18) as “*Orthis costata* Sowerby in Murchison, 1839” would be identical to *Dalmanella? pauciplicata* Grüneberg, 1925. Grüneberg (1925) erected the species *pauciplicata* for minute brachiopods from the upper Famennian Cypridinenschiefer of Bergisches Land (locality Üllendahl) in Western Germany, that he considered as the same than *Orthis* n. sp. described by Paeckelmann (1913) from the same horizon but also from the lowest Etrœungt-Schiefer of the same area. Jux and Krath (1974) assigned Grüneberg's species to *Hypsomyonia*, in studying material from the lower Famennian of Bergisches Land, but without investigation of the internal features. The dorsal steinkern from the Dasberg-“Stufe” (locality Diedenshausen) illustrated by Paeckelmann (1930, plate 9, figure 2) does not match that of typical *Hypsomyonia* representatives (compare with Cooper, 1955, plate 11, figures 6-11) as it lacks a long septum and a cruralium. The same remarks are also valid for the material from Western Germany illustrated by Gallwitz (1932) as *Dalmanella? cf. pauciplicata*. Furthermore, the upper Famennian material identified as *H. pauciplicata*

from the Refrath 1 Borehole (Rhenish Massif) by Müller (2004) cannot be assigned to *Hypsomyonia* as the dorsal valve is also devoid of a cruralium supported on a high septum. In conclusion, *Dalmanella? pauciplicata* needs a revision urgently and additional material from Thuringia is needed to confirm (or otherwise) its conspecificity with Grüneberg's species.

Occurrence. Gleitsch Formation, Breternitz Member (Figure 4).

Order RHYNCHONELLIDA Kuhn, 1949
Rhynchonellide gen. et sp. indet.
Figure 5, Figure 7.15-17

Material. Pfaffenberg–NE (bed 1): two articulated specimens, one ventral valve and one dorsal valve; Pfaffenberg–SE (bed 1): one ventral valve.

Remarks. Due to their very poor state of preservation, these small-sized (ca. 6 mm in width) and ribbed rhynchonellides are left in open nomenclature. They are included here in order to provide the most complete survey of the brachiopod fauna.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*kockeli* conodont Zone) (Figure 5).

Superfamily PUGNACOIDEA Rzhonsnitskaya,
1956

Family PUGNACIDAE Rzhonsnitskaya, 1956
Genus THURINGORHYNCHUS gen. nov.

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Type species. *Thuringorhynchus pseudoequitans* gen. et sp. nov., by monotypy.

Etymology. In reference to Thuringia (Germany), where the type locality of its type species is located, and τό πυγχος (Greek), beak.

Diagnosis. Shell small, sharply dorsibiconvex, wider than long, subcircular to transversally ovate in outline; anterior margin sharply emarginate; anterior commissure uniplicate; fold and sulcus originating at some distance from umbones; tongue very high, subrectangular, strongly bent dorsally; flanks smooth or exceptionally with few ribs; fold and sulcus generally smooth or more rarely with one or two low, rounded ribs in sulcus and two to three low ribs on fold only developed close to anterior margin; dental plates short; dorsal median septum short; septalium absent.

Remarks. *Thuringorhynchus* gen. nov. is included in the family Pugnacidae on the basis of the following features: high fold and tongue, few ribs, short dental plates and dorsal median septum, and absence of septalium. *Thuringorhynchus* gen. nov. displays strong external similarities (e.g., strongly dorsibiconvex lateral profile, markedly emarginate anterior margin, high tongue, strong fold and sul-

cus) with the pugnacid genus *Pammegetherhynchus* Sartenaer, 1977 from the upper Frasnian of northern France and Poland (Sartenaer, 1977, 1997; Sartenaer et al., 1998), but differs by the presence of a short dorsal median septum. *Thuringorhynchus* gen. nov. is markedly different from the rozmanariid genus *Rozmanaria* Weyer, 1972 even if it superficially looks close to the latter (e.g., outline strongly emarginate, high fold and tongue). The markedly dorsibiconvex lateral profile (vs. strongly ventribiconvex lateral profile in *Rozmanaria*), the uniplicate anterior commissure (vs. unisulcate anterior commissure in *Rozmanaria*), the presence of dental plates and of a dorsal median septum in *Thuringorhynchus* gen. nov. allow an easy discrimination between both genera.

Thuringorhynchus pseudoequitans gen. et sp. nov.
Figure 5, Figure 9, Figure 10, Figure 11, Table 2

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- v 1986 *Rozmanaria equitans* (Schmidt, 1924); Bartsch and Weyer, plate 1 (right column), figure 1a-b.
- v 2015 *Rozmanaria?* nov. sp.; Bartsch et al., figure 14.1 (Brachiopoda) (copy of Bartsch and Weyer, 1986).

Etymology. In reference to the confusion with the rhynchonellide species *Rozmanaria equitans* (Schmidt, 1924).

Holotype. An articulated specimen (MB.B.9852) (Figure 9.39-44), illustrated by Bartsch and Weyer (1986, plate 1 (right column), figure 1a-b), from the locality Pfaffenberg–NE (bed 8β) (Figures 2.1, 5).

Additional material. Pfaffenberg–NE (beds 6δ, 7, 8α-β, 9α): 52 articulated specimens, four ventral valves, two dorsal valves; Pfaffenberg–SW (bed 6δ): two articulated specimens and one ventral valve.

Type locality. Pfaffenberg–NE (Figure 2.1).

Type stratum. Gleitsch Formation, Pfaffenberg Member (Tournaisian, Hastarian) (Figures 3, 5).

Diagnosis. As for genus.

Description. Shell small (up to 16.8 mm in width), sharply dorsibiconvex, wider than long, widest slightly anteriorly to mid-length, subcircular to transversally ovate in outline; anterior margin strongly emarginate; anterior commissure sharply uniplicate. Ventral valve gently inflated in both lateral and posterior profiles with anterolateral areas inclined to become flat; beak small, straight in juveniles to incurved in adults, close to dorsal umbo in adults but not in contact with it; foramen small, permesothryid (only observed in one specimen, partly destroyed); palintropes small, curved; deltidial

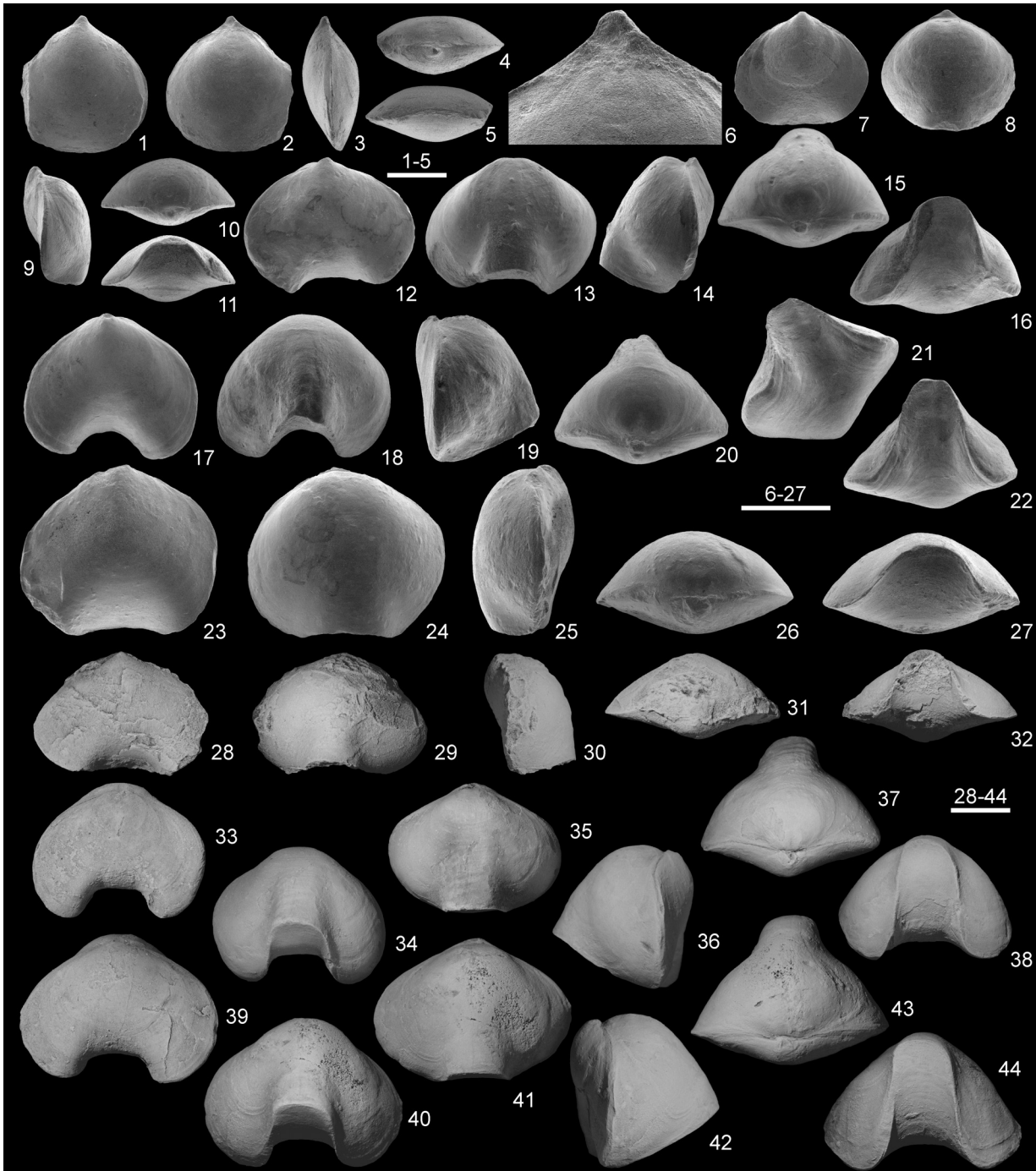


FIGURE 9. *Thuringorhynchus pseudoequitans* gen. nov. et sp. nov. from the Pfaffenberg Member (Pfaffenberg–NE). **1-6**, juvenile articulated specimen (MB.B.9845), almost complete, in ventral, dorsal, lateral, posterior and anterior views, and detail of the posterior margin (bed 8 β). **7-11**, juvenile articulated specimen (MB.B.9846) in ventral, dorsal, lateral, posterior and anterior views (bed 6 δ). **12-16**, articulated specimen (MB.B.9847) in ventral, dorsal, lateral, posterior, oblique anterior and anterior views (bed 6 δ). **17-22**, articulated specimen (MB.B.9848) in ventral, dorsal, lateral, posterior and anterior views (bed 6 δ). **23-27**, articulated specimen (MB.B.9849) in ventral, dorsal, lateral, posterior and anterior views (bed 8 α). **28-32**, articulated specimen (MB.B.9850) in ventral, dorsal, lateral, posterior and anterior views (bed 8 α). **33-38**, articulated specimen (MB.B.9851) in ventral, dorsal, dorsal (with inclined lateral commissures), lateral, posterior and anterior (with inclined lateral commissures) views (bed 9 α). **39-44a**, articulated specimen (holotype, MB.B.9852) in ventral, dorsal, dorsal (with inclined lateral commissures), lateral, posterior and anterior (with inclined lateral commissures) views (bed 8 β). Scale bars: 1-5 (2.5 mm), 6 (1 mm), 7-44 (5 mm). All SEM, except 28-44.

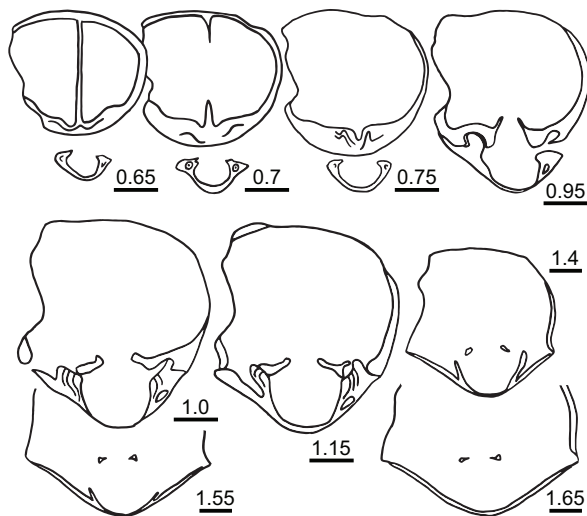


FIGURE 10. Transverse serial sections of *Thuringorhynchus pseudoequitans* gen. et sp. nov. from the Pfaffenberg Member (Pfaffenberg–NE, bed 8α) (MB.B.9853) Numbers refer to distances in mm from the tip of the ventral umbo. Scale bars: 1 mm.

plates observed in transverse serial sections; sulcus wide, deep, inconspicuously originating at mid-valve or more anteriorly, with blunt margins; flat-bottomed at front but shallow in the distal part of the tongue; tongue very high, narrow subrectangular in outline, strongly bent dorsally. Dorsal valve sharply and regularly convex (leaving aside the fold) in posterior view, highest at front; fold inconspicuously originating at about mid-valve, with top slightly rounded at anterior margin.

Shell generally smooth, usually with no ribs developed on flanks (only a single specimen [1.7%] displays two ribs on right ventral flank [none on the other flank] and one on the dorsal left flank); fold and sulcus generally smooth, but some specimens (10.2%) display one or two low, rounded ribs in sulcus and two or three ribs on fold, developed close to anterior margin; growth lines numerous, sometimes thickened.

Ventral interior (Figure 10) with short dental plates diverging dorsally in transverse section and delimiting narrow lateral apical cavities; teeth small, relatively rounded in transverse section. Dorsal interior (Figure 10) with short and high

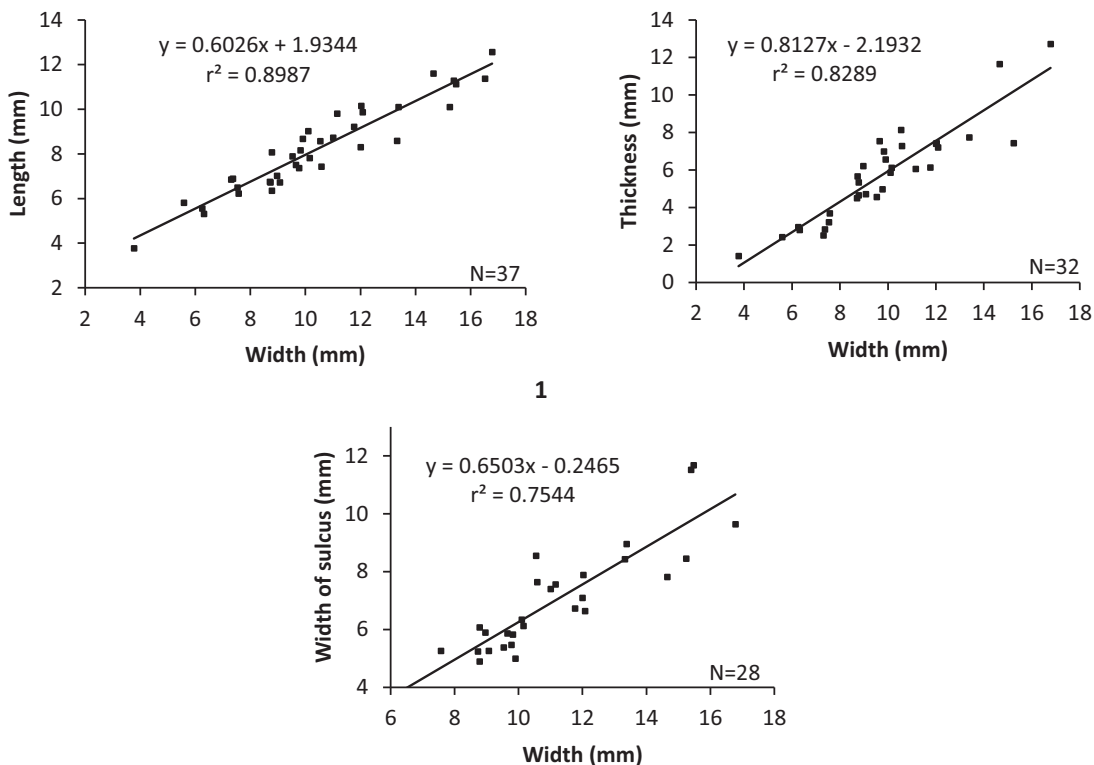


FIGURE 11. Scatter diagrams of *Thuringorhynchus pseudoequitans* gen. et sp. nov. Abbreviations: N, number of specimens measured; r^2 : coefficient of linear regression. **1**, Relation between shell width and length. **2**, Relation between shell width and thickness. **3**, Relation between shell width and sulcus width.

TABLE 2. Measurements in mm of *Thuringorhynchus pseudoequitans* gen. et sp. nov. Abbreviations: L – length of the shell, T – thickness of the shell, W – width of the shell, Wi – width of the interarea, Ws – width of the sulcus.

	W	L	T	Ws	L/W	T/W	Ws/W
N	37	37	32	28	37	32	28
Mean value	10.4	8.2	5.8	7.1	0.81	0.57	0.63
Standard deviation	3.1267	1.9875	2.5029	1.8289	0.0915	0.1228	0.0749
Standard error	± 0.5140	± 0.3267	± 0.3505	± 0.3456	± 0.0150	± 0.0217	± 0.0141
MIN	3.8	3.8	1.4	4.9	0.64	0.34	0.51
MAX	16.8	12.6	12.7	11.7	1.04	0.80	0.81

median septum; hinge plates divided with inner edges converging dorsally; dental sockets deep; crural bases stout (due to strong recrystallization, development of crura unknown).

Measurements. See Figure 11 and Table 2.

Remarks. Although both species look like similar superficially (e.g., shell usually smooth, anterior commissure strongly developed), *Thuringorhynchus pseudoequitans* gen. et sp. nov. cannot be confused with *Rozmanaria equitans* (Schmidt, 1924) (see above) notably due to its markedly different lateral profile (dorsibiconvex vs. ventribiconvex), its distinct anterior commissure (uniplicate vs. unisulcate) and the presence of dental plates in the former.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*jii*–*sandbergi* conodont zones) (Figure 5). Outside Thuringia, some poorly preserved specimens were recovered from the Rhenish Slates Mountains (Hönnetal railway cut section near Oberrödinghausen, Hangenberg Limestone [*Gattendorfia*-“Stufe”], collections gathered by Schindewolf in 1935 and Weyer in 1993). These specimens are from beds 2, 3c1 and 3d1 sensu Korn and Weyer (2003, figure 5), thus from the *Paprothites dorsoplanus*, *Pseudarietites westfalicus* and *Paragattendorfia patens* ammonoid zones sensu Vöhringer (1960) or Upper *Siphonodella duplicata* (now *Siphonodella jii*) and lower *Siphonodella sandbergi* conodont zones sensu Sandberg et al. (1978).

Family ROZMANARIIDAE Havlíček, 1982
Genus HADYRHYNCHA Havlíček, 1979

Type species. *Hadyrhyncha hadyensis* Havlíček, 1979; from the upper Famennian Hádý Limestone (“do V or do VI”), Moravia, Czech Republic.

Hadyrhyncha hadyensis Havlíček, 1979
Figure 4, Figure 12.1-25

* 1979 *Hadyrhyncha hadyensis* Havlíček, p. 99, text-figure 8, plate 2, figures 6-9.

- v 1986 1986 *Hadyrhynchia* (*sic*) *hadyensis* Havlíček, 1979; Bartsch and Weyer, plate 1 (right column), figure 6.
1998b *H.* (= *Hadyrhyncha*) *hadyensis*; Sartenaer, p. 117.
v 2008 *Hadyrhyncha*; Bartsch et al., p. 71.
v 2015 *Hadyrhyncha hadyensis* Havlíček, 1979; Bartsch et al., figure 14.6 (Brachiopoda) (copy of Bartsch and Weyer, 1986).

Material. Breternitz-Middle (beds 2.1-2, 5.2, 6, 11.1-5): five articulated specimens, one dorsal valve; Breternitz-West (bed 1.1-3): two articulated specimens; Fischersdorf-Gositzfelsen (beds 1.1-3, 6, 7): four articulated specimens, one ventral valve; Fischersdorf-Middle (beds 4.1, 5.1, 5.2): three articulated specimens, one ventral valve.

Description. Shell medium-sized (up to 18.3 mm in width), aequibiconvex to ventribiconvex, wider than long, widest at about mid-length, transversally elliptic in outline; anterior margin straight; anterior commissure unisulcate. Ventral valve regularly convex in posterior and lateral profile views, with flanks sloping gently towards lateral commissures; umbo relatively prominent; beak curved; fold inconspicuously originating near mid-valve or anteriorly to it, very low, flat-topped at front. Dorsal valve regularly convex in posterior and lateral profile views, with flanks sloping gently towards lateral commissures; sulcus inconspicuously originating near mid-valve, with blunt margins, wide, flat-bottomed at front; tongue semi-elliptic to subtrapezoidal in outline, low, generally not perpendicular to commissural plane.

Ornamentation of low, rounded costae (up to six in sulcus and eight on flanks), originating close to the umbones, frequently dividing both on flanks and in sulcus (intercalation not observed on fold, most probably due to deficient preservation); growth lamellae not preserved.

Ventral and dorsal interiors are not investigated.

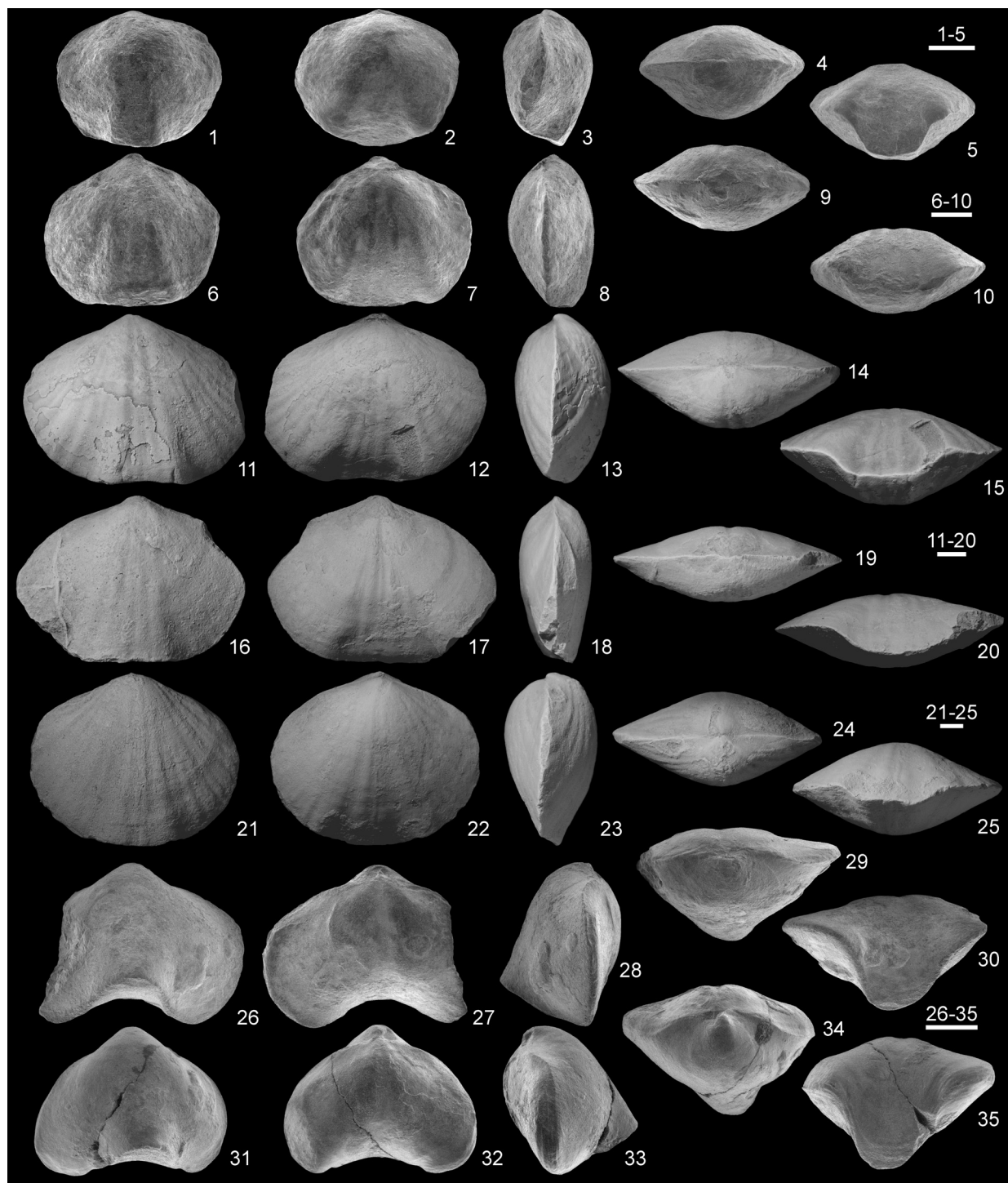


FIGURE 12. 1-25, *Hadyrhyncha hadyensis* Havlíček, 1979 from the Breternitz Member (do V). 1-5, juvenile articulated specimen (MB.B.9854) in ventral, dorsal, lateral, posterior and anterior views (Breternitz–Middle, bed 2.1-2). 6-10, juvenile articulated specimen (MB.B.9855) in ventral, dorsal, lateral, posterior and anterior views (Breternitz–Middle, bed 6). 11-15, articulated specimen (MB.B.9856) in ventral, dorsal, lateral, posterior and anterior views (Fischersdorf–Middle, bed 5.1). 16-20, articulated specimen (MB.B.9857) in ventral, dorsal, lateral, posterior and anterior views (Fischersdorf–Middle, bed 4.1). 21-25, articulated specimen (MB.B.9858) in ventral, dorsal, lateral, posterior and anterior views (Breternitz–Middle, bed 11.1-5). 26-35, *Rozmanaria equitans* (Schmidt, 1924) from the Breternitz Member (do V). 26-30, incomplete articulated specimen (MB.B.9859) in ventral, dorsal, lateral, posterior and anterior views (Fischersdorf–Gositzfelsen, bed 18.1-5). 31-35, articulated specimen (MB.B.9860) in ventral, dorsal, lateral, posterior and anterior views (Mühlfelsen–North, bed 18.1-2). Scale bars: 2 mm. All SEM, except 11-25.

Remarks. The Thuringian material from the lower *Clymenia*-“Stufe” (*Clymenia laevigata* Zone), which was previously illustrated by Bartsch and Weyer (1986), fits well the diagnosis of the Moravian species described by Havlíček (1979) in spite of its relatively poor preservation. In Europe, the genus *Hadyrhyncha* was reported by Halamski and Baliński (2009) in the uppermost Famennian (do VI) of Poland, but this age determination is not sure, as the authors themselves (p. 290) admit that also ammonoids of the *Clymenia*-“Stufe” had been found in their “bed L”. The records from Northern Africa are older: Mottequin et al. (2015a) (Algeria, boundary of *Platy Clymenia*-/*Clymenia*-“Stufe”), Sartenaer (1998b) (Morocco, *Clymenia*-“Stufe”). The precise age of the Czech type materials from Moravia (Hady Limestone near Brno, “do V-VI”) remains unclear without more accurate locality data, e.g., as used by Chlupáč (1966, tab. 2) during his trilobite studies; we need detailed recollecting, underlined by index fossils as ammonoids and/or conodonts.

Occurrence. Gleitsch Formation, Breternitz Member (Figure 4).

Genus NOVAPLATIROSTRUM Sartenaer, 1997

Type species. *Novaplatirostrum sauerlandense* Sartenaer, 1997, upper Famennian, northwestern Sauerland, Germany.

Novaplatirostrum cf. *fibrosissimum* (Tietze, 1870)

Figure 4, Figure 13.1-26, Figure 14, Table 3

- 1848 *Terebratula* [sp.]; Richter, p. 40, plate 5, figures 153-159.
- 1856 *Terebratula subcurvata* Münster var.; Richter, p. 115, plate 1, figures 37-39.
- cf.* 1870 *Atrypa* (*Spirigera*?) *fibrosissima* nova species Tietze, p. 148, plate 17, figures 38, 38a.
- v 1979 *Planovatiostrum fibrosissimum* (Tietze, 1870); Weyer, plate 4, figure 14.
- v 1979 *Planovatiostrum* cf. *planoovale* (Nalivkin, 1937); Weyer, p. 79, plate 4, figure 13.
- v 1986 *Planovatiostrum fibrosissimum* (Tietze, 1870); Bartsch and Weyer, plate 1, figure 5 (right column).
- 1997 *Novaplatirostrum* sp.; Sartenaer, p. 33-34, table 1, figure 2 (see this author for a detailed synonymy of the material from Thuringia).
- v 1999 *Novaplatirostrum*; Bartsch et al., p. 178.
- 2000 *Planovatiostrum fibrosissimum* (Tietze, 1870); Sartenaer, p. 76.
- v 2015 *Novaplatirostrum* nov. sp.; Bartsch et al., figure 14.4 (Brachiopoda) (copy of Bartsch and Weyer, 1986).

- v 2015 *Novaplatirostrum fibrosissimum* (Tietze 1870); Bartsch et al., figure 14.5 (Brachiopoda) (copy of Bartsch and Weyer, 1986).

Material. Railway cut Gleitsch: 39 articulated specimens; Breternitz—East, Middle, and West: 155 articulated specimens; Fischersdorf—East and West: 45 articulated specimens; Geipel-Steinbruch in Schleiz: one articulated specimen; Fischersdorf-Gositzfelsen: 188 articulated specimens; Reschwitz—Hoher Schuss: one articulated specimen; Reschwitz—Mühlfelsen—North and South: 21 articulated specimens; Oberrnitz—Bornleite: 28 articulated specimens; Oberrnitz—Schlosspark: 11 articulated specimens; Oberrnitz—Vorderbohlen: 40 articulated specimens; Probstzella: one articulated specimen.

Description. Shell medium-sized (up to ca. 30.5 mm in width), flatly biconvex (valves subaequally thick), variable in outline (transverse-elliptical to subrounded), generally wider than long; hinge line short; anterior margin flat to rounded; anterior commissure uniplicate in adults (rectimarginate in juveniles), exceptionally slightly parasulcate, slightly (generally) to moderately serrate or only very slightly undulated by the median costae, if present. Ventral valve with small beak, erect to slightly incurved, overhanging the hinge line, often almost in contact with the dorsal umbonal region; palintropes low, concave, defined by sharp beak ridges; no deltidial plates seen; in juveniles, sulcus absent; in adults, sulcus only perceptible close to anterior margin, very shallow, wide, flat- to slightly round-bottomed at front or only indicated by the presence of median ribs; tongue wide, very low, trapezoidal in outline and sharp borders, sometimes non-existent. Dorsal valve with maximum height in posterior third of valve, then decreasing regularly towards anterior margin; in juveniles, fold absent; in adults, fold only developed close to anterior margin, very low, wide, flat-bottomed to slightly depressed.

General rib formula: 0 to 4/3 (median), 0 (parietal), 0 (lateral); median ribs restricted to anterior shell part, variably developed: simple, rounded to angular, low and well-marked or very low and moderately marked or poorly discernible or absent; parietal ribs absent; lateral ribs not frequent, being mere commissure undulations; capillae numerous (ca. 8 per 1 mm) (Figure 12.1); growth lamellae irregularly spaced.

Internal morphology illustrated by Sartenaer (1997, figure 2). Ventral interior with small, wide, strong, and unsupported teeth. Dorsal interior with clearly distinct layer of secondary shell, resting on hinge plate; hinge plate divided; outer hinge plates flat to slightly concave; inner socket ridges moder-

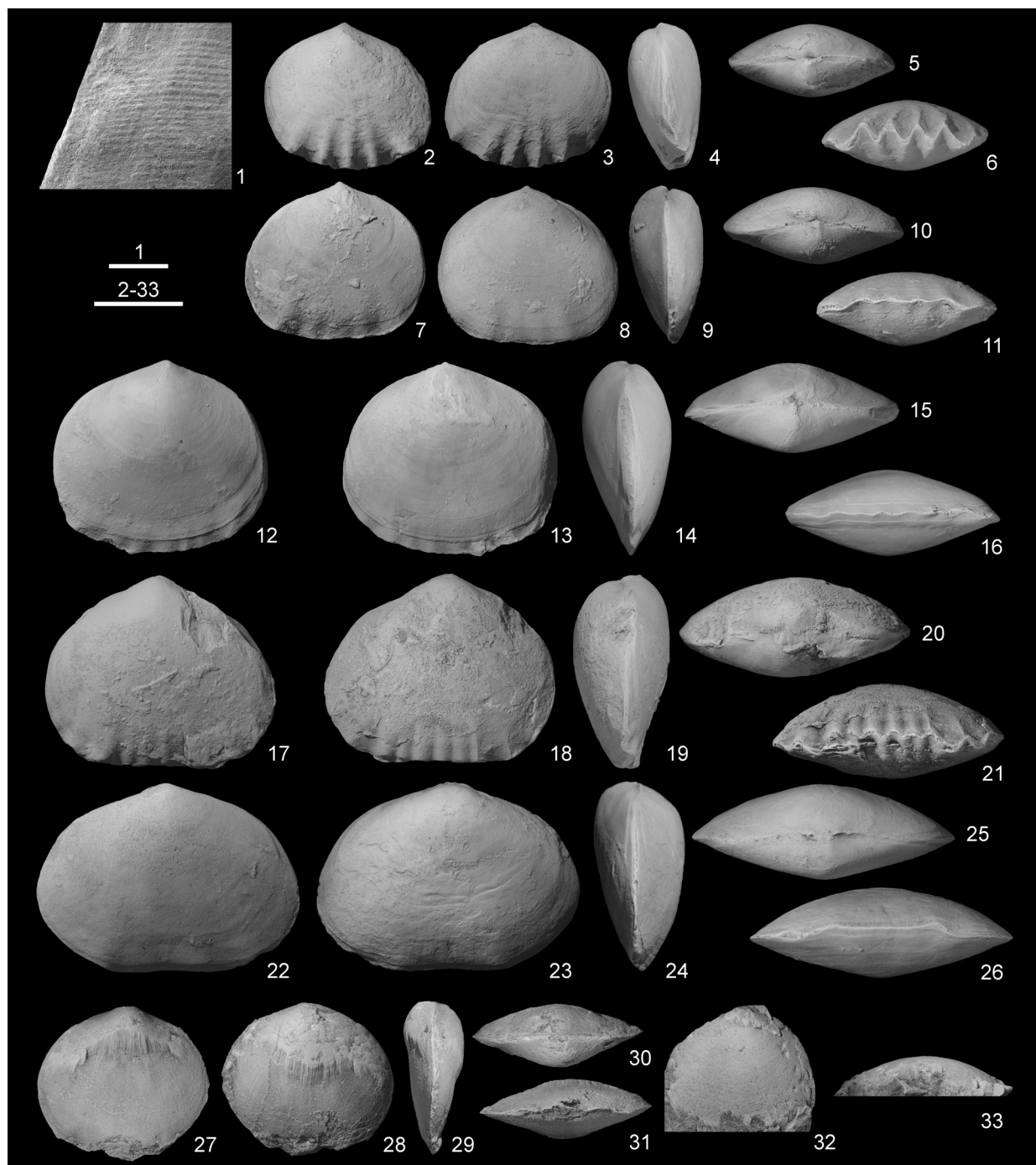


FIGURE 13. 1-26, *Novaplatirostrum* cf. *fibrosissimum* (Tietze, 1870) from the Breternitz Member (do V-VI). 1, close-up of radial capillae in sulcus of an articulated specimen (MB.B.9861), close to the anterior margin (SEM) (Breternitz–East, bed 18.1–3). 2-6, articulated specimen (MB.B.9862) in ventral, dorsal, lateral, posterior and anterior views (Fischersdorf–Gositzfelsen, bed 26.1–3). 7-11, articulated specimen (MB.B.9863) in ventral, dorsal, lateral, posterior and anterior views (Fischersdorf–Gositzfelsen, bed 23.1–3). 12-16, articulated specimen (MB.B.9864) in ventral, dorsal, lateral, posterior and anterior views (Fischersdorf–Gositzfelsen, bed 23.1–3). 17-21, articulated specimen (MB.B.9865) in ventral, dorsal, lateral, posterior and anterior views (Breternitz–East, bed 22.7–12). 22-26, articulated specimen (MB.B.9866) in ventral, dorsal, lateral, posterior and anterior views (Obernitz–Bornleite–South, bed 28.3). 27-33, *Novaplatirostrum fibrosissimum* (Tietze, 1870), Dzikowiec near Nowa Ruda, Lower Silesia (Poland), do VI. 27-31, articulated and decorticated specimen (MB.B.9867) in ventral, dorsal, lateral, posterior and anterior views. 32-33, ventral valve (MB.B.9868) embedded in carbonate matrix in ventral and posterior views. Scale bars: 1 (1 mm), 2-33 (10 mm).

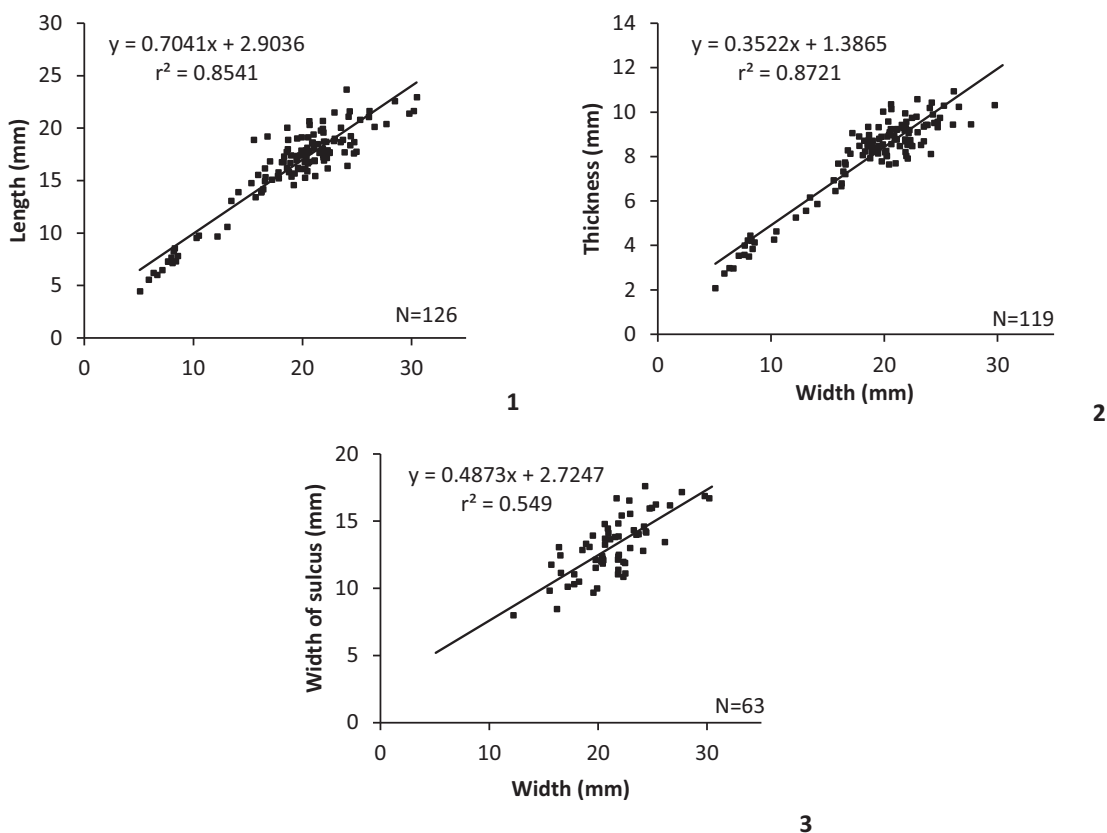


FIGURE 14. Scatter diagrams of *Novaplatirostrum* cf. *fibrosissimum* (Tietze, 1870). Abbreviation: N, number of specimens measured; r^2 : coefficient of linear regression. **1**, Relation between shell width and length. **2**, Relation between shell width and thickness. **3**, Relation between shell width and sulcus width.

ately high, stretched ventrodorsally; crural bases stout; crura short, proximally triangle-shaped in section, and distally hockey-stick-shaped.

Measurements. See Figure 14 and Table 3.

Remarks. Sartenaer (1997) extensively discussed the synonymy of the Thuringian species that he considered as distinct from the contemporaneous species *Novaplatirostrum sauerlandense* Sartenaer, 1997 on the basis of its generally smaller size, its usually suboval and more commonly asymmetri-

cal outline, its weaker ribs and the more seldom presence of lateral ribs. However, this comparison was based on only three specimens of the former. The dissymmetric outline of our material is most probably due to the schistosity affecting the Thuringian rocks and both species displaying the same size range and a variable outline. The main difference between both species lies in the distribution and strength of the ribs. The general rib formulae are 0-4/0-3; 0; 0, and 4-5/3-4; 0; 0-2/0-3 for the

TABLE 3. Measurements in mm of *Novaplatirostrum* cf. *fibrosissimum* (Tietze, 1870). Abbreviations: L – length of the shell, T – thickness of the shell, W – width of the shell, Wi – width of the interarea, Ws – width of the sulcus.

	W	L	T	Ws	L/W	T/W	Ws/W
N	126	126	119	63	125	119	63
Mean value	19.2	16.4	8.1	13.1	0.87	0.43	0.62
Standard deviation	5.3313	4.0687	1.9596	2.1912	0.0898	0.0422	0.0740
Standard error (\pm)	± 0.474	± 0.3625	± 0.1796	± 0.2761	± 0.0080	± 0.0039	± 0.0093
MIN	5.1	4.5	2.1	8.0	0.68	0.34	0.49
MAX	30.5	23.7	11.0	17.6	1.22	0.54	0.80

Thuringian species and *N. sauerlandense*, respectively. The median ribs are generally reduced to a faint undulation of the anterior commissure in the former. Nevertheless, we reasonably have to admit that both species are very closely related if not conspecific. When he erected *N. sauerlandense*, Sartenaer (1997) astonishingly did not discuss the Polish species *Atrypa* (*Spirigera*?) *fibrosissima* Tietze, 1870 from the “Clymenienkalk” of Ebersdorf near Neurode in county Glatz (now Dzikowiec near Nowa Ruda in county Klodzko, Lower Silesia), which is found in rocks of the same age and facies as *Novaplatisrostrum sauerlandense*. The external features cited by Tietze (1870) are found in the Thuringian species, although he did not report the presence of ribs or capillae. Unfortunately, the specimen illustrated by Tietze (1870), deposited in the collections of the Geological Museum of the Institute of Geological Sciences of the Wrocław (former Breslau) University, did not survive the destructions and the turmoil of the last world war (inspection of DW 1994 in Wrocław). Between 1978 and 2002, one of us (DW) has collected at least four ventral valves and one articulated specimen in the type locality. The single articulated shell, which displays the first sign of a low tongue (maybe with traces of ribs) and could be an immature shell, and one ventral valve are illustrated here (Figure 13.27-33). This very limited material is insufficient to revise Tietze’s (1870) species but there are enough elements to include it in *Novaplatisrostrum*. Due to the impossibility to precisely know at this stage the range of variation of the species from the Sudetes, and thus to determine if *N. fibrosissimum* and the Thuringian species are conspecific, we tentatively compare the latter to Tietze’s species. Additional material from Dzikowiec is thus required to compare *N. fibrosissimum* and the possibly also conspecific *N. sauerlandense* validly. Note that Halamski and Baliński (2009) identified material from the Holy Cross Mountains as *N. sauerlandense* that display more median ribs than the type material from the Sauerland, thus reflecting a stronger variability than that reported by Sartenaer (1997).

Occurrence. Gleitsch Formation, Breternitz Member (Figure 4).

Genus ROZMANARIA Weyer, 1972

Type species. *Liorhynchus? equitans* Schmidt, 1924; from the *Wocklumeria*-“Stufe” (do VI) of northern Sauerland, Germany.

Rozmanaria equitans (Schmidt, 1924)
Figure 4, Figure 12.26-35

- 1840 *Terebratula subundata* [n. sp.] Münster, p. 76, plate 14, figure 7 [non J. Sowerby, 1813 in 1812–1815].
- * 1924 *Liorhynchus? equitans* n. sp. Schmidt, p. 145, plate 7, figures 16-17.
- 1962 *Plectorhynchella equitans equitans* (Schmidt); Rozman, p. 176, plate 30, figure 12.
- p 1972 *Rozmanaria equitans* (H. Schmidt); Weyer, p. 87, plate 1, figures 1-6, plate 2, figures 1-2, non plate 2, figures 3-4 (= rozmanariid? gen. et sp. indet., see below) (see this author a more complete synonymy).
- non 1986 *Rozmanaria equitans* (Schmidt, 1924); Bartsch and Weyer, plate 1 (right column), figure 1a-b (= *Thuringorhynchus pseudo-equitans* gen. et sp. nov., see above).
- 2009 *Rozmanaria equitans* (Schmidt, 1924); Halamski and Baliński, p. 295, figure 3A.

Material. Breternitz–E (bed 17.4): one articulated specimen; Fischersdorf–Gositzfelsen (bed 18.1-5): one articulated specimen; Reschwitz–Mühlfelsen–North (bed 18.1-2): one articulated specimen. Oberritz–Bornleite (bed 28.7-14): one articulated specimen (Weyer, 1972, plate 2, figure 1).

Description. See Weyer (1972).

Remarks. Among the material assigned to *Rozmanaria equitans* by Weyer (1972), two specimens (Weyer, 1972, plate 2, figures 3-4) from the *Wocklumeria*-“Stufe” must be transferred to another taxon, which is left in open nomenclature (= rozmanariid? gen. et sp. indet., see below) due to the lack of material, as they do not possess the characteristic bilobate outline and present a clearly dorsibiconvex profile. It is clear that Schmidt’s (1924) species corresponds to *Terebratula subundata* Münster, 1840 (locality Schübelhammer, Upper Franconia, *Clymenia*- or *Wocklumeria*-“Stufe”; figured type preserved in the Palaeontological Institute, Bavarian State collections (no. BSP-ASVII852), University of München), a junior primary homonym of the Cenomanian species *T. subundata* J. Sowerby, 1813 in 1812-1815. The latter was assigned to the gibbithyridid genus *Concinthyris* Sahni, 1929 (Terebratulida) by Owen (1988). This species has absolutely nothing in common with *Roemerithyris macrogaster* (Roemer, 1852), a probable representative of the Superfamily Martiniioidea from the Upper Visean (top Asbian–Lower Brigantian) of the Harz mountains contrary to Gischler’s (1994) opinion who considered *R. equitans* as a synonym of Roemer’s species [see Mottequin and Weyer’s (2019) redescription of *R. macrogaster*]. Thus, the specimens illustrated as *Actinoconchus macrogaster* by

Gischler (1994) cannot be assigned to Roemer's species and were tentatively referred to the genus *Cleiothyridina* Buckman, 1906 by Mottequin and Weyer (2019). Note that the stratigraphic value of the genus *Rozmanaria* was discussed by Sartenaer (1998a), who stressed on the need of re-examination of the Tournaisian specimens assigned to Schmidt's species by Bartzsch and Weyer (1986). This material has been revised herein (see above).

Occurrence. Gleitsch Formation, Breternitz Member (Figure 4). Outside Thuringia, *Rozmanaria equitans* was reported in upper and uppermost Famennian strata of the Rhenish Massif, Poland (Holy Cross Mountains) and Ural (Schmidt, 1924; Rozman, 1962; Weyer, 1972; Halamski and Baliński, 2009). Biernat (1983) cited the species in the lower Famennian of the Holy Cross Mountains, but this report is dubious according to Halamski and Baliński (2009).

Rozmanariid? gen. et sp. indet.

Figure 4, Figure 15.1-5

p 1972 *Rozmanaria equitans* (H. Schmidt); Weyer, p. 87, plate 2, figures 3, 4.

Material. Breternitz–E (bed 17.4): one articulated specimen; Reschwitz–Mühlfelsen–South (bed 26.3-5): one articulated specimen.

Remarks. The available specimens display the following features: shell small-sized (ca. 6 mm in width) smooth, aequibiconvex, slightly wider than long, widest at about midlength, with rounded lateral margins; ventral valve strongly inflated; ventral sulcus shallow, flat-bottomed at front; dorsal valve strongly inflated, highest at front; dorsal fold high, flat-topped at front; dorsal umbo inflated. These specimens are identical to those identified as *Rozmanaria equitans* (Schmidt, 1924) by Weyer (1972, plate 2, figures 3, 4) from contemporaneous strata of the Rhenish Massif and eastern Thuringia. Externally, these four specimens differ notably from Schmidt's species by their aequibiconvex to dorsibiconvex shell, their uniplicate anterior commissure and their straight anterior margin (not excavated by the ventral sulcus) whereas it is markedly excavated by a deep dorsal sulcus in *R. equitans*. The lack of data related to their internal morphology precludes a generic identification. They are tentatively included within the family Rozmanariidae on the basis of their external similarity with representatives of this family, which is particularly well-developed in the course of the Famennian.

Occurrence. Gleitsch Formation, Breternitz Member (do VI) (Figure 4). Weyer's (1972) specimens are from the *Wocklumeria*-"Stufe" of the Rhenish

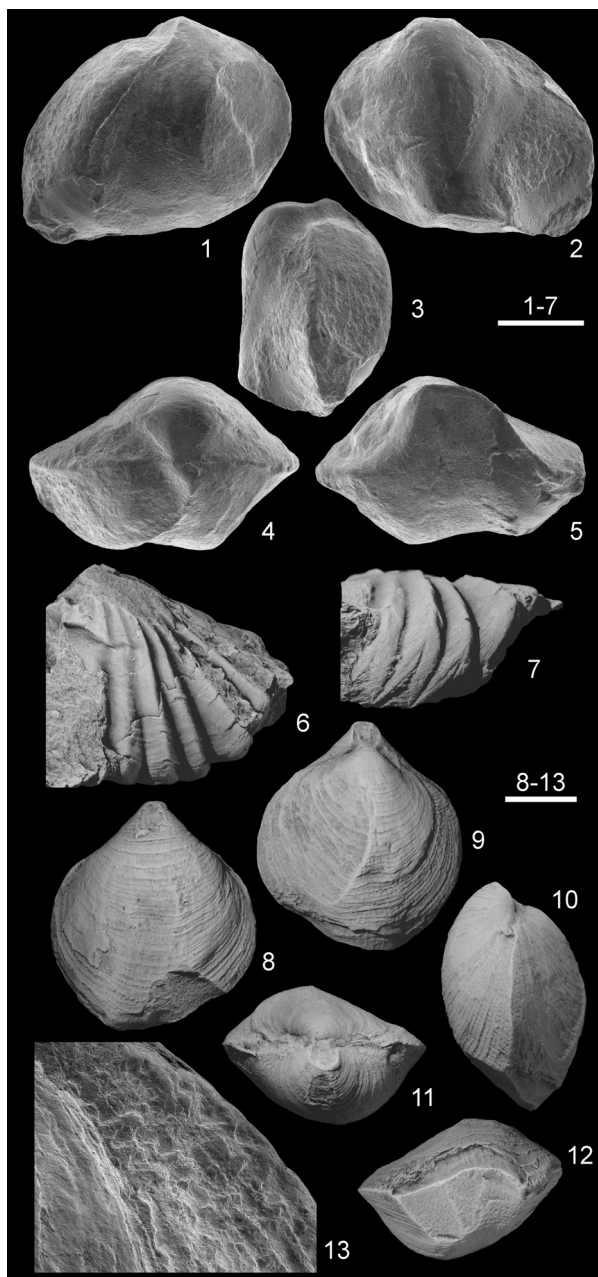


FIGURE 15. 1-5, *Rozmanariid?* gen. et sp. indet. from the Breternitz Member (do VI) distorted articulated specimen (MB.B.9869) in ventral, dorsal, lateral, posterior and anterior views (Reschwitz–Mühlfelsen–South, bed 26.3–5). 6-7, *Allorhynchus?* sp. from Pfaffenberg Member, incomplete and distorted ventral valve (MB.B.9870) in ventral and anterior views, (Pfaffenberg–SW, bed 5 α). 8-13, *Cleiothyridina* sp. indet. from the Breternitz Member, articulated specimen (MB.B.9871) in ventral, dorsal, lateral, posterior and anterior views and close-up of the flat spines (Obernitz–Vorderbohlen, bed 21.1-12, do VI). Scale bars: 1-5 (2 mm), 6-7 (4 mm), 8-12 (5 mm), 13 (1 mm). All SEM, except 6-12.

Massif (Hönnetal railway cut section Oberrödinghausen) and eastern Thuringia (Geipel quarry in Schleiz).

Superfamily Wellerelloidea Licharew (in Rzhonsnitskaya, 1956)

Family Allorhynchidae Cooper and Grant, 1976
Genus ALLORHYNCHUS Weller, 1910

Type species. *Rhynchonella heteropsis* Winchell, 1865; from the Prospect Hill Sandstone (Kinderhookian), Burlington, Iowa, USA.

Allorhynchus? sp. indet.
Figure 5, Figure 15.6-7

Material. Pfaffenberg–SW (bed 5α): one incomplete, distorted and partly decorticated ventral valve.

Remarks. This small-sized (ca. 14 mm in width) ventral valve is characterized by strong, angular costae originating from the beak (three in the sulcus; more than three on the right flank), a well-defined, wide, and shallow sulcus at front, and a relatively low tongue. Although its internal morphology is unknown, its external features suggest a tentative assignment to the long-ranging Weller's genus, which is first recorded at the base of the Kinderhookian (Carter, 1990), rather than to *Pleuropugnoides* Ferguson, 1966 on the basis of its low tongue and shallow sulcus. In Europe, *Allorhynchus* was reported in the basal Tournaisian of Bohemia in Czech Republic by Havlíček (1979), but also in the Serpukhovian–Bashkirian in the French central Pyrenees by Martínez Chacón and Delvolvé (1986).

Occurrence. Gleitsch Formation, Pfaffenberg Member (*duplicata* conodont Zone) (Figure 5).

Order ATHYRIDIDA Boucot et al., 1964
Suborder ATHYRIDIDINA Boucot et al., 1964
Superfamily ATHYRIDOIDEA Davidson, 1881
Family ATHYRIDIDAE Davidson, 1881
Subfamily CLEIOTHYRIDININAE Alvarez et al., 1998
Genus CLEIOTHYRIDINA Buckman, 1906

Type species. *Atrypa pectinifera* J. de C. Sowerby, 1840; from the Upper Permian (lower Zechstein, middle Wuchiapingian) of Humbleton Hill, County Durham, England.

Cleiothyridina sp. indet.
Figure 4, Figure 15.8-13

Material. Oberritz–Vorderbohlen (bed 21.1-12): one articulated specimen.

Remarks. This elongate specimen with a slightly uniplicate anterior commissure is covered by densely crowded growth lamellae that projects as

flat spines anteriorly and anterolaterally. These external features are suggestive of *Cleiothyridina* rather than *Crinisarina* Cooper and Dutro, 1982 which is more strongly uniplicate and pentagonal in outline. Although markedly smaller, this specimen might be related to the elongate specimens identified as *Cleiothyridina struniensis* (Dehée, 1929) by Halamski and Baliński (2009) from the most probably uppermost Famennian of the South Polish shelf [see also discussion in Mottequin and Brice (2016) about the generic assignment of Dehée's species].

Occurrence. Gleitsch Formation, Breternitz Member (lower *Wocklumeria*-“Stufe”) (Figure 4).

Cleiothyridina pfaffenbergensis sp. nov.
Figure 5, Figure 16, Figure 17

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Etymology. In reference to the type locality of the species (Pfaffenberg, southeast of Saalfeld).

Holotype. An articulated specimen (MB.B.9875) (Figure 16.19-23), from the locality Pfaffenberg–NE (bed 1, nodule layer) (Figures 2.1, 4).

Additional material. Pfaffenberg–NE (beds 1, 2, 7, 9α): 13 articulated specimens and one ventral valve; Pfaffenberg–SW (beds 1-4, 5δ, 6α): 14 articulated specimens, 18 ventral and one dorsal valves; Kahlleite-quarry-E-I (bed 3): one articulated specimen; Kahlleite-quarry-E-II: one articulated specimen.

Type locality. Pfaffenberg–NE (Figure 2.1).

Type stratum. Gleitsch Formation, Pfaffenberg Member (Tournaisian, Hastarian), *Acutimitoceras prorsum* Zone = *Protognathodus kockeli* Zone (former Upper *Siphonodella praesulcata* Zone) (Figures 3, 5).

Diagnosis. Shell small-sized (up to 7.4 mm in width), ovate in outline, longer than wide, widest slightly posteriorly to mid-length, dorsibiconvex to ventribiconvex; anterior margin straight to poorly emarginate; anterior commissure rectimarginate to slightly undulose (dorsally directed); sulcus shallow, poorly delimited, only perceptible close to the anterior margin; fold undeveloped; growth lamellae densely crowded (6 per 1 mm).

Description. Shell small-sized (up to 7.4 mm in width), ovate in outline, longer than wide, widest slightly posteriorly to mid-length, dorsibiconvex to ventribiconvex; anterior margin straight to poorly emarginate; anterior commissure rectimarginate to slightly undulose (dorsally directed). Ventral valve regularly convex in posterior and lateral profile views, with flanks slopping gently to moderately towards lateral commissures; beak erect to incurved, truncated by large, permesothyrid foramen; palintropes small, concave; sulcus shallow,

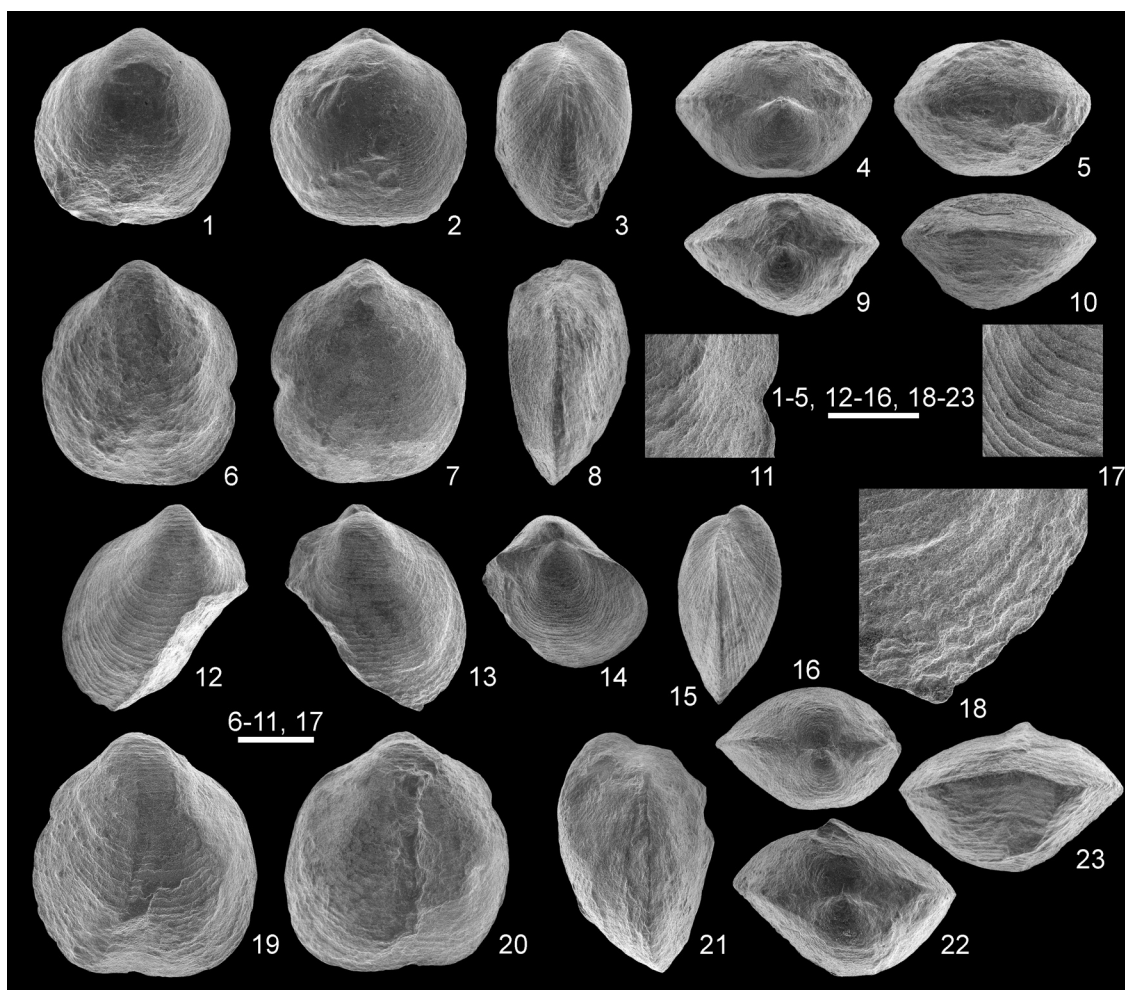


FIGURE 16. *Cleiothyridina pfaffenbergensis* sp. nov. from the Pfaffenberg Member (Pfaffenberg–NE and SW). **1-5**, articulated specimen (MB.B.9872) in ventral, dorsal, lateral, posterior and anterior views (bed 3 SW). **6-11**, articulated specimen (MB.B.9873) in ventral, dorsal, lateral, posterior and anterior views, and detail of predation trace on ventral valve (bed 1 NE, nodules). **12-18**, incomplete articulate specimen (MB.B.9874) in ventral, dorsal, oblique dorsal, lateral and posterior views, and details of growth lamellae in ventral valve and on dorsal valve with spinous projections (bed 1 NE, nodules). **19-23**, articulated specimen (holotype, MB.B.9875) in ventral, dorsal, lateral, posterior and anterior views, (bed 1 NE, nodules). Scale bars: 1-5 and 6-10 (2 mm), 11 and 17 (1 mm), 12-16 and 19-23 (3 mm), and 18 (800 μ m). All SEM.

poorly delimited, only perceptible close to the anterior margin; if developed, tongue corresponding to a vague dorsally directed undulation not perpendicular to commissural plane. Dorsal valve regularly convex in posterior and lateral profile views, highest near mid-valve, then decreasing near anterior margin; fold undeveloped.

Ornamentation of densely crowded growth lamellae (6 per 1 mm in the central part of the shell), projecting anteriorly and anterolaterally as flat, solid spines (rarely preserved) (Figure 16.12-18).

Ventral interior (Figure 17) with thin, short and vertical dental plates supporting small and subrectangular teeth in transverse section; central apical cavity wide; lateral apical cavities strongly filled in by callus. Dorsal interior (Figure 17) with almost flat cardinal plate (not possible to differentiate inner and outer hinge plates); dental sockets deep; only some fragments of spiral cones observed.

Remarks. *Cleiothyridina pfaffenbergensis* sp. nov. is slightly smaller than two relatively similar Carboniferous North American species, namely *C. tenuilineata* (Rowley, 1900) (see Carter, 1967,

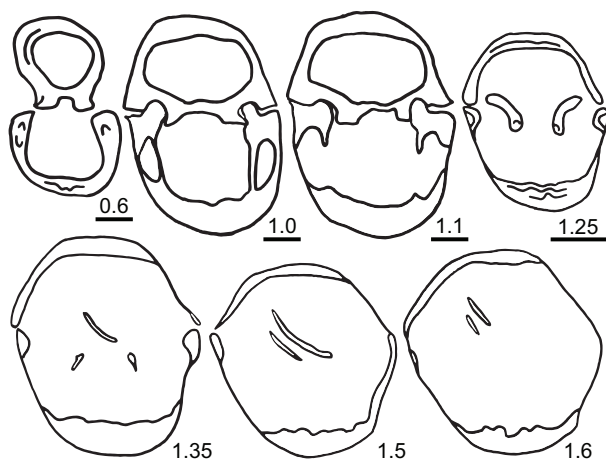


FIGURE 17. Transverse serial sections of *Cleiothyridina pfaffenbergensis* sp. nov. from the Pfaffenberg Member (Pfaffenberg–SW, bed 1, nodules) (MB.B.9876). Numbers refer to distances in mm from the tip of the ventral umbo. Scale bars: 1 mm for all, except sections 0.6, 1.0, and 1.1 (500 μ m).

1987) and *C. hirsuta* (Hall, 1858), notably on the basis of the rectimarginate or vaguely undulose anterior commissure, and thus the poor development of sulcus. However, the German species is clearly longer than wide and has thus a different outline.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*kockeli-sandbergi* conodont zones) (Figure 5). A poorly preserved and slightly larger specimen from the Buschteich quarry (Göschitz Formation, Löhma Member) might be assigned to this species.

Subfamily SPIRIGERELLINAE Grunt, 1965
Genus COMPOSITA Brown, 1845

Type species. *Spirifer ambiguus* Sowerby, 1822 in 1821–1822; from the Visean of Derbyshire, England.

Composita? sp. indet.

Figure 3, Figure 4, Figure 18

Material. Pfaffenberg–NE (beds 3, 8 α , 8 β): six articulated specimens; Pfaffenberg–SW (beds 3, 4, 5 α , 5 β , 5 δ): ten articulated specimens and two ventral valves.

Description. Shell small-sized (up to 4.8 mm in width); slightly wider than long to longer than wide, widest at about midlength or slightly anteriorly to it; aequibiconvex to ventribiconvex, ovate in outline; anterior margin rounded; anterior commissure rectimarginate; impunctate shell.

Ventral valve regularly convex in posterior and lateral profiles, with flanks sloping moderately

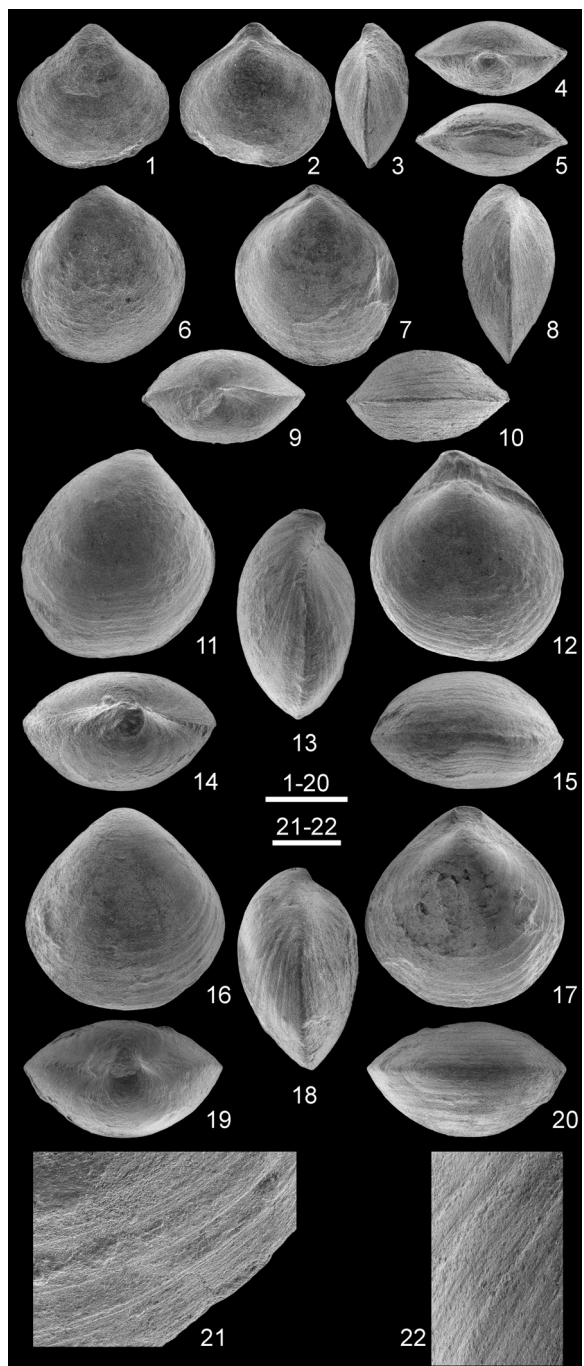


FIGURE 18. *Composita?* sp. indet. from the Pfaffenberg Member (Pfaffenberg–SW). **1-5**, articulated specimen (MB.B.9877) in ventral, dorsal, lateral, posterior and anterior views (bed 3). **6-10**, articulated specimen (MB.B.9878) in ventral, dorsal, lateral, posterior and anterior views (bed 3). **11-15**, articulated specimen (MB.B.9879) in ventral, dorsal, lateral, posterior and anterior views (bed 5 δ). **16-22**, articulated specimen (MB.B.9880) in ventral, dorsal, lateral, posterior and anterior views, and detail of the concentric ornamentation (bed 3). Scale bars: 1-20 (2 mm), 21-22 (400 μ m). All SEM.

towards lateral commissures; umbo not or poorly individualized; beak erect to slightly incurved; foramen poorly preserved for precise description; no sulcus. Dorsal valve regularly convex in posterior and lateral profile, highest at mid-valve or posteriorly to it, then decreasing towards anterior commissure; no fold.

Ornamentation of irregularly spaced growth varices and growth microlines.

Transverse serial sections in one specimen revealed the presence of dental plates in ventral valve, but its dorsal interior was not preserved.

Remarks. The identification of this poorly preserved material is only tentative. External analogies can be made with small-sized, but larger *Composita* species from the Carboniferous of North America (e.g., Weller, 1914; Carter, 1987), but further material is needed to reach a better identification.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*sulcata*–*sandbergi* conodont zones) (Figure 5).

Order SPIRIFERIDA Waagen, 1883

Spiriferide gen. et sp. indet.

Figure 4, Figure 19.1-3

Material. Fischersdorf–West (bed 32.5): one incomplete, distorted ventral valve.

Remarks. It is one of the very rare spiriferides recovered from the uppermost Famennian strata of the Saalfeld area. The flanks of this minute and impunctate ventral valve are covered by at least five (exact number unknown due to poor preservation) wide, simple and round-topped ribs. The sinus is very shallow and smooth. Numerous capillae are present. This very limited material is currently impossible to identify at the generic level.

Occurrence. Gleitsch Formation, Breternitz Member (*Wocklumeria sphaeroides* ammonoid Zone) (Figure 4).

Suborder SPIRIFERIDINA Waagen, 1883

Superfamily AMBOCOELIOIDEA George, 1931

Family AMBOCOELIIDAE George, 1931

Subfamily AMBOCOELIINAE George, 1931

Genus CRURITHYRIS George, 1931

Type species. *Spirifer urei* Fleming, 1828; from the Viséan of Strathaven, Lanarkshire, Scotland.

Crurithyris sp. indet.

Figure 5, Figure 19.4-17

Material. Pfaffenberg–NE (beds 1, 4, 6 α , 7, 8 β): six articulated specimens, 11 ventral valves; Pfaffenberg–SW (beds 2-4, 5 β , 6 δ): three articulated specimens, 11 ventral valves and two dorsal

valves; Fischersdorf–West (bed 3): one ventral valve.

Description. Shell small-sized (up to 4.6 mm in width), wider than long, widest at mid-length, markedly ventribiconvex; hinge line narrower than greatest width; anterior margin straight; anterior commissure rectimarginate. Ventral valve regularly convex in posterior and lateral profile views, with flanks sloping moderately towards lateral commissures; umbo strongly prominent; beak curved; interarea high, catacline at the base then becoming apsacline, concave; delthyrium bordered by narrow deltidial plates; median sulcus poorly developed. Dorsal valve highest in the posterior third part of the valve, then decreasing anteriorly; interarea rectilinear, anacline, flat.

Shell is smooth with some growth lines and numerous, concentrically arranged spine bases.

Ventral interior (Figure 19.14-15) with muscle scars (narrow diductor muscle scars) separated medially by a long myophragm. Dorsal interior is unknown.

Remarks. These specimens indubitably belong to *Crurithyris* on the basis of their external (e.g., shell strongly ventribiconvex, spinous microornament) and internal (e.g., absence of dental plates) morphology. From the specific assignment viewpoint, the relatively poor preservation of the Thuringian specimens precludes a confident identification. As recently stressed by Mottequin et al. (2015b) and Mottequin and Simon (2017), Tournaisian and Viséan *Crurithyris* species from Western Europe need to be revised, notably those described and/or discussed by George (1931).

Occurrence. Gleitsch Formation, Pfaffenberg Member (*sulcata*–*sandbergi* conodont zones) (Figure 5).

Crurithyris? sp. indet.

Figure 4, Figure 19.18-22

Material. Obternitz–Bornleite–North (bed 21.1-22.12): one articulated specimen.

Remarks. This identification is made for a tiny, smooth and markedly ventribiconvex ambocoeliid with a subcircular outline and a strong ventral umbo. Its ventral valve bears a shallow sulcus originating close to the tip of the umbo. The external morphology suggests a tentative assignment to *Crurithyris* in the absence of knowledge of its internal morphology. Consequently, it is not currently possible to demonstrate that the specimens identified as *Crurithyris* sp. indet. from the Pfaffenberg Member and this single one from the Breternitz Member are conspecific. Further material from Breternitz Member is thus required to solve this issue.

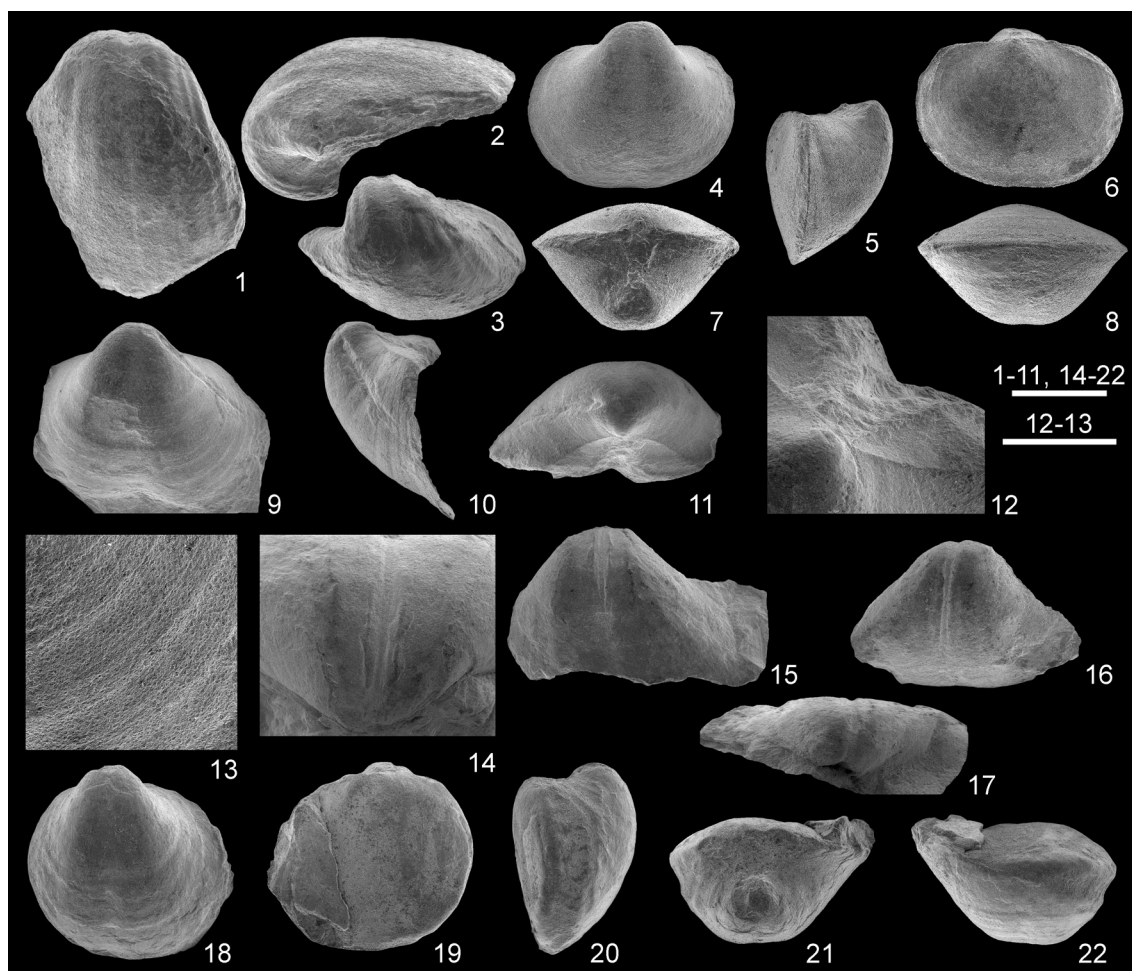


FIGURE 19. 1-3, *Spiriferide* gen. et sp. indet. from the Breternitz Member (Fischersdorf–West, bed 32.5, upper do VI), incomplete and distorted ventral valve (MB.B.9881) in ventral, lateral and posterior views. 4-17, *Crurithyris* sp. indet. from the Pfaffenberg Member (Pfaffenberg–NE and SW). 4-8, articulated specimen (MB.B.9882) in ventral, lateral, dorsal, posterior and anterior views (bed 4 NE). 9-13, almost complete ventral valve (MB.B.9883) in ventral, lateral and posterior views, detail of the interarea showing the narrow deltidial plates, and close-up of the microornament on the right flank (bed 4 NE). 14-15, incomplete ventral interior (MB.B.9884), detail of the muscle field and ventral view (bed 4SW). 16-17, incomplete ventral interior (MB.B.9885) in ventral and posterior views (bed 5 β SW). 18-22, *Crurithyris?* sp. indet. from the Breternitz Member (do VI) (Obernitz–Bornleite–North, bed 21.1–22.12), slightly distorted, articulated specimen (MB.B.9886) in ventral, dorsal, lateral, posterior and anterior views. Scale bars: 1-11, 15, and 18-22 (2 mm), 12, 14 and 16-17 (1 mm), 13 (600 μ m). All SEM.

Occurrence. Gleitsch Formation, Breternitz Member (do VI) (Figure 4).

Superfamily MARTINIOIDEA Waagen, 1883
Family CRASSUMBIDAE Carter (in Carter and Gourvennec, 2006)
Genus CRASSUMBO Carter, 1967

Type species. *Crassumbo inornatus* Carter, 1967; from the Chappel Limestone (Kinderhookian), McCulloch County, Central Texas, USA.

Crassumbo germanicus sp. nov.
Figure 5, Figure 20, Figure 21, Figure 22, Table 4

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- | | | |
|------|-----------------------|---|
| 1848 | <i>Delthyris</i> sp.; | Richter, p. 45, plate 6, figure 210. |
| ? | 1954 | <i>Spirifer (Martinia) cf. globosa</i> ; Pfeiffer, p. 69. |
| v | 1979 | <i>Crassumbo?</i> n. sp.; Weyer, p. 100. |
| v | 1986 | <i>Crassumbo?</i> n. sp.; Bartzsch and Weyer, plate 1 (right column), figure 3. |
| v | 2015 | <i>Martinia?</i> nov. sp.; Bartzsch et al., figure 14.3 (Brachiopoda) (copy of Bartzsch and Weyer, 1986). |

Etymology. From *Germanicus*, *a*, *um* (Latin): Germanic.

Holotype. An articulated specimen (MB.B.9891) (Figure 20.21-25) from the locality Pfaffenberg–SW (bed 4) (Figure 2.1, Figure 5).

Additional material. Pfaffenberg–NE (beds 1, 3, 4, 5 α - γ , 6 δ , 10 α): 34 articulated specimens, 24 ventral and five dorsal views, and 12 ventral and four dorsal interiors; Pfaffenberg–SW (beds 1-5 γ , 6 α , 6 δ): 53 articulated specimens, 57 ventral and 13 dorsal valves, and 59 ventral and 36 dorsal interiors. Kahlleite quarry–E–II (beds 3, 4): one articulated specimen and one ventral valve.

Type locality. Pfaffenberg–NE (Figure 2.1).

Type stratum. Gleitsch Formation, Pfaffenberg Member (Tournaisian, Hastarian) (Figures 3, 5).

Diagnosis. A small species of *Crassumbo* (up to 15.3 mm in width) wider than long, widest at mid-length, ventribiconvex, subquadrate to transversally ovate in outline. Sulcus poorly defined, very shallow, flat to round-bottomed at front. Fold absent or only visible close to anterior margin in some adult specimens. Shell devoid of ribbing, but with numerous irregularly spaced growth lamellae bearing ca. 19 capillae per mm.

Description. Shell small-sized (up to 15.3 mm in width), wider than long, widest at mid-length, markedly ventribiconvex, subquadrate to transversally ovate in outline; hinge line narrower than maximal width; cardinal margins rounded; anterior margin straight; anterior commissure uniplicate. Ventral valve with flanks sloping moderately towards lateral commissures; umbo prominent; beak curved; interarea catacline at its base then becoming apsacline, concave, high; delthyrium large, bordered by prominent deltidial plates; sulcus large, inconspicuously originating in the umbonal area, poorly delimited, very shallow, flat to round-bottomed at front; tongue subtrapezoidal to semi-elliptic in outline, relatively low, almost perpendicular to commissural plane in adults. Dorsal valve highest at mid-valve or posteriorly to it, then progressively decreasing towards anterior margin; umbo small; interarea rectilinear, anacline, flat; fold absent or very low, only perceptible close to anterior margin in some adult specimens, round-topped at front.

Ornamentation of some irregularly spaced growth lamellae; microornament of numerous capillae (ca. 19 per mm) (Figure 20.27).

Ventral valve interior (Figures 20.28-29, 21) with relatively long, intrasinal and divergent dental plates (21–43 degrees, $n = 7$), converging dorsally in umbonal region (as seen in transverse section), but becoming much less convergent to almost par-

allel more anteriorly; teeth small; muscle field poorly impressed in valve floor. Dorsal valve interior (Figures 20.30-35, 21) with unsupported ctenophoridium (number of lamellae unknown); dental sockets small; dorsal adminicula connecting the crural bases to the valve floor (Figure 20.30-31) well-developed (Figure 20.30-32) or obscured by callus deposits (Figure 21); crural bases dorsally convergent; adductor scars impressed, separated by a thin myophragm; vascula media canals well-developed; spiralia laterally directed, with four whorls.

Measurements. See Figure 22 and Table 4.

Remarks. The morphological characters of the Thuringian species fit well with the diagnosis of *Crassumbo*, except the absence of scattered nodes developed on the capillae. This genus was firstly reported in the top of the Kinderhookian succession of Texas (Carter 1967, 1990). *Crassumbo germanicus* sp. nov. differs from the Texan species *C. inornatus* Carter, 1967 by its smaller size, its proportionately higher ventral interarea and the absence of strong callosities in ventral and dorsal valves which obscure the cardinalia in the latter. The German species is distinguished from *Crassumbo turgidus* Carter, 1967, also from Texas, by its less developed fold and sulcus and its dorsal valve clearly shorter than the ventral one. *Crassumbo germanicus* sp. nov. is markedly smaller than the eastern Australian species *C. gresfordensis* Qian and Roberts, 1995. Moreover, the former is devoid of ribs and has a less developed sulcus. *Crassumbo germanicus* sp. nov. cannot be confused with *C.? jonesi* Roberts, 1971 from northwestern Australia notably due to its lack of ribbing, its markedly lower tongue and its clearly less inflated dorsal valve.

Occurrence. Gleitsch Formation, Pfaffenberg Member (*kockeli*–*quadruplicata* conodont zones) (Figure 5).

Suborder DELTHYRIDINA Ivanova, 1972
Superfamily DELTHYRIDOIDEA Phillips, 1841
Family MUCROSPIRIFERIDAE Boucot, 1959
Subfamily TYLOTHYRIDINAE Carter, 1972
Genus TEXATHYRIS Carter, 1972

Type species. *Texathyris elegantula* Carter, 1972; from the Chappel Limestone (Kinderhookian), San Saba County, central Texas, USA.

Texathyris? tarpata (Schmidt, 1924)
Figure 5, Figure 23, Figure 24

v* 1924 *Spiriferina tarpata* n. sp. Schmidt, p. 158, plate 8, figures 34-36.

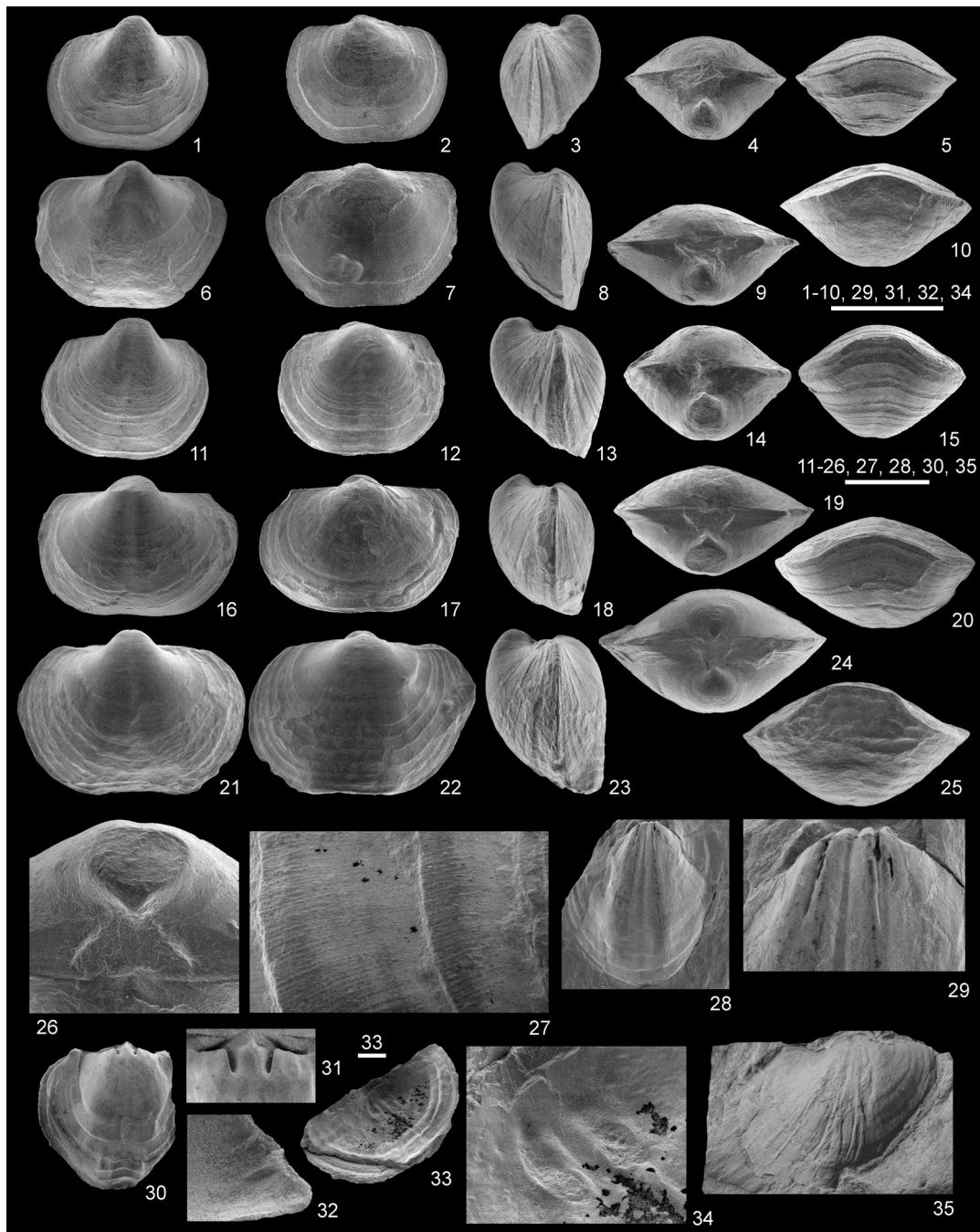


FIGURE 20. *Crassumbo germanicus* sp. nov. from the Pfaffenberg Member (Pfaffenberg–NE and SW). **1-5**, slightly distorted articulated specimen (MB.B.9887) in ventral, dorsal, lateral, posterior and anterior views (bed 5 α SW). **6-10**, almost complete specimen (MB.B.9888) in ventral, dorsal, lateral, posterior and anterior views (bed 5 γ NE). **11-15**, articulated specimen (MB.B.9889) in ventral, dorsal, lateral, posterior and anterior views (bed 3SW). **16-20, 26**, articulated specimen (MB.B.9890) in ventral, dorsal, lateral, posterior and anterior views and detail of the delthyrium bordered by narrow deltidial plates (bed 4 SW). **21-25**, articulated specimen (holotype, MB.B.9891) in ventral, dorsal, lateral, posterior and anterior views (bed 4SW). **26**, Close-up of the growth lamellae and capillae on ventral valve of an articulated specimen (MB.B.9892) (bed 5 α SW). **27**, Close-up of the growth lamellae and capillae on ventral valve of an articulated specimen (MB.B.9892) (bed 5 α SW). **28-29**, incomplete ventral internal mould specimen (MB.B.9893) and detail of the muscle field and dental plates (bed 4SW). **30-32**, incomplete dorsal internal mould specimen (MB.B.9894) in dorsal view, detail of the posterior region, lateral oblique view of the latter (bed 3 SW). **33-34**, incomplete dorsal interior (MB.B.9895) in lateral oblique view and detail of the muscle field (bed 4 SW). **35**, incomplete dorsal mould (MB.B.9896) with well-preserved vascular canals (bed 4 SW). Scale bars: 1-10, 11-25, 28, 30, and 35 (5 mm), 26, 29, 33, 31, 32 and 34 (2 mm), 27 (1 mm). All SEM, except 35.

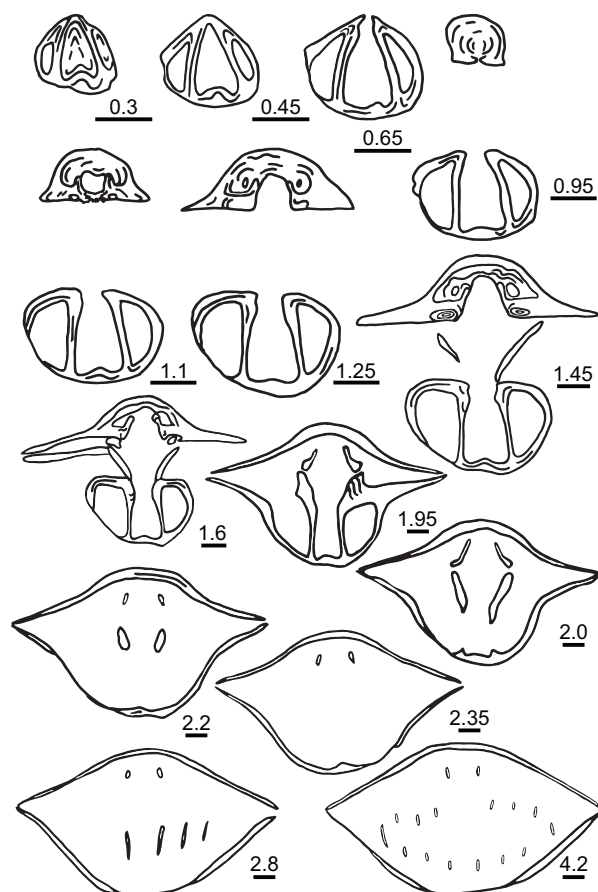


FIGURE 21. Transverse serial sections of *Crassumbo germanicus* sp. nov. from the Pfaffenberg Member (Pfaffenberg–SW, bed 5 β) (MB.B.9897). Numbers refer to distances in mm from the tip of the ventral umbo. Scale bars: 1 mm.

1996 “*Spiriferina*” *tarpatata* Schmidt; Becker, p. 25, plate 3, figures 15–19.

Types. The type material is from Stockum (*Acutimitoceras prorsum* ammonoid Zone and *Protognathodus kockeli* conodont Zone) in Sauerland, Rhenish Slate Mountains. The ventral valve BGR-X5732 (Figure 23.1–4), illustrated by Schmidt (1924, plate 8, figure 35), is selected here as the lectotype whereas the dorsal valve BGR-X5731 (Schmidt, 1924, plate 8, figure 34; Figure 23.11–15) is a paralectotype as is the case of a second smaller ventral valve (associated to BGR-X5731; Figure 23.5–10) and of a second incomplete dorsal valve (associated to BGR-X5732; Figure 23.16–20).

Material. Pfaffenberg–NE (beds 1–3, 6 δ , 7, 8 α): seven articulated specimens, seven ventral and eight dorsal valves, four dorsal moulds; Pfaffenberg–SW (beds 1–3, 5 α , 5 γ , 6 α , 6 β , 6 δ): seven articulated specimens, five ventral and six dorsal

valves, two ventral and five dorsal internal moulds; Fischersdorf–Gositzfelsen (bed 1): one articulated specimen and one dorsal valve; Fischersdorf–East (bed 7): one dorsal valve.

Description. Shell small-sized (up to ca. 14 mm in width), wider than long, widest at mid-length, biconvex, rounded trapezoidal in outline; hinge line narrower than maximum width; cardinal margins rounded; anterior margin straight; anterior commissure uniplicate. Ventral valve regularly convex in posterior and lateral profile views, with flanks sloping moderately towards lateral commissures; beak strongly curved; interarea low, catacline at its base, then becoming apsacline, concave; delthyrium unobserved (cancelled by sediment); sulcus originating at umbo, well-defined, wide, shallow, flat-bottomed at front; tongue almost perpendicular or perpendicular to commissural plane, high, rounded in outline. Dorsal valve highest at mid-valve or anteriorly to it, then decreasing towards anterior margin; fold originating at front, well-defined by two grooves, round- to flat-topped at front leaving aside the median groove occurring in some specimens; interarea rectilinear, anacline, flat.

Flanks covered by at least seven rounded (poorly preserved!) and simple ribs separated by similar grooves, obsolescent near posterolateral margins; fold and sulcus smooth; numerous irregularly spaced concentric lamellae; concentric micro-lines numerous (ca. 10 per 0.5 mm); possible traces of capillae (Figure 23.10, 34).

Ventral interior (Figures 23.8, 24) with short, thickened, vertical and extrasinal dental plates; teeth short, rounded in transverse section; central and lateral apical cavities not filled in by shelly material; median septum moderately long, high. Dorsal interior (Figure 24) with unsupported ctenophoridium (number of lamellae unknown); crural bases dorsally convergent; spiralia not preserved (fragments of whorls observed).

Remarks. As its shell is impunctate, *Spiriferina tarpatata* Schmidt, 1924 cannot be included in a spiriferinide genus. Its general shape, prominent growth lamellae, smooth fold and sulcus and the presence of a strong ventral median septum strongly suggest an assignment to *Texathyris* Carter, 1972, which is only recorded with certainty in the Tournaisian of central Texas. Nonetheless, the absence of strong sulcus-bounding ribs and of fold-bounding ridges makes this generic identification doubtful. Moreover, Carter (1972) did not report the presence of capillae in *Texathyris elegantula* Carter, 1972, but this may be due to preservation bias.

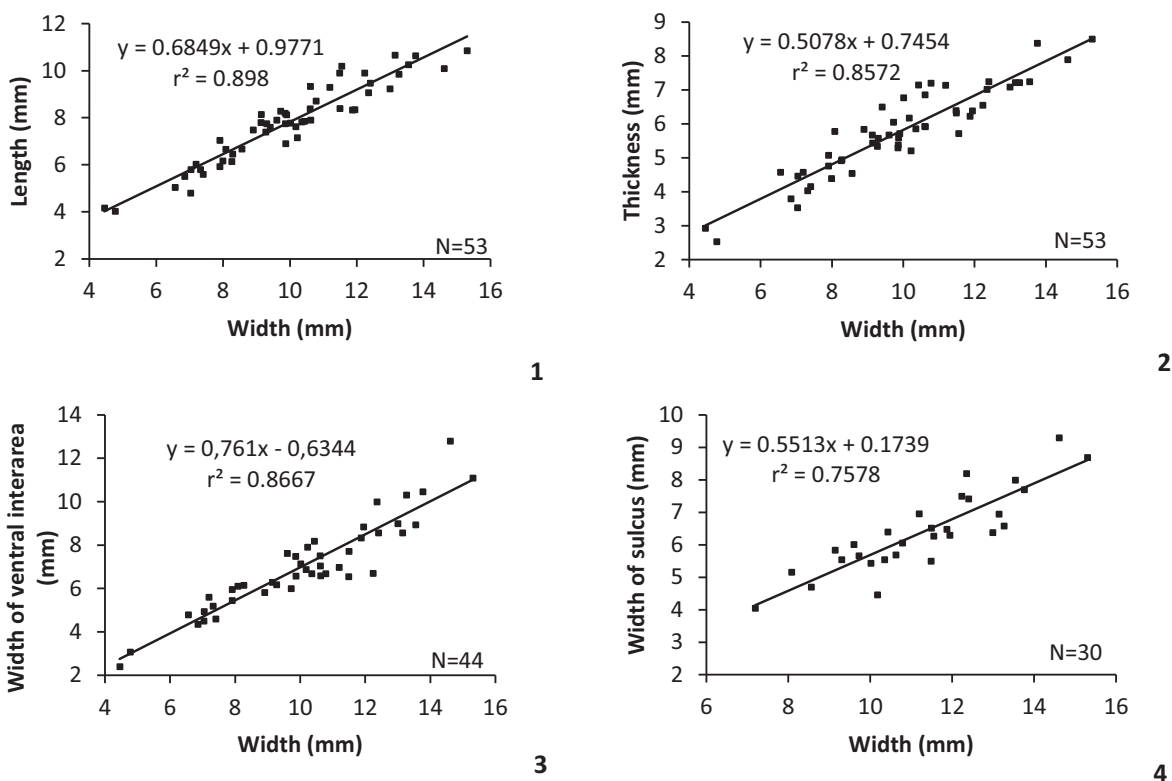


FIGURE 22. Scatter diagrams of *Crassumbo germanicus* sp. nov. Abbreviations: N, number of specimens measured; r^2 : coefficient of linear regression. **1**, Relation between shell width and length. **2**, Relation between shell width and thickness. **3**, Relation between shell width and ventral interarea width. **4**, Relation between shell width and sulcus width.

Contrary to the definition of the subfamily Tylothyridinae (*Tylothyris* North, 1920 and *Texathyris*) by Johnson and Hou (2006), who indicated the absence of radial microornament, it appears that the type species of *Tylothyris*, i.e. *T. laminosa* (M'Coy 1841), displays capillae which are only observed in particularly well-preserved material (Mottequin and Simon 2017). Due to preservation bias, such a microornament was not observed in *T.*

laminosa specimens from its type locality by Brunton (1984), Bassett and Bryant (2006) and Mottequin (2010).

Occurrence. Gleitsch Formation, Pfaffenberg Member (*kockeli-sandbergi* conodont zones) (Figure 5). Schmidt (1924) described his species on the basis of material from the basal Tournaisian of the Rhenish Slate Massif (see above). Péneau (1928) doubtfully assigned material from the upper

TABLE 4. Measurements in mm of *Crassumbo germanicus* sp. nov. Abbreviations: L – length of the shell, T – thickness of the shell, W – width of the shell, Wi – width of the interarea, Ws – width of the sulcus.

	W	L	T	Wi	Ws	L/W	T/W	Wi/W	Ws/W
N	53	53	53	43	30	53	53	43	30
Mean value	9.9	7.8	5.8	7.0	6.3	1.27	0.60	0.69	0.57
Standard deviation	2.3508	1.6991	1.2893	2.0649	1.2388	0.0950	0.0543	0.0708	0.0535
Standard error (\pm)	0.3229	0.2334	0.3229	0.3229	0.2262	0.0130	0.0075	0.0107	0.010
MIN	4.5	4.0	2.5	2.4	4.1	1.07	0.50	0.54	0.44
MAX	15.3	10.9	8.5	12.8	9.3	1.46	0.72	0.88	0.66

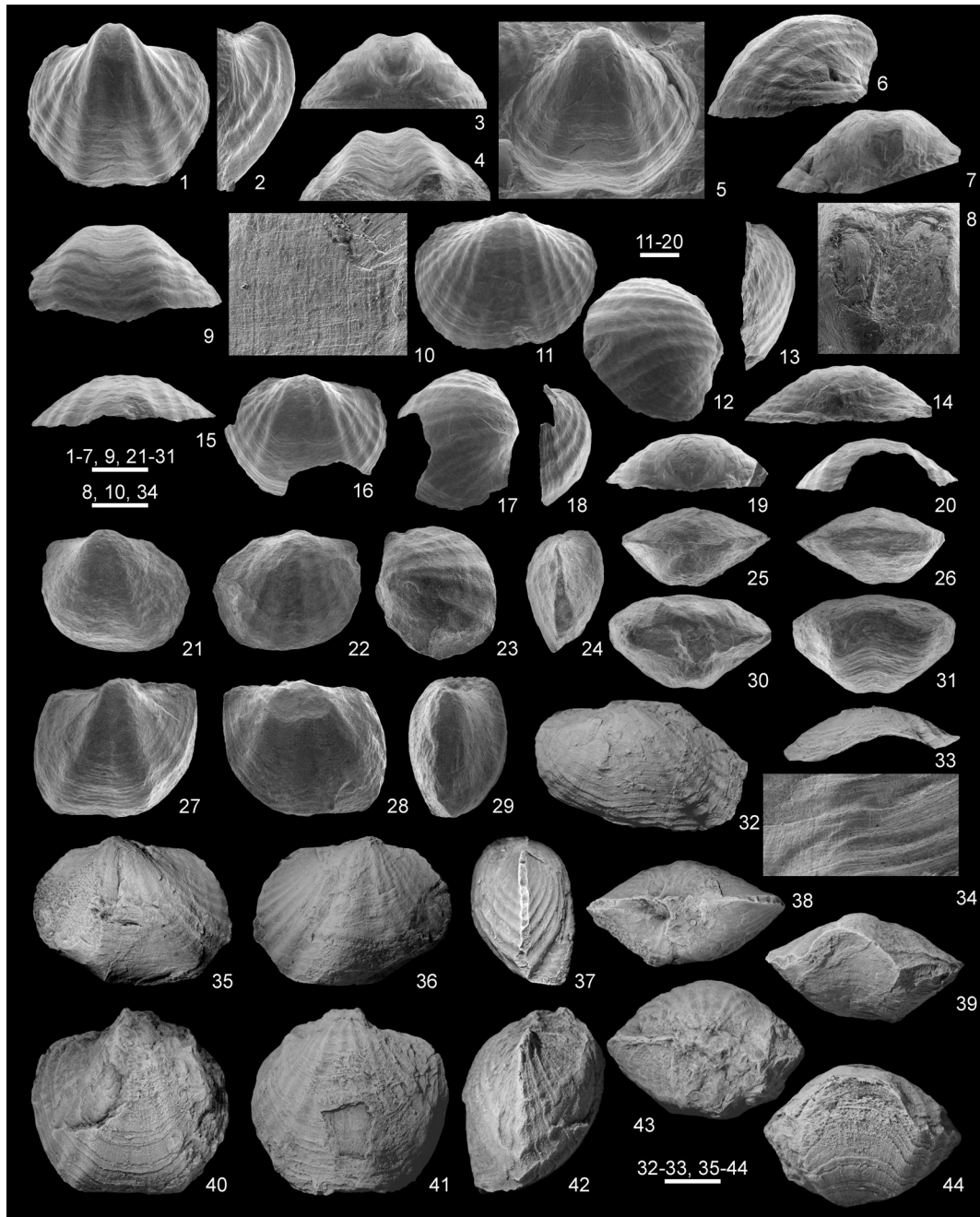


FIGURE 23. *Texathyris? tarpata* (Schmidt, 1924). **1-20**, Rhenish type material from Stockum locality (*Acutimitoceras prorsum* Zone). **1-4**, ventral valve (lectotype, BGR-X5732) in ventral, lateral, posterior and anterior views. **5-10**, ventral valve partly embedded in carbonate matrix (associated to BGR-X5731) in ventral, lateral, posterior and anterior (9) views, close-up of the umbonal region showing the median septum (8), and detail of the capillae in the sulcus (10). **11-15**, almost complete dorsal valve (BGR-X5731) in dorsal, lateral oblique, lateral, posterior and anterior views. **16-20**, incomplete dorsal valve (associated to BGR-X5732) in dorsal, lateral oblique, lateral, posterior and anterior views. **21-26**, Thuringian material from the Pfaffenberg Member (Pfaffenberg-SW). **21-26**, almost complete juvenile specimen (MB.B.9898) in ventral, dorsal, lateral oblique, lateral, posterior and anterior views (bed 2). **27-31**, almost complete juvenile specimen (MB.B.9899) in ventral, dorsal, lateral, posterior and anterior views (bed 3). **32-33**, slightly distorted ventral valve (MB.B.9900) in dorsal and anterior views (bed 3). **34**, detail of the microornament of a distorted ventral valve (MB.B.9901) (bed 2SW). **35-39**, slightly distorted articulated specimen (MB.B.9902) in ventral, dorsal, lateral, posterior and anterior views (bed 1, nodules). **40-44**, almost complete articulated specimen (MB.B.9903) in ventral, dorsal, lateral, posterior and anterior views (bed 1, nodules). Scale bars: 1-7, 9, and 21-31 (2 mm), 11-20 (3.5 mm), 8 (500 µm), 10 (250 µm), 32-33 and 35-44 (4 mm), 34 (1 mm). All SEM, except 32-33, 35-44.

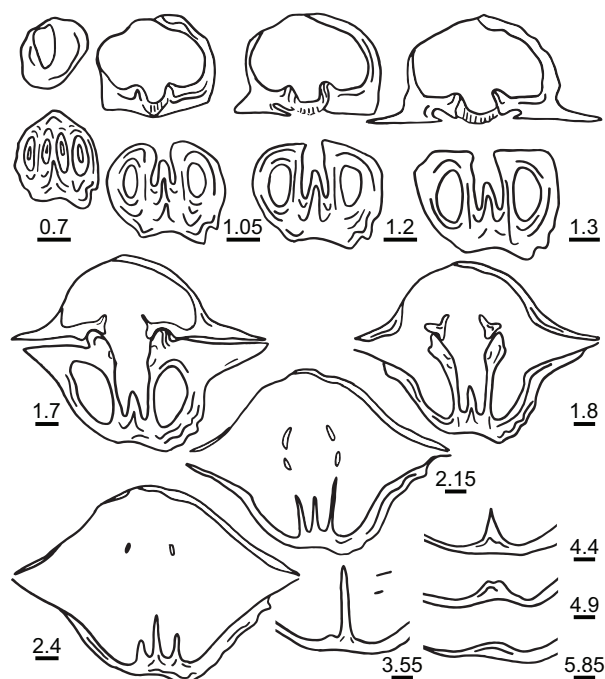


FIGURE 24. Transverse serial sections of *Texathyrus? tarpata* (Schmidt, 1924) from the Pfaffenberg Member (Fischersdorf–Gositzfelsen, bed 1, nodules) (MB.B.9904). Numbers refer to distances in mm from the tip of the ventral umbo. Scale bars: 1 mm.

Famennian *Clymenia* Limestone of the Armorican Massif (western France) to Schmidt's species.

Order TEREBRATULIDA Waagen, 1883

Terebratulide gen. et sp. indet.

Figure 4, Figure 25

Material. Fischersdorf–Gositzfelsen (bed 22.7-12): one almost complete articulated shell.

Remarks. This small, dorsibiconvex, and longer than wide shell is characterized by the following features: widest at mid-length; anterior commissure bisulcate; five rounded ribs on ventral and four on dorsal valves inconspicuously arising in anterior part of each valve; thin microlines present. The broken ventral valve shows dental plates delimiting a large central apical cavity and two small lateral ones (Figure 25.6). The lack of data related to the dorsal morphology precludes a generic and specific identification.

Occurrence. Gleitsch Formation, Breternitz Member (do VI) (Figures 4, 26).

STRATIGRAPHIC SUMMARY

The stratigraphic range of the brachiopods recognized within the Gleitsch Formation (Breter-

nitz and Pfaffenberg members only), which is exposed in several sections southeast of Saalfeld (Thuringia) (Figures 1, 2.1), is summarized in Figure 26. For the detailed distribution, the reader is referred to Figures 4 and 5 as well as to the bed numbers included in the paragraphs devoted to the material available for each species. No brachiopods occur in the Oberrnitz Member (8 m of siltstones and turbiditic quartzites, representing an extremely short time interval, obviously shorter than one ammonoid or conodont biozone of 0.2–0.4 Ma).

As previously stated, brachiopods are particularly scarce in the top Famennian and basal Hastarian succession developed on the northeastern flank of the Berga Anticline (Figures 1-3). Their poor preservation prevents a detailed systematic study. The Kapfenberg Member exposed at the Buschteich quarry yielded "*Lingularia*" sp. indet. (do VI), chonetidine gen. indet. (do V, do VI), productidine gen. indet. (do V), *Rozmanaria?* sp. indet. (do V, do VI) and *Crurithyrus?* sp. (do V). There, the Löhma Member includes *Oehlertella?* sp., *Productina* sp., athyridide? gen. et sp. indet., *Cleiothyridina* cf. *pfaffenbergensis* sp. nov., and *Crurithyrus?* sp. The following species are reported from the Kahlleite quarry (Löhma Member): *Productina saalfeldensis* sp. nov., *Cleiothyridina pfaffenbergensis* sp. nov., and *Crassumbo germanicus* sp. nov.

PALAEOECOLOGY AND TAPHONOMY

The mixed siliciclastic–carbonate Gleitsch Formation (upper Famennian–Tournaisian) corresponds to a basinal facies of entomozoid ostracode shales (Cypridinenschiefer), interrupted by occurrences of regressive siltstone and turbiditic quartzitic sandstone sequences less than 10 m thick, corresponding to the Reschwitz and Oberrnitz members (Weyer, 1979; Bartsch and Weyer, 2012) (Figures 3-5). The shales include numerous early diagenetic nodules whereas the biomicritic limestones correspond to biomicrites with a certain amount of clay (Weyer, 1979). The environment was generally quiet with some periods of agitation and bottom currents, reflected notably by the presence of millimetric silty and sandy layers, crinoidal lenses and accumulations of dissociated valves of posidoniid bivalves (*Guerichia*) and fragments of trilobites (Weyer, 1979). The fauna is diverse and besides the brachiopods described above, it includes numerous pelagic (placoderms, ammonoids, nautiloids, posidoniid bivalves, conodonts, entomozoid ostracods) and benthic (e.g.,

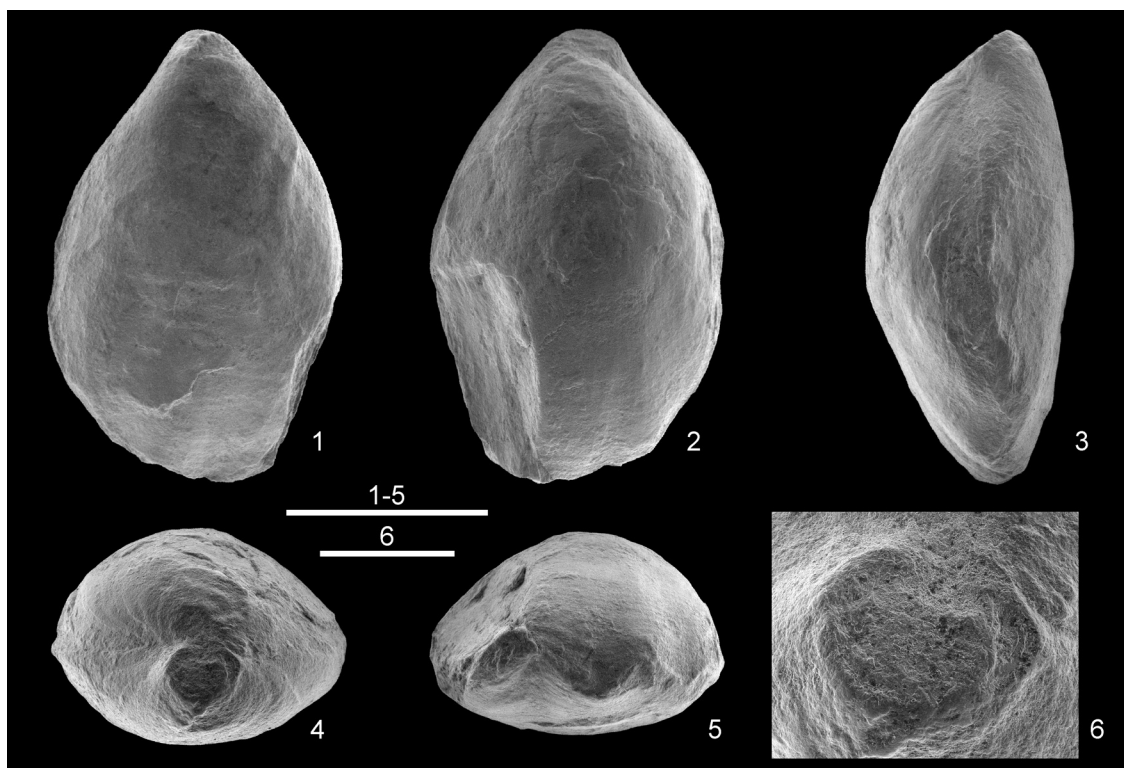


FIGURE 25. Terebratulide gen. et sp. indet. from the Breternitz Member, Fischersdorf–Gositzfelsen (bed 22.7-12, do VI), articulated specimen (MB.B.9905) in ventral, dorsal, lateral, posterior and anterior views and detail of the ventral umbo showing dental plates and apical cavities. Scale bars: 1-5 (5 mm) and 6 (1 mm). All SEM.

crinoids, gastropods, bivalves, solitary rugose corals, tabulate corals, trilobites, psychrospheric ostracods of Thuringian ecotype, bryozoans, foraminifera organisms (see references in Bartzsch et al., 1998; Bartzsch and Weyer, 2012). Deep-water conditions are thus reflected by the cephalopods (clymeniids and goniatites) and blind trilobites (Weyer, 1979). Burrows of ichnofossils, which are normally completely destroyed by compaction of argillaceous sediments, are preserved in the limestone nodules of early diagenetic origin or preserved in shale by pyrite infiltration (e.g., Bartzsch et al., 1998). The summit of the Breternitz Member (beds 27.8–30.9; Figure 4 and Kononova and Weyer, 2013: figure 7b-o) would be characterized by a regression as reflected by the presence of the ostracod genus *Tetrasacculus* according to Blumenstengel's (1994, 1997) interpretation. After the deposition of the Oberritz Member, reflecting a short regressive sequence (Bartzsch and Weyer, 1986; Bartzsch et al., 1999, 2015), the Pfaffenberg Member is interpreted as a deepening-upward sequence that culminated with the Rußschiefer Formation.

Ten brachiopod species occurring within the Breternitz Member have been recorded so far, but this number is slightly underestimated as some poorly preserved specimens remain difficult to identify. Spire-bearing brachiopods (Athyridida, Spiriferida) are very scarce (three specimens!). Small- to medium-sized, poorly ornamented, thin-shelled, and uniplicate or unisulcate rhynchonellides (*Rozmanaria*, *Hadyrhyncha*, *Novaplattrostrum*, rozmanariid? gen. indet.) represent 40% of this assemblage with *Novaplattrostrum* cf. *fibrosissimum* as the predominant species. These rhynchonellides belong to the superfamily Pugnacoidea, of which representatives rank among the most common elements of Devonian–Carboniferous dysaerobic environments (e.g., Bowen et al., 1974; Biernat and Racki, 1986a; Racki, 1989; Alexander, 1994; Sartenaer et al., 1998; Mottequin and Legrand-Blain, 2010; Mottequin et al., 2015a). Palaeobiological implications of the co-occurrence of uniplicate and unisulcate rhynchonellides in Polish contemporaneous succession was discussed by Halamski and Baliński (2009). In contrast with the situation observed in the Breternitz Member, the Tournaisian brachiopod

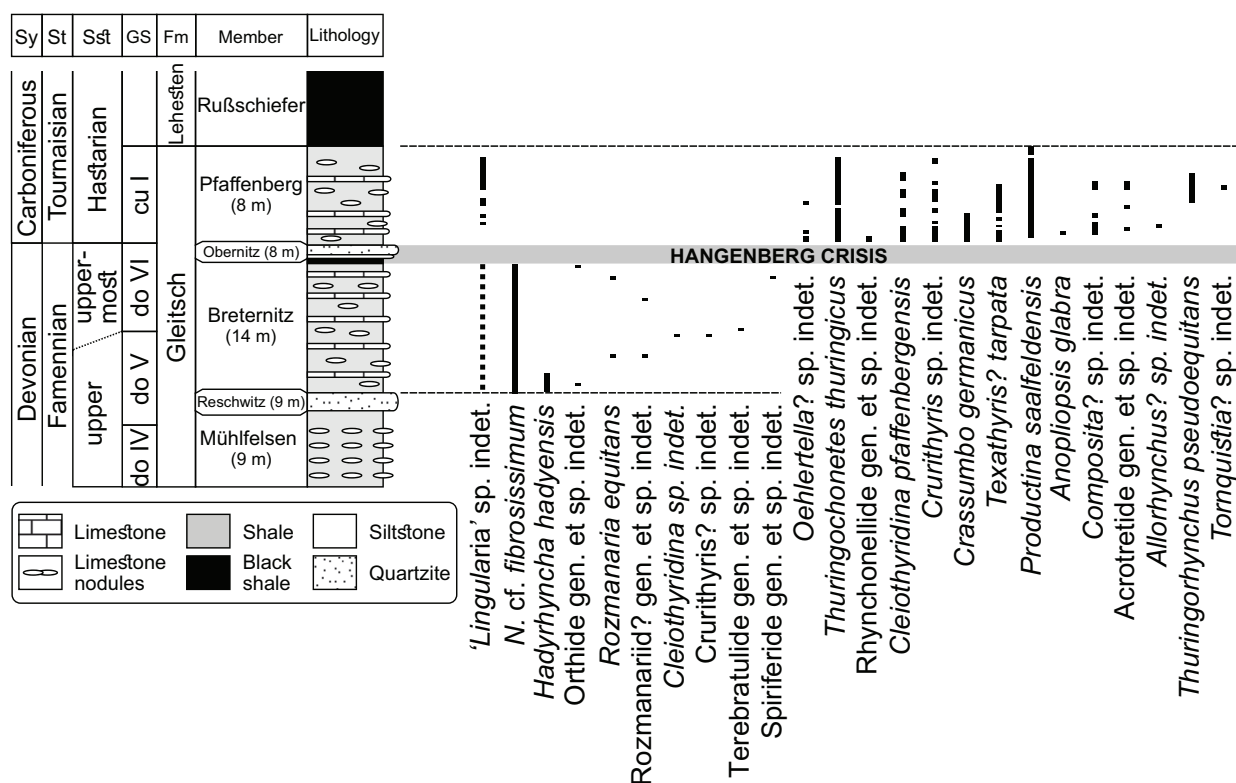


FIGURE 26. Distribution of the brachiopods within the Gleitsch Formation (Breternitz and Pfaffenberg members; modified from Bartzsch et al., 2008) in the Saalfeld area (SE Thuringia), on both sides of the Devonian–Carboniferous boundary. The range of *Anopliopsis glabra* and *Thuringoconetes thuringicus* is based on Afanasjeva (2002). Abbreviations: Fm, formation; GS, German “Stufe”; N., *Novaplatirostrum*; Sst, substage; St, stage; Sy, system.

fauna recognized in the Pfaffenberg Member is more diverse (at least 15 species) and dominated by productides (*Chonetidina* and *Productidina*) and spiriferides, which represent almost 50% of the whole assemblage. In terms of number of specimens, *Productina saalfeldensis* sp. nov. is by far the most common species. Rhynchonellides are clearly less diverse and less abundant here, although the pugnacid *Thuringorhynchus pseudoequitans* gen. et sp. nov. occurs in a relative abundance within the bed 6δ in the locality Pfaffenberg–NE (Figures 2.1, 5). Only *P. saalfeldensis* sp. nov. is still present in the bed 10γ but no suitable outcrops to collect fossils above this bed are available; limestones nodules are nearly absent or strongly weathered. The Rußschiefer Formation (Figure 3) includes black shales (*crenulata* Event) with phosphatic nodules rich in radiolarians, but yields only some rare ammonoids.

Within the Pfaffenberg Member, the degree of articulation of the rhynchonellides and the spire-bearers (*Athyridida*, *Spiriferida*), which all possess strong articulatory processes, is high in compari-

son with the productides which are essentially represented by dissociated valves. No articulated lingulids were recovered; according to Emig (1986), their preservation as single valves reflects the influences of environmental changes (salinity, influx of coarse sedimentary particles, storm) that induced their death and thus the exit from their burrow. Delicate shelly structures, such as the hinge spines in the chonetidines *Thuringoconetes thuringicus* (see Afanasjeva, 2002, plate 4, figures 5-6) and *Tornquistia?* sp. indet. (Figure 7.10), are sometimes preserved. All these observations strongly suggest that the brachiopod assemblage recognized in the Pfaffenberg Member represents an autochthonous one as is also the case for the assemblage recorded in the Breternitz Member where the great majority of the rhynchonellides is articulated.

One of the striking features of the brachiopod faunas recognized in this part of Thuringia is the minute or small size of numerous species. It is especially true for those of the Pfaffenberg Member in which the largest sizes are reached by *Thur-*

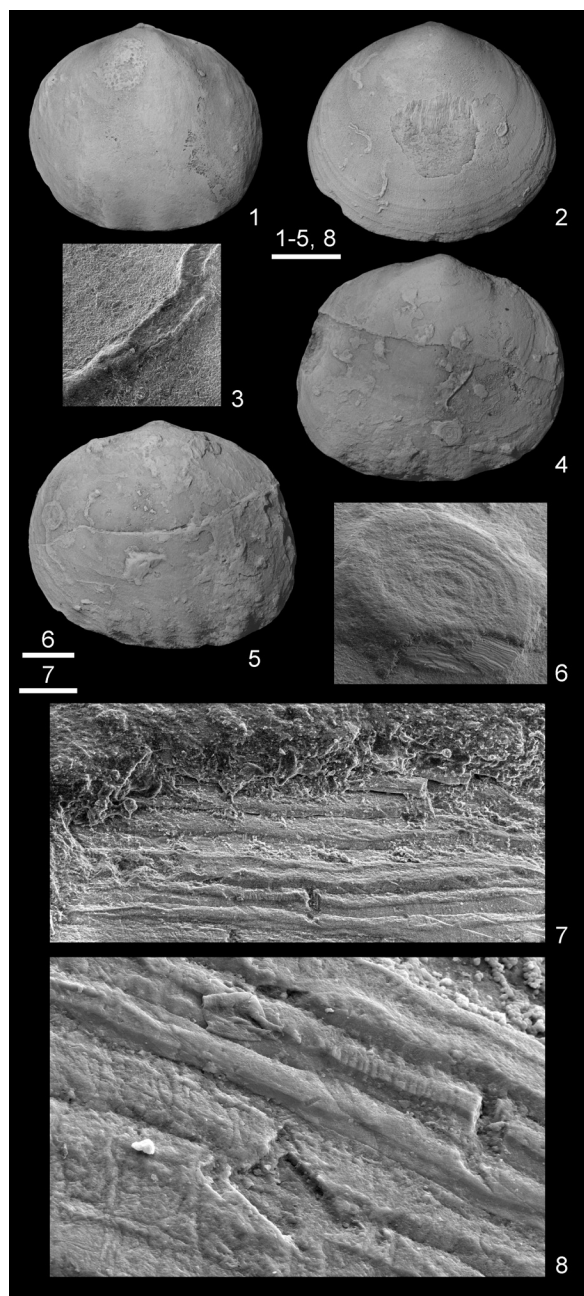


FIGURE 27. *Novaplatisrostrum* cf. *fibrosissimum* (Tietze, 1870) with epizoans. **1**, dorsal view of an articulated specimen (MB.B.9906) with a bryozoan colony in its posterior part (Fischersdorf-Gositzfelsen, beds 22.7-12, do VI). **2-3**, dorsal view of an articulated specimen (MB.B.9907) with unidentified tube-worm epizoans and close-up of one of them (Fischersdorf-Gositzfelsen, bed 11.2-5, do V). **4-8**, articulated specimen (MB.B.9908), partly coated with gold, in ventral and dorsal views with enigmatic circular epizoans, close-up of that attached to ventral valve and detail of the structure of its shell (Fischersdorf-Gositzfelsen, beds 22.7-12, do VI). Scale bars: 1-2 and 4-5 (5 mm), 3 and 6 (500 μ m), 7 (50 μ m), and 8 (25 μ m). All SEM, except 1-2, 4-5.

ingorhynchus pseudoequitans gen. et sp. nov. and *Texathyris? tarpata*. Several species belong to genera, which also occur in ramp and/or platform settings, where their representatives generally reach a larger size (e.g., *Productina*, *Cleiothyridina*), but micromorphic brachiopods occur also in shallow environments (e.g., Alexander, 1977; Mottequin et al., 2015b). Based on Pérez-Huerta and Sheldon (2006) discussion, the nutrient availability, the depth and the water oxygenation are most probably the biotic and physicochemical factors that played the most important roles in controlling the size of brachiopods in the Thuringian deep-water environments. According to Pérez-Huerta and Sheldon (2006), the productides would be larger than spire-bearers (Athyridida, Spiriferida) and dominant in food-depleted environments, but this is not really matched in the present case concerning the size of the brachiopods, but it is evident that productides are particularly abundant. It is also worthwhile to stress the fact that the Hastarian brachiopods recognized in Thuringia do not reach the size of the largest rhynchonellides known from the Famennian Breternitz Member (*Hadyrhyncha* and *Novaplatisrostrum*). This could be related to more stressful conditions during the first stages of the post-Hangenberg recovery. As the Pfaffenberg Member would correspond to a deepening-upward sequence, the small size of the brachiopods could be explained by the necessity for these organisms to reproduce as soon as possible in a relatively hostile environment and thus may involve heterochronic processes.

Encrustation by epizoans are particularly scarce. Only specimens of *Novaplatisrostrum* cf. *fibrosissimum* from the Breternitz Member, that can be counted on the fingers of one hand, show encrustations by bryozoans (Figure 27.1) and worm-tube organisms (Figure 27.2-3). Rare encrustations of arenaceous foraminifers also occur; as with bryozoans, they could have been also postmortal, using the dead brachiopod shell as hardground. Encrusting *Aulopora* (tabulates) has never been observed. On one specimen of *Novaplatisrostrum* cf. *fibrosissimum* two circular epizoans with clearly concentric structures have been discovered (Figure 27.4-8). This kind of epizoan does not belong to a group of corals and cannot represent the holdfast of an echinoderm (G. Sevastopulo, personal communication, 2017). One of these epizoans has its shell slightly broken on one side, which reveals its detailed constitution. It is formed of superimposed mineralized layers of very regular thickness, composed of CaCO_3 (no trace of

phosphorous) as shown by qualitative EDS-analysis. The question of its attribution to phylum Mollusca arose insofar as fossil encrusting bivalves are known from several geological formations (*Atreta* for instance). Nonetheless, the concentric structure does not reveal traces of muscular scars or any particular spot that might suggest the existence of a possible hinge. We have therefore rejected this hypothesis and the possibility of belonging to a group of linguliform brachiopods, and more precisely to be the ventral valve of a Discinoidea. This particular group has a shell whose fabric is typically baculate. Baculi are apatitic structure included in a crossed network inside an organic matrix. Large magnifications using the SEM were not able to put such a structure in evidence. In some places parallel crystalline prisms were observed, but they are never separated by a different material of cementation: they are merely contiguous. The assignment to the Discinoidea is thus rejected as also suggested by the calcitic composition of the shell. These concentric structures resemble the circular holdfasts of *Sphenothallus* attached to brachiopods that were illustrated by Neal and Hannibal (2000), but they cannot be assigned to this genus, which corresponds to chitonous or phosphatic tubes (Neal and Hannibal, 2000; Wei-Haas et al., 2011). This epizoan is therefore considered temporarily as an *incertae sedis* pending a plausible interpretation.

No drill holes or pedicle boring traces were observed in the investigated Material. One articulated shell of *Cleiothyridina pfaffenbergensis* sp. nov. (Figure 16.6-11) displays symmetrically arranged damage along its lateral margins, probably resulting from the bite of a predator ("fish"?). This bite was not lethal as reflected by the distortion of the shell outline and the deviation of the concentric ornamentation.

BRACHIOPOD CHANGES AT THE DEVONIAN–CARBONIFEROUS BOUNDARY

Although the criteria used for the definition of the Devonian–Carboniferous is now the focus of an international working group (Becker et al., 2016), this boundary is still defined by the incoming of the supposed first *Siphonodella* (*Eosiphonodella*) *sulcata* at La Serre (Global Stratotype Section and Point) in Montagne Noire (southern France) (Paproth et al., 1991). In Thuringia, the brachiopod assemblages from the Beternitz and the Pfaffenberg members display strong differences in their composition (see above). The fact that the brachiopod turnover took place within the *Protognathodus*

kockeli conodont Zone, so below the current Devonian–Carboniferous boundary (Figures 5, 26), promotes the use of another criterion to define this boundary. From this viewpoint, during the International Workshop of the joined Subcommissions on Devonian and Carboniferous Stratigraphy task group (Montpellier, September 2016), it was proposed to use the base of the *P. kockeli* Zone, the beginning of radiation, the top of major regression (top of the Rhenish Hangenberg Sandstone and its regional equivalents) and the end of the mass extinction as potential boundary horizon and criterion for the redefinition of the base of the Carboniferous (Spalletta et al., 2017).

Among the rhynchonelliform brachiopods, none of the species recognized in the Breternitz Member survive to the Hangenberg Crisis (Figure 26) unless the conspecificity of *Crurithyris* sp. indet. and *C.?* sp. indet. is demonstrated in the future (see discussion above). The last brachiopods (orthide gen. et sp. indet.) from the Breternitz Member are known from the top of this lithostratigraphic unit (bed 32.11), so just below an anoxic black shale horizon (bed 32.12) interpreted as the first episode of the Hangenberg Crisis (Bartzsch et al., 1998; Bartzsch and Weyer, 2012) and equivalent to the Rhenish Hangenberg Black Shale (Figure 4). The Oberritz Member, which corresponds to the Rhenish Hangenberg Shale and Sandstone (Bartzsch et al., 2015), is devoid of brachiopods. The lack of data related to the linguliform species ("*Lingularia*" sp. indet.) does not permit to affirm (or otherwise) if the Famennian and Tournaisian forms are conspecific (see above). Brachiopods thus underline the drastic synchronous extinction and faunal change at the Devonian–Carboniferous boundary (Hangenberg Crisis), already well known from nearly all other invertebrate groups (Ammonoidea, Trilobita, Ostracoda, Anthozoa) and conodonts. They disprove the opposite opinion of Schindewolf (1928, p. 654) about a cascade boundary: corals, brachiopods, trilobites and ammonoids should have their critical faunal changes at different stratigraphical levels. This error had arisen not only from the restricted knowledge of his times (especially for Rugosa), but also from neglecting facial differentiation (mixing of photic and aphotic communities).

The brachiopod fauna from the Pfaffenberg Member includes representatives of pre-existing genera known from Famennian strata (e.g., *Cleiothyridina*, *Composita*) and of new ones (e.g., *Thuringorhynchus* gen. nov., *Crassumbo*). Members of the family Rozmanariidae, which were particularly

well-represented during the Famennian and especially in Thuringia, do not cross the Devonian–Carboniferous boundary (Mottequin et al., 2014). Kaiser et al. (2016) proposed a so-called *Rozmanaria* post-crisis fauna on the basis of Bartzsch et al.'s (2015) report of *Rozmanaria?* nov. sp. [= *Rozmanaria equitans* (Schmidt, 1924) in Bartzsch and Weyer, 1986] within the Pfaffenberg Member, but this terminology has to be rejected definitely. These so-called Tournaisian *Rozmanaria* belong to the genus *Thuringorhynchus* gen. nov. (see above) and only represent a small part of the brachiopod fauna from the Pfaffenberg Member. Furthermore, it appears that another genus, yet to be defined, was confused with *Rozmanaria* by Weyer (1972). This genus temporarily identified here as *rozmanariid?* gen. indet. (see above) is recognized in do VI succession of the Rhenish and Thuringian Slate Mountains and is thus probably useful for biostratigraphic purposes. The brachiopod assemblage recorded in the first bed of the Pfaffenberg Member (*Protognathodus kockeli* Zone, in the past identified as Upper *Siphonodella praesulcata* Zone) already includes seven species whereas the peak of diversity is reached in bed 3 with nine species (Figure 5). After this peak, the number of species tends to decrease progressively and perhaps reaches a nadir (only one species) within bed 10 (Figure 5), though this is only very poorly fossiliferous. It clearly appears that the basal Hastarian aphotic environments were colonized by a more diverse brachiopod panel than previously because of the drastic decline of the rhynchonellides which were yet so abundant during the Late Devonian.

The occurrence of a single terebratulide within the upper part of the Breternitz Member (do VI) is remarkable as they are not common and diverse during the Famennian, in which García-Alcalde (in Brice et al., 2000) reported four long-ranging genera, which were all known before this stage. In Europe, they were reported at least in the middle Famennian of the Holy Cross Mountains of Poland (Biernat and Racki, 1986a) but are absent there from the top of the Famennian (Halamski and Baliński, 2009). They seem to be unrecorded in the upper and uppermost Famennian shallower deposits like in the Franco-Belgian Basin (Dehée, 1929; Mottequin and Brice, 2016) or in the Cantabrian Mountains in Spain (García-Alcalde, 1996). The record of terebratulides by Dantz (1893) (see also Paul, 1937) within (at least) the upper Famennian

of the Aachen area (Germany), which corresponds to the eastern extension of the Franco-Belgian Basin, needs to be confirmed.

PERSPECTIVES

This study of the brachiopod faunas, which colonized the deep-water environments from Thuringia (Saalfeld area) at the end of the Devonian and during the early Carboniferous, needs to be complemented in the future by the investigation of those occurring in similar facies as exposed in the numerous sections of the Rhenish Slate Massif (Germany). It will permit to refine our understanding of the processes responsible for the Hangenberg Crisis at the end of the Devonian within the deep-water settings of this part of Laurussia. Investigation of contemporaneous brachiopod faunas from North Africa, where similar facies are particularly well-developed, is also required as most of the studies are focused only on the rhynchonellides. Last but not least, the thorough revision of the contemporaneous brachiopod faunas from shallower (Strunian), mixed siliciclastic–carbonate environments described notably by Paeckelmann (1930, 1931), Gallwitz (1932) and Paul (1939) is urgently needed.

ACKNOWLEDGEMENTS

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