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Devonian rugose corals of the *Phillipsastrea hennahii* species group

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ABSTRACT

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Massive phillipsastreid tetracorals similar to *Phillipsastrea hennahii*, defined as a *Ph. hennahii* species group, are characterized by reduced intercorallite walls (thamnasterioid or subthamnasterioid habit), by variable but generally good development of horseshoe dissepiments at the tabularium/dissepimentarium boundary, and by strongly deflected peripheral platforms at corallite margins. Seven species of the *Ph. hennahii* species group, mostly from the Givetian of southern Euramerica, Iberia and northern Gondwana, are reviewed. Two species, the Middle Givetian *Phillipsastrea sobolewi* (RÓŻKOWSKA 1956) and the Late Givetian *Phillipsastrea jachowiczi*, a new species described herein, both from the Holy Cross Mountains (Poland) are described and illustrated. Also described from that area is *Phillipsastrea falsa* COEN-AUBERT 1987 from the Upper Frasnian.

Key words: Rugosa, Phillipsastreidae, *Phillipsastrea hennahii*, Species groups, Devonian, Givetian, Variability, Holy Cross Mts, Poland.

INTRODUCTION

This paper presents the results of an investigation of massive and submassive Phillipsastreidae from the Devonian of the Holy Cross Mountains, central Poland (Text-figs 1.10 and 2-3), focused on the *Phillipsastrea hennahii* species group. In the material studied, the group is represened by seven, mostly Givetian species, with 85 colonies measured; among them is the new species, *Phillipsastrea jachowiczi* from the Upper Givetian. Some other species of the group from the Givetian and the Frasnian are also discussed and illustrated.

The main methodological concept of the present paper is the paleophenon (DZIK 1990, p. 274), defined as a homogeneous sample of fossils restricted in space and time, without evident polymodal character distribution. The recognised paleophena are treated as distinct species.

MATERIAL AND METHODS

The core of the material studied is represented by the collection of non-cerioid, massive and submassive (subphaceloid) Phillipsatreidae collected during more than twenty years of studies in the Devonian of the Holy Cross Mountains, central Poland (Text-figs 2-3). Comparative material has been collected in the Ardennes (Belgium), Devonshire (England), Harz Mountains (Germany), Canadian Rocky Mountains and the Cantabrian Mountains in Spain (Text-fig. 1); additional material has been obtained or loaned from British and north African collections, including the

topotypic colonies of *Phillipsastrea hennahii* from the Barton Quarry (Devonshire).

Data base

Almost 900 colonies collected by the present author or taken from the literature have been measured; their numerical characters are listed in Table 1. Of these, about 720 specimens are "complete", i.e. with both transverse and longitudinal sections measured.

The analytical material described in the present paper (tables, text and numerical data, as well as scanned thin-sections in the case of the author's original and loaned material) is available from the website of the Department of Ecosystem Stratigraphy of the University of Silesia at the following address: http://www.rugosa.wnoz.us.edu.pl/ as "Massive Phillipsastreidae – *Phillipsastrea hennahii* species group".

SPECIES GROUPS

Eight species groups are recognized within the massive non-cerioid phillipsastreids of the Devonian World.

1) The *Phillipsastrea hennahii* species group (ca. 120 colonies) comprises almost all of the pre-Frasnian non-cerioid phillipsastreids. Only a small fraction of the Frasnian colonies belong to this group. The colonies of *P. hennahii* group have common horseshoe dissepiments (PP≥0.6), strongly everted calicinal margins (AZ roughly 60 degrees) and an astreoid to thamnasterioid habit;

2) The *Scruttonia kunthi* species group (10 colonies) is known exclusively from the Upper Famennian of the Sudetes (FEDOROWSKI 1991, BERKOWSKI 2002), this being the only reliable Famennian record of the family Phillipsastreidae. The group is represented predominantly by aphroid colonies, with very thin and very long septa.

3) The *Frechastraea pentagona* species group (ca. 130 colonies) is characterized by small corallites (DIC <6 mm) and rare horseshoe dissepiments (typically PP<0.4) and by long septa within tabularia (L/T≥0.335).

4) The *Frechastraea micrommata* species group (ca. 25 colonies) is very similar to the former group (small corallites (DIC<6 mm) and rare horseshoe dissepiments (typically PP < 0.4)), but is characterised by very short septa within tabularia (L/T<0.335).

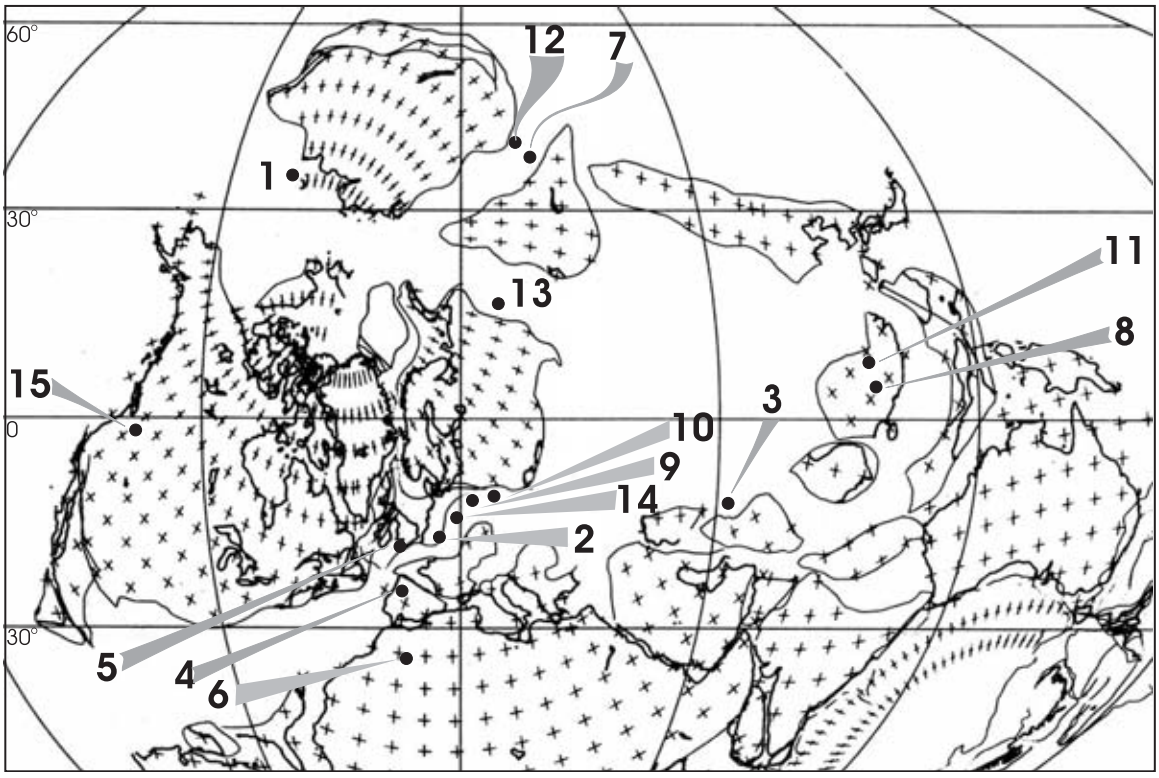

Fig. 1. Givetian palaeogeography (after MCKERROW & SCOTESE 1990, fig. 15) with location of corals studied, in alphabetic order: 1 – Angara, 2 – Ardennes, 3 – Armenia, 4 – Cantabrian Mts, 5 – Devonshire, 6 – Moroccan Antiatlas, 7 – Gornyi Altai, 8 – Guangxi, 9 – Harz Mts, 10 – Holy Cross Mts, 11 – Hunan, 12 – Kuznetsk Basin, 13 – Polar Urals, 14 – Rhenish Slate Mts, 15 – Washington State. Please note that the map presents the location of continental cratons, and that coral locations in South China, Washington State, Spain and Morocco indicate the presence of epeiric seas at these sites

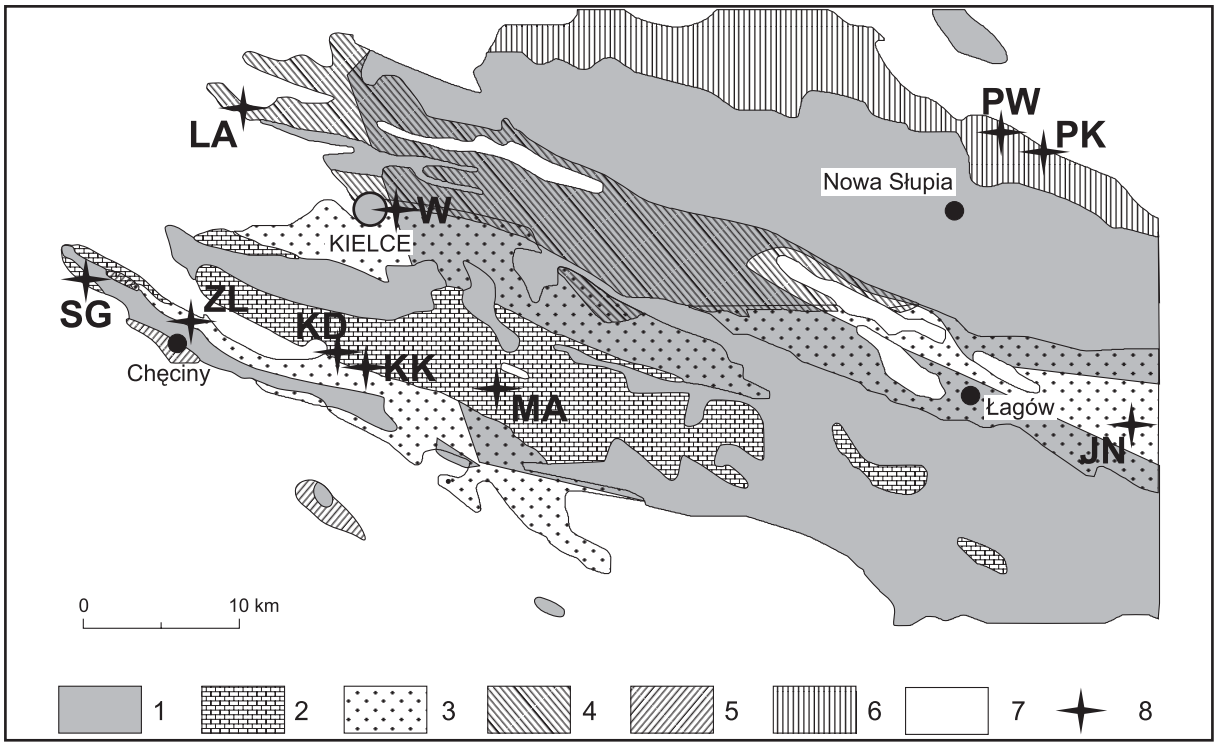

Fig. 2. Geological bedrock map of the Holy Cross Mountains, central Poland (after WRZOŁEK 2002, fig. 1, modified); geology: 1 – Lower Palaeozoic, Devonian: 2 – Kielce carbonate platform, 3 – Dyminy facies of the platform's foreslope, 4 – Kostomłoty transition facies, 5 – Chęciny intrashoal depression, 6 – Łysogóry Basin (deeper shelf); 7 – post-Devonian; outcrops: JN – Janczyce, KD – Kowala road-cutting, KK – Kowala Quarry, LA – Laskowa Quarry at Kostomłoty, MA – Marzysz, PK – Skały, PW – Włochy, SG – Sowie Górki Quarry at Miedzianka, W – Wietrznia Quarry in Kielce, ZL – Zelejowa hill, eastern part

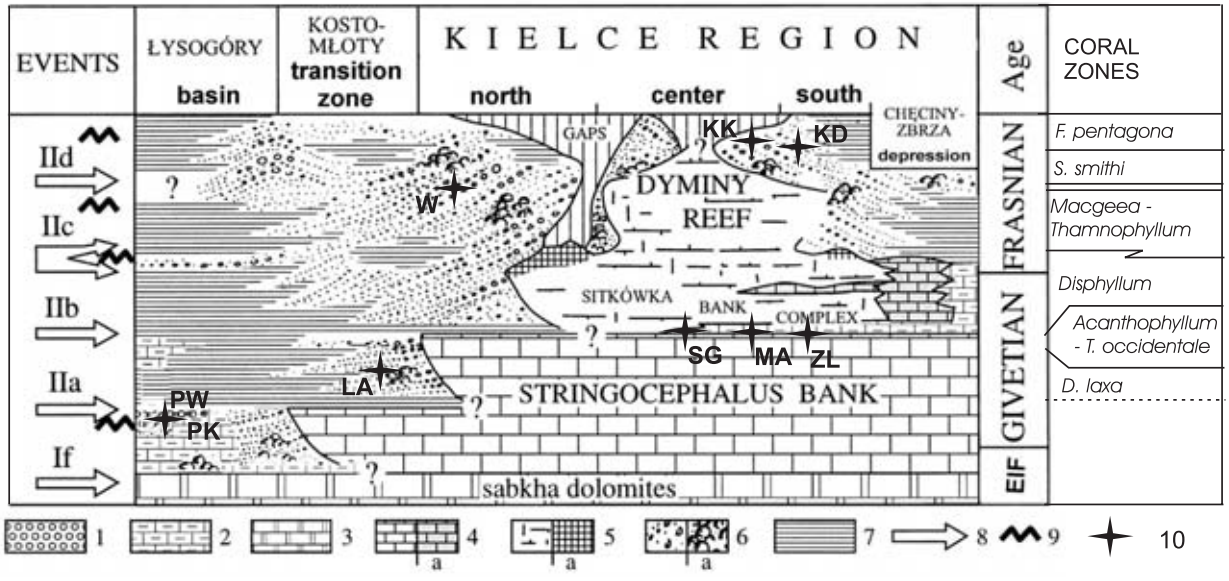

Fig. 3. Stratigraphy of the Devonian of the Holy Cross Mountains and geological setting of the corals studied in the present paper (from TURNAU & RACKI 1999, fig. 2C; coral zones from WRZOŁEK 1988, fig. 2): 1 – siliciclastics (Świętomarz sandstones); 2 – marly deposits; 3 – dolomites; 4 – biostromal limestones (a – intershoal facies); 5 – reef limestones (a – mud mounds); 6 – detrital foreslope limestones (a – local organic buildups); 7 – basinal clays and shales; 8 – major transgressive events; 9 – supposed epeirogenic events; 10 – location of outcrops studied; outcrops: KD – Kowala road-cutting, KK – Kowala Quarry, set G; LA – Laskowa Quarry at Kostomłoty, MA – Marzysz, PK – Skały, PW – Włochy, SG – Sowie Górki Quarry at Miedzianka, W – Wietrznia Quarry west, set D; ZL – Zelejowa hill, eastern part; JN – Janczyce (unmarked in this section) is located in the Upper Frasnian marly-detrital deposits in the eastern part of the Holy Cross Mountains

feature	explanation
CO	ratio of space filling by corallites as deduced from transverse section; 0.1 for protocorallites
MU	intercorallite walls: **1** individual epithecae, **2** juxtaposed epithecae (cerioid wall), **3** septal (pseudocerioid) wall, **4** wall absent
SC	ratio of septal continuity between the calicinal margins of neighboring corallites
IN1	internal wall as percentage of tabularium margin - from 0.0 to 1.0
IN2	expansion of the major septa - ratio of expanded part of septum to its total length
CA	septal carinae: **0** absent, **1** delicate, **2** significant
TB	tabularium profile: **0** concave, **1** flat, **2** mesa-shaped in axis, **3** domical
TC	proportion of complete tabulae: from 0.0 to 1.0
PP	proportion of horseshoe dissepiments: from 0.0 to 1.0
DIC	calculated corallite diameter (mm)
L/T	*2*L1/TM, i.e. ratio of length of major septa within tabularium to tabularium radius*
N/D1	*#S1/TM*
N/D2	*#S1/DIC*
#S1	number of major septa
TM	tabularium diameter in transverse section (mm)
L1	length of the major septa in tabularium (mm)
L2	length of the minor septa in tabularium (mm)
D1	maximum thickness of the major septa (mm)
D2	maximum thickness of the minor septa (mm)
TW	tabularium diameter in longitudinal section (mm); essentially it is expected to be equal to TM
W	number of vertical series of internal dissepiments
Z	number of vertical series of external dissepiments
AZ	inclination of peripheral calicinal platform to corallite axis (degrees)
AW	inclination of internal dissepiments to corallite axis (degrees)
TT	mean distance between tabulae / tabellae (mm)
D/L	*(2*Z)/(DIC-TM), i.e. average length of peripheral dissepiments*

1 – characters represent mean values for up to five corallites measured in transverse and up to three in longitudinal section; 2 – *italics* for calculated values; 3 – fractional values for parameters MU, CA and TB indicate intermediate states; 4 – DIC calculated from corallite area as measured in transverse section and corrected for obliqueness of section (as calculated by ratio of major to minor axis if tabularium outline is elliptical)

Table 1. Explanation of features analyzed in the *Phillipsastrea hennahii* species group

5) The *Smithicyathus* species group (ca. 100 colonies) possesses short septa in tabularia ($L/T \leq 0.335$) and common horseshoe dissepiments ($PP \geq 0.4$).

6) The *Phillipsastrea ananas* species group (ca. 200 colonies) is characterized by rare horseshoe dissepiments ($PP < 0.6$) and larger corallites ($DIC \geq 6$mm); *Frechastraea sanctacrucensis* also seems to belong here.

7) The *Pachyphyllum* species group (ca. 20 colonies) is characterized by numerous horseshoe dissepiments ($PP \geq 0.6$), long septa in tabularia ($L/T > 0.335$) and very large corallites ($DIC > 12$mm).

8) The *Medusaephyllum progressum* species group (about 150 colonies) is very similar to the former group in respect of the horseshoe dissepiments and in possession of long septa in tabularia, but is characterised by smaller corallites ($DIC < 12$mm) and predominantly aphroid habit.

PHILLIPSASTREA HENNAHII SPECIES GROUP

The material of the group studied comprises 85 specimens; an additional 34 colonies represent comparative material as well as specimens provisionally referred to the group. Numerical data of all of the specimens are provided in Tables 2-5. The details are as follows:

(1) Eight well defined species: *Ph. hennahii* (17 colonies); *Ph. jachowiczi* sp.nov. (36 colonies); *Ph. sobolewi* (7 colonies); the Iberian species *Ph. torreana* (5 colonies) and *Ph. "pradoana"* (3 colonies), and the North African species *Ph. tafilaltensis* (8 colonies), *Ph. weyeri* (4 colonies) and *Ph. hollardi* (4 colonies).

(2) Nine species provisionally referred to the group (with each species represented in the material by a single colony): *Pachyphyllum* (?) *chenouensis* and *Phillipsastrea* sp.nov. aff. *irregularis* from North Africa; *Phillipsastrea enbyskae* from western North America; *Pachyphyllum giveticum* from Gornyi Altai, Siberia,

feature \ sample	BGS GSM 6185	Barton quarry	other locations	total sample	GIUS421 LA264	Laskowa quarry other	HCMts other locations	total sample
	Phillipsastrea hennahii				*Phillipsastrea jachowiczi* sp. n.			
	a	b	c	b + c	d	e	f	e + f
CO	1	1	1	1	1	0.9-1	1	0.9-1
MU	4	3.5-4	3.5-4	3.5-4	3.5	3.5-4	3.5	3.5-4
SC	1	1	1	1	1	0,9-1	1	0,9-1
IN1	0.9	0.3-0.9	0.4-0.9	0.3-0.9	0.5	0.3-1	0.3-0,8	0.3-1
IN2	0.3	0.2-0,5	0.2-0.8	0.2-0.8	0.2	0.1-0.4;0.8	0.2-0.3	0.1-0.4;0.8
CA	0	0-0.5	0-0.5	0-0.5	0	0-1	0-0.5	0-1
TB	1.5	1.5-2	0.5-2	0.5-2	1.5	1-2.5	1.5	1-2.5
TC	0	0-0.1;0.4	0-1	0-1	0.1	0-0.1	0;0.8	0-0.1;0.8
PP	0.4	0.4-1	0.2-1	0.2-1	0.9	0-1	0.8-1	0-1
DIC	9.8	7.9-11.5	8.1-11.6	7.9-11.6	11.3	7-15.6	7.9-10.5	7-15.6
L/T	0.82	0.47-0.82	0.62-0.86	0.47-0.86	0.77	0.59-0.87	0.55-0.73	0.55-0.87
N/D1	5.71	4.71-7.04	4.29-6.67	4.29-7.04	5.2	4.16-6.83	5.28-5.56	4.16-6.83
N/D2	1.35	1.13-1.71	1.21-2.22	1.13-2.22	1.13	0.95-1.76	1.36-1.63	0.95-1.76
#S1	13.2	12-14.3	12.2-18	12-18	12.8	11.6-16.8	12.4-15.2	11.6-16.8
TM	2.31	2.03-2.9	1.92-3.5	1.92-3.5	2.46	1.98-3.41	2.23-2.75	1.98-3.41
L1	0.95	0.5-0.99	0.68-1.33	0.5-1.33	0.95	0.66-1.29	0.75-1.01	0.66-1.29
L2	0.13	0.01-0.13	0.04-0.38	0.01-0.38	0.01	0-0.2	0.03-0.21	0-0.21
D1	0.24	0.17-0.3	0.12-0.25	0.12-0.3	0.24	0.18-0.43	0.28-0.29	0.18-0.43
D2	0.18	0.11-0.22	0.06-0.2	0.06-0.22	0.15	0.12-0.37	0.21-0.24	0.12-0.37
TW	2.3	2.1-2.9	1.84-3.75	1.84-3.75	2.3	1.98-3.76	2.63-3.18	1.98-3.76
W	0	0-1	0-3	0-3	0.3	0-1	0-1	0-1
Z	8.5	6-12	6-15	6-15	8.7	4.5-15	4.3-8.5	4.3-15
AZ	47	45-75	40-75	40-75	57	38-72	38-53	38-72
AW	0	0-15	0-40	0-40	3	0-42	0-38	0-42
TT	0.21	0.11-0.27	0.21-0.4	0.11-0.4	0.22	0.19-0.39	0.23-0.31	0.19-0.39
D/L	2.27	1.6-3.22	1.36-4.83	1.36-4.83	1.97	1.26-3.84	1.31-2.82	1.26-3.84
N	1	9	8	17	1	33	3	36

a – the holotype of *Ph. hennahii*, from Barton Quarry, Devonshire, England; b – topotypic material, including the holotype; c – non-topotypic material from Devonshire (3 colonies); from the Rhenish Slate Mts., Germany (2 colonies) and from Kuznetsk Basin, Northern Siberia and Armenia (1 colony from each area); d – the holotype of *Ph. jachowiczi* sp. nov., from Laskowa quarry, Holy Cross Mts., Poland; e – topotypic material, including the holotype; f – material from Marzysz, Sowie Górki and Zelejowa in the Holy Cross Mts. (one colony from each location)

Table 2. Variability in *Phillipsastrea hennahii* (N=17) and in *Ph. jachowiczi* sp. nov. (N=36)

Pachyphyllum intermedium from Kuzbass, *Frechastraea pentagoniformis* from the Polar Urals; and three Chinese species: *Phillipsastrea primitiva* and *Ph. producta* from Guangxi, and *Ph. xinhuanense* from Hunan.

(3) Comparative material of *Medusaephyllum ibergense* (six colonies) from the Lower Frasnian of the Harz Mountains and from Russia.

(4) Comparative material of three Late Frasnian species (with 19 colonies measured), represented by: *Ph. ussheri* (Devonshire), *Ph. falsa* (Ardennes and the Holy Cross Mts), *Ph. ranciae* and *Ph.* cf. *ranciae* (Ardennes).

REPOSITORIES

BGS GSM – British Geological Survey, Keyworth, England; collection of the Geological Survey Museum, London; in older literature prefixed GSM

GIUS – University of Silesia, Earth Sciences Department, Sosnowiec, Poland

MBK – Museum für Naturkunde of the Humboldts Universität, Berlin, Germany; coral collection

NHM – Natural History Museum, London, England; formerly acronymed BM(NH)

OUM – Oxford University Museum, Oxford, England

SYSTEMATIC PALAEONTOLOGY

Family Phillipsastreidae C. F. ROEMER, 1883
Genus *Phillipsastrea* d'ORBIGNY, 1849

TYPE SPECIES: *Phillipsastrea hennahii* (LONSDALE, 1840), selected by MILNE-EDWARDS & HAIME (1850, p. 71).

DISCUSSION: Among the various genera used for classification of phillipsastreids presented in this paper, *Pachyphyllum* MILNE-EDWARDS & HAIME, is currently used for the colonies with a few large corallites, significantly raised distally above the corallum, and with numerous horseshoe dissepiments (MCLEAN 1986); *Medusaephyllum* ROEMER is poorly known but possibly it is very close if not identical to *Phillipsastrea* (MCLEAN 1994a, p. 53). The main difference between these two genera seems to be in the development of the thickened horseshoe dissepiments; they are always present as a distinct series in *Medusaephyllum* (PP=1.0), whereas in *Phillipsastrea* (e.g. *Ph. hennahii*) they may form a discontinuous (PP<1.0) and not thickened series. The genus *Frechastraea* SCRUTTON lacks the horseshoe dissepiments and its peripheral dissepiments are arranged horizontally (AZ close to 90). The colonies of *Scruttonia* CHEREPNINA have a strong thamnasterioid aspect. Although it is regarded by MCLEAN (1994b, p. 82) as a possible junior synonym of *Frechastraea*, it may in fact be a separate genus, as indicated by its species representing the only massive phillipsastreids in the Frasnian of the Boulonnais (ROHART 1982; 1988, table 1), and hence representing a unique paleophenon. Similarly *Scruttonia* is the only morphotype present in the Famennian of the Sudetes (BERKOWSKI 2002). *Smithicyathus* RÓŻKOWSKA possesses thickened septa, which typically almost obscure the horseshoe dissepiments, and has very short septa in the tabularium (L/T≤0.335).

feature \ species	*Ph. hennahii*	*Ph. jachowiczi* sp. n.	*Ph. sobolewi*	*Ph. torreana*	*Ph. "pradoana"*	*Ph. weyeri*	*Ph. hollardi*	*Ph. tafilaltensis*
CO	1	0.9-1	1	1	1	1	1	1
MU	3.5-4	3.5-4	3.5	3.5	3.5	3.5-4	3.5-4	3.5-4
SC	1	0.9-1	1	1	1	1	1	1
IN1	0.3-0.9	0.3-1	0.2-0.4	0.7-1	0.3-0.4	0.5-0.7	0.6-0.8	0.4-1
IN2	0.2-0.8	0.1-0.4;0.8	0-0.4	0.3-0.5	0.2-0.3	0.3-0.4	0.3-0.4	0.3
CA	0-0.5	0-1	0	0-0.5	0	0-0.5	0	0-0.5
TB	0.5-2	1-2.5	0.5-2	0.5;1.5	0;1.5	0.5;1.5	0.5-1.5	0.5-1.5
TC	0-1	0-0.1;0.8	0	0-0.2	0-0.9	0	0-0.6	0.1-0.5
PP	0.2-1	0-1	0.6-0.9	0.6-1	0.9-1	0-0.4	0-0.3	0.7-1
DIC	7.9-11.6	7-15.6	12.7-17	7.6-10.5	4.2-9.4	7.7-9.6	7.4-12.1	7.5-10
L/T	0.47-0.86	0.55-0.87	0.61-0.88	0.69-0.85	0.4-0.88	0.62-0.86	0.31-0.74	0.41-0.62
N/D1	4.29-7.04	4.16-6.83	3.17-4.83	4.11-5.8	3.36-5.81	5.0-6.17	4.8-6.75	5.13-7.2
N/D2	1.13-2.22	0.95-1.76	1.25-1.65	1.36-1.81	1.54-3.38	1.25-1.84	0.93-1.59	1.18-1.73
#S1	12-18	11.6-16.8	18.6-21.8	12.2-18.2	14.2-14.5	12-15.4	10.8-12	10.8-13
TM	1.92-3.5	1.98-3.41	4-6	2.4-4.28	2.46-4.32	2.2-3	1.6-2.5	1.5-2.3
L1	0.5-1.33	0.66-1.29	1.37-2.33	0.84-1.68	0.87-1.08	0.68-1.23	0.25-0.93	0.33-0.62
L2	0.01-0.38	0-0.21	0-0.5	0-0.33	0.16-0.32	0-0.03	0	0-0.05
D1	0.12-0.3	0.18-0.43	0.05-0.41	0.22-0.35	0.14-0.41	0.17-0.38	0.23-0.35	0.16-0.26
D2	0.06-0.22	0.12-0.37	0.05-0.33	0.14-0.26	0.11-0.34	0.09-0.16	0.13-0.19	0.09-0.17
TW	1.84-3.75	1.98-3.76	4-5.5	2.4-4.2	2.66-3.93	2.4-3	1.6-2.4	1.6-2.6
W	0-3	0-1	0.7-4	0-1.3	0-1	0	0	0
Z	6-15	4.3-15	4.7-10.5	5-9.7	2.3-5.5	6-8.5	7-8	5-12
AZ	40-75	38-72	45-75	47-65	58-67	45-67	50-65	35-73
AW	0-40	0-42	15-40	0-30	0-30	0	0	0
TT	0.11-0.4	0.19-0.39	0.27-0.58	0.24-0.41	0.28-0.5	0.23-0.26	0.27-0.3	0.26-0.54
D/L	1.36-4.83	1.26-3.84	1.04-2.51	1.52-3.5	0.91-6.15	2.11-2.48	1.43-2.86	1.54-3.16
N	17	36	8	5	3	4	4	8
area	various	Holy Cross	Holy Cross	Spain	Spain	Morocco	Morocco	Morocco

Ph. = Phillipsastrea

Table 3. Variability in eight species of the *Phillipsastrea hennahii* species group

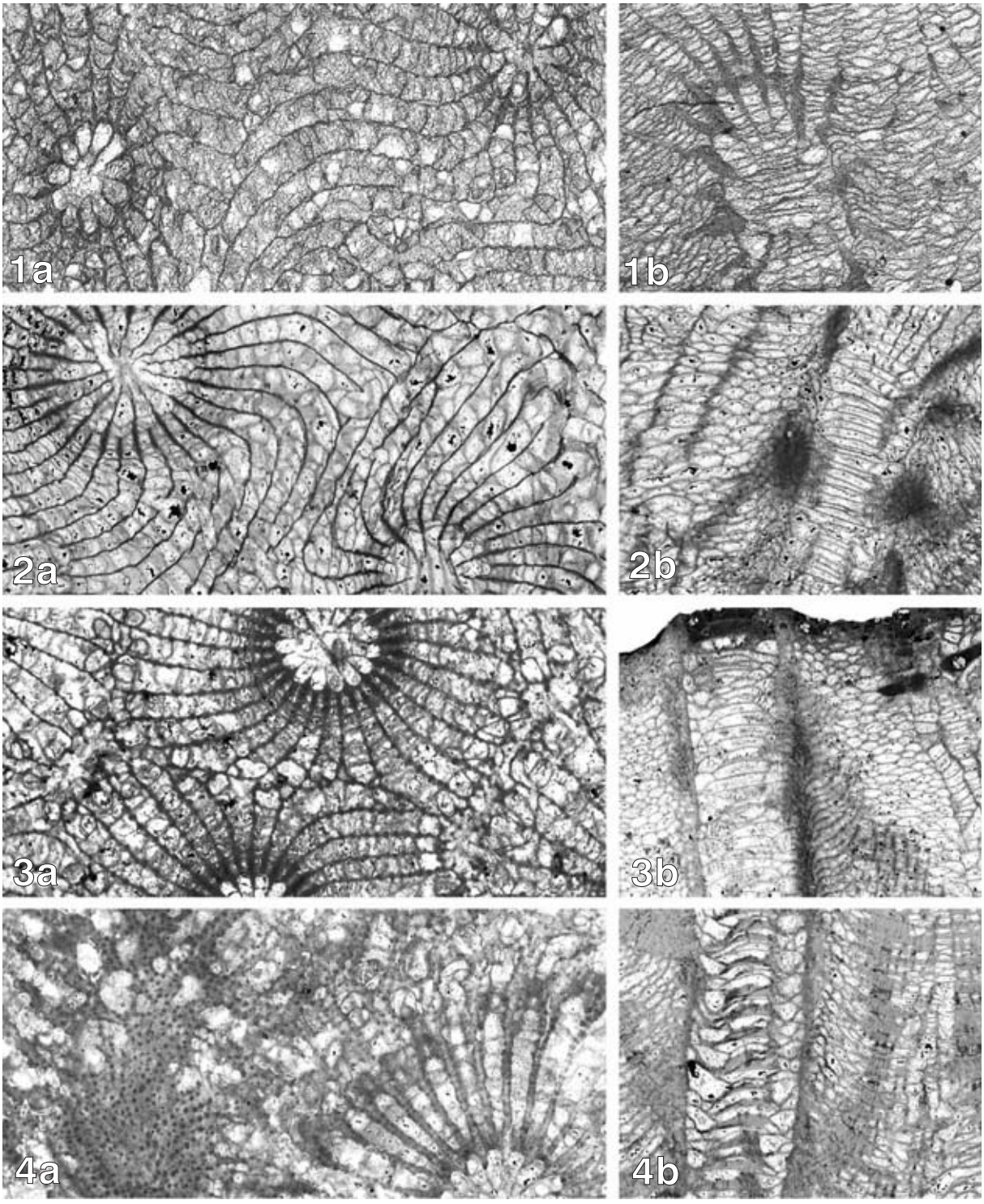

Fig. 4. Septal and wall structures in *Phillipsastrea hennahii* (Fig. 4: 1) and in *Phillipsastrea jachowiczi* sp. nov. (Figs 4: 2 – 4); magnified × 6; 1 – OUM D519 – Barton Quarry, Devonshire, England, Upper Givetian; relatively simple, unexpanded septa at corallite peripheries; intercorallite walls practically misssing (thamnasterioid colony), 1a – transverse, 1b – longitudinal section; 2 – 4 – colonies from the Laskowa Quarry, biolithites, Upper Givetian, a – transverse, b – longitudinal sections; 2 – GIUS 421LA 253, thamnasterioid colony with large corallites; 3 – GIUS 421LA 283, local displacement of septal wall by dissepiments and isolated trabeculae; 4 – GIUS 421LA 271, significant expansion of septa, locally masses of trabecular/dissepimental tissue at wall site, although no solid walls can be seen in longitudinal section

Phillipsastrea hennahii (LONSDALE, 1840)
(Text-figs 4.1, 5.1)

pars 1840. *Astrea (Siderastrea) hennahii* sp. n.; LONSDALE, p. 697; pl. 58, figs 3, 3b, *non* 3a.
1952. *Phillipsastraea pentagona* (GOLDFUSS); SOSHKINA, p. 102; pl. 43, 145.
1958. *Pachyphyllum ibergense* (ROEMER); BULVANKER, p. 90; pl. 43, fig. 1.
1968. *Phillipsastrea hennahi hennahi* (LONSDALE); SCRUTTON, p. 214, pls 1, 2 (*cum synonyma*).
non 1968. *Phillipsastrea hennahi ussheri* ssp. n.; SCRUTTON, p. 221, pl. 3 [poorly known Upper Frasnian species, possibly close to *Phillipsastrea falsa* COEN-AUBERT]
1975. *Phillipsastraea ibergensis* (F. ROEMER, 1855); SPASSKIY & KRAVTSOV *in* BESPROZVANNYKH & *al*., p. 61, pl. 13, fig. 3, pl. 14, fig. 1.
non 1987. *Phillipsastrea hennahi falsa* ssp.n.; COEN-AUBERT, p. 47; pl. 1, figs 1-4.
1990. *Phillipsastrea hennahi* (LONSDALE, 1840); BIRENHEIDE, p. 267; pls 9, fig. 23, pl. 11, fig. 27.
1993. *Phillipsastrea hennahi* (LONSDALE, 1840); ERRENST, p. 22; figs 3c, 3d; pls 3, figs 1-3, pl. 4, figs 1-3.
1994a. *Phillipsastrea hennahi* (LONSDALE, 1840); MCLEAN, pl. 1, figs 1, 2.

TYPES: The lectotype, designated by MILNE-EDWARDS and HAIME (1851, p. 421), is the original of LONSDALE (1840, pl. 58, figs 3, 3b), which is BGS GSM6185 (see TSIEN 1968), also registered as BGS GSM PF1245 (thin sections and peels), illustrated by SCRUTTON (1968, pl. 1, figs 1-4, 6), measured herein (Table 2, column a) from the Upper Givetian Torquay Limestone of the Barton Quarry, Torquay, Devonshire, England. Among the

feature \ species	*Ph. givetica*	*Ph. intermedia*	*Ph. pentagoni-formis*	*Ph. primitiva*	*Ph. producta*	*Ph. xinhuanense*	*Ph. enbyskae*	*Ph. chenouensis*	*Ph. aff. irregularis*
CO	1	0.8	1	1	1	1	1	1	1
MU	4	4	4	4	4	3.5	4	4	3.5
SC	1	0.2	1	0.3	1	1	0.6	1	1
IN1	0.4	0.4	0.4	0.3	0.3	0.3	0.6	0.3	0.3
IN2	0.3	0.2	0.3	0.4	0.5	0.4	0.3	0.4	0.5
CA	0	0	0	0	0	0	0	0	0.5
TB	1.5	1.5	1.5	1.5	1.5	1.5	2	0	1.5
TC	0	0	0.5	0.2	0.1	0	0	0	0
PP	0.7	0.8	0.3	1	0.8	0.7	0.8	1	0.9
DIC	6.6	8.7	5.5	9.3	9.4	6.7	4.7	9.8	10.4
L/T	0.87	0.76	0.93	0.75	0.49	0.96	0.78	0.94	0.61
N/D1	6.61	4.65	7.6	4.0	5.16	4.42	6.06	5.21	7.12
N/D2	2.77	1.99	2.07	1.94	2.29	2.09	2.06	2.49	2.26
#S1	18.3	17.3	11.4	18	21.5	14	9.7	24.4	23.5
TM	2.77	3.72	1.5	4.5	4.17	3.17	1.6	4.68	3.3
L1	1.2	1.41	0.7	1.68	1.02	1.52	0.62	2.2	1.0
L2	0.19	0.11	0.09	0.22	0	0.23	0.13	0.76	0
D1	0.12	0.18	0.19	0.16	0.13	0.25	0.12	0.18	0.14
D2	0.11	0.09	0.11	0.1	0.1	0.12	0.1	0.14	0.09
TW	2.8	3.5	1.9	4.5	4	2.9	2.3	6.1	4.8
W	0	0	0	1.5	3	0	0	3.5	4
Z	7	3	4	6	7	6	8.5	6	5
AZ	63	80	55	73	40	65	65	55	75
AW	0	0	0	18	40	0	0	40	25
TT	0.26	0.41	0.2	0.44	0.4	0.26	0.19	0.41	0.41
D/L	3.66	1.2	2	2.5	2.68	3.4	5.48	2.34	1.41
N	1	1	1	1	1	1	1	1	1
area	Gornyi Altai	Kuzbass	Polar Urals	Guangxi	Guangxi	Hunan	Washington State	Algeria	Morocco

Ph. = Phillipsastrea

Table 4. Variability in nine species with affinities to *Phillipsastrea hennahii*

topotypes NHM R50268 is illustrated by McLEAN (1994A, pl. 1, figs 1, 2); numerous other topotypic colonies are listed by SCRUTTON (1968, pp 214-221); some of them were measured for the present study (Table 2, column b) and two are also illustrated (Text-figs 4.1, 5.1).

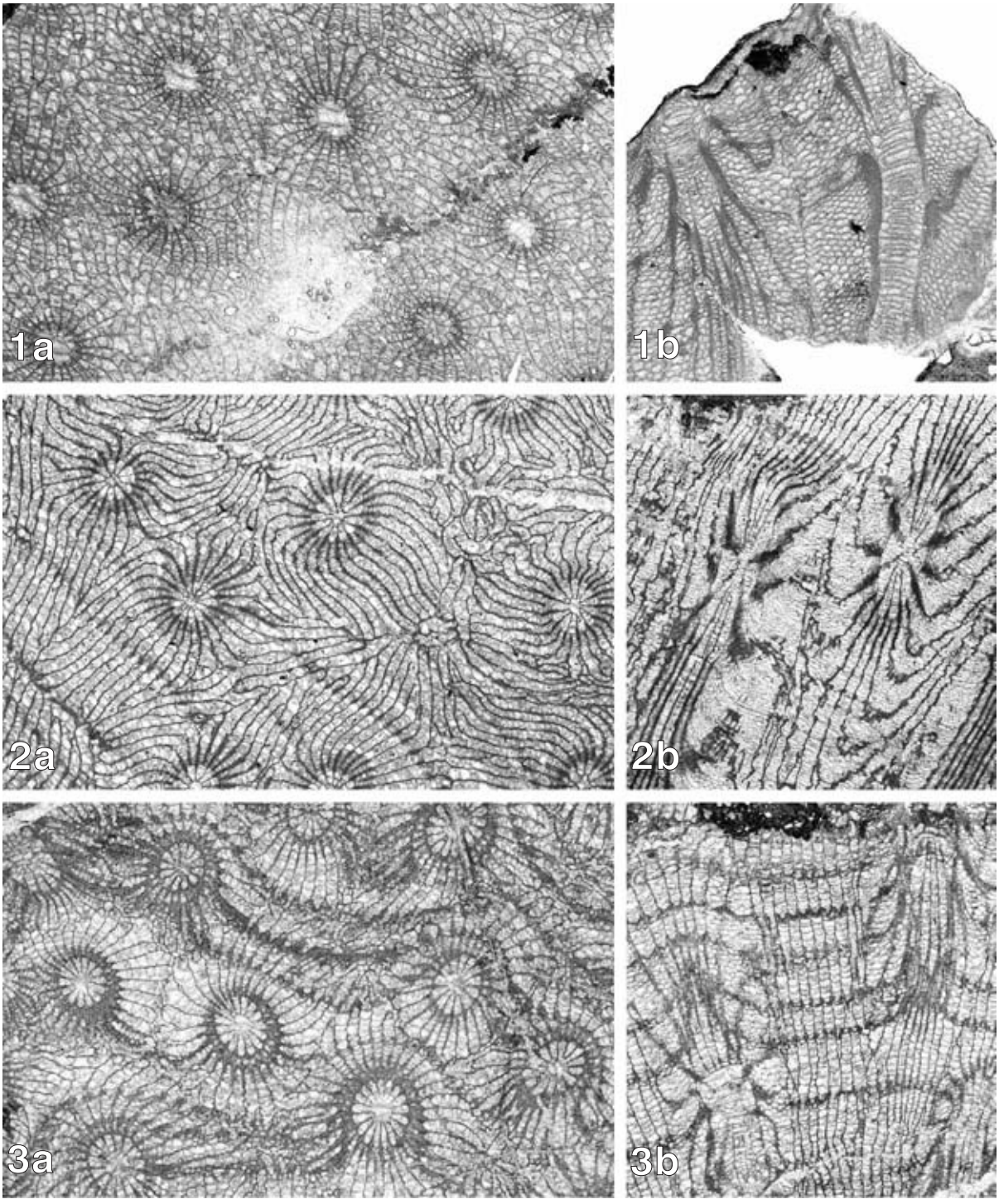

Fig. 5. *Phillipsastrea hennahii* (Fig. 5: 1) and *Phillipsastrea jachowiczi* sp. nov. (Figs 5: 2, 3), a – transverse, b – longitudinal sections; magnified × 3; 1 – OUM D520, Barton Quarry, Devonshire, England, Upper Givetian; 2 – GIUS 421LA 264 – the holotype of *Phillipsastrea jachowiczi* sp. nov., Laskowa Quarry, biolithites, Upper Givetian; septa arranged parallel to walls in some parts of the colony; 3 – GIUS 360SG 07, Sowie Górki quarry, set C, Jaźwica Member of the Kowala Formation, Upper Givetian; locally strong septal expansion, especially at tabularium / dissepimentarium boundaries

DIAGNOSIS: Astreoid to thamnasterioid species, with tabularium 2-3 mm in diameter and with 10-16 major septa; horseshoe dissepiments common (PP of 0.4 to 0.8); flat-topped tabellae in axis, downturned tabellae occuring at tabularium periphery.

OTHER MATERIAL: Five measured colonies: two from the Rhenish Slate Mountains of Germany (BIRENHEIDE 1990; ERRENST 1993); one from the Frasnian (?) of Armenia (SOSHKINA 1952); two from Asiatic Russia: one from the Upper Givetian of Kuzbass (BULVANKER 1958), one from the Frasnian of Northern Siberia (BESPROZVANNYKH & *al*. 1975).

DISCUSSION: There is some confusion in separating *Phillipsastrea hennahii* from *Medusaephyllum ibergense*. Based on the author's own material from the Harz Mts. (see chapter "Frasnian species close to *Ph. hennahii*", below), *M. ibergense* possesses a continuous series of thickened horseshoe dissepiments, and may thus be a "missing link" between the typically Givetian *Ph. hennahii* species group and the Late Frasnian massive Phillipsastreidae.

DISTRIBUTION: Upper Givetian of Devonshire (details in SCRUTTON 1968, pp 215-16), Upper Givetian to lowermost Frasnian of the Rhenish Slate Mts. (BIRENHEIDE 1990, ERRENST 1993), Upper Givetian of Kuznetsk Basin, Russia (BULVANKER 1958, pp 90-92), probable Frasnian of Armenia (SOSHKINA 1952, p. 102, fig. 145), and Frasnian of northern Siberia, Russia (SPASSKIY & KRAVTSOV in BESPROZVANNYKH & *al*. 1975, p. 61).

Phillipsastrea jachowiczi sp.nov.
(Text-figs 4.2-4.4, 5.2-5.3, 6, 7.1-7.3)

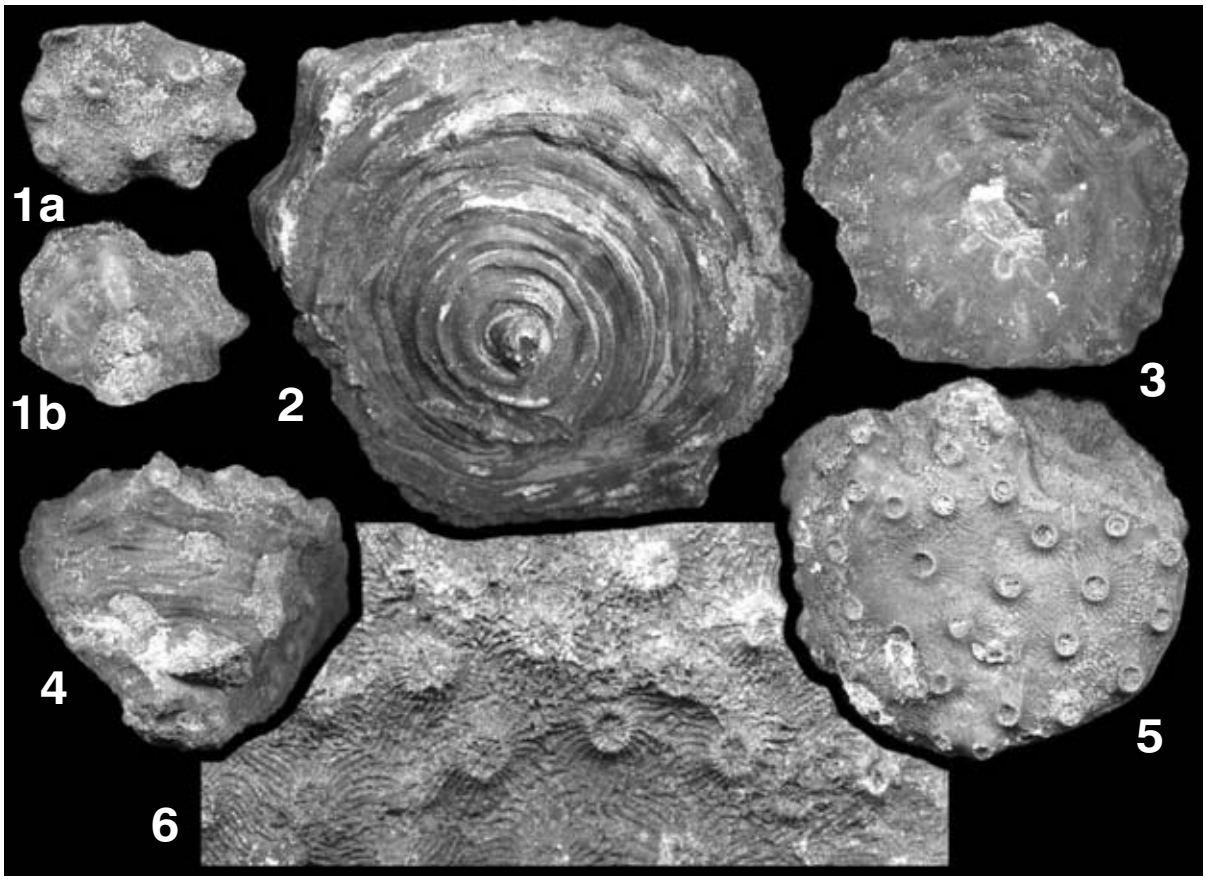

Fig. 6. Exteriors of colonies and colony fragments (?) of *Phillipsastrea* cf. *jachowiczi* sp. nov., Laskowa Quarry, biolithites, Upper Givetian; natural size, except for 6, which is × 2; 1 – GIUS 421LA 292 – distal (1a) and proximal (1b) view of a small colony (colony fragment?) with a dozen corallites; its apical angle is roughly 120 degrees; 2 – GIUS 421LA 297 - proximal view of a discoid colony with extreme development of transverse wrinkles at holotheca; 3 – GIUS 421LA 291 – as before, but weak development of transverse wrinkles and longitudinal striae at slightly eroded proximal surface; the attachment scar of the protocorallite is also visible; 4 – GIUS 421LA 293 – side view of a small colony with apical angle of *ca* 90 degrees and typically flat distal surface; 5 – GIUS 421LA 290 – distal view of a colony similar to the former; shrinking of colony size can be observed, as demonstrated by traces of a new holotheca, developing in the upper-right middle portion of this surface; 6 – enlarged (× 2) fragment of distal surface of GIUS 421LA 298, with weak intercorallite walls and prominent circumtabularial elevations corresponding to zones of horseshoe dissepiments

HOLOTYPE: GIUS 421LA 264 (Text-fig. 5.2).

TPYPE LOCATION & TYPE LEVEL: Laskowa Quarry at Kostomłoty, Poland; biolithites of set A, (RACKI & *al*. 1985, *hermanni-cristatus* to *disparilis* zonal interval; see also Text-figs 2-3, LA).

DERIVATION OF NAME: In honour of professor Aleksander JACHOWICZ (1928-1989), a student of Carboniferous spores, and organizer of the Faculty of Earth Sciences at the University of Silesia.

MATERIAL: Besides the holotype, 32 paratypes were cut and measured. In addition, 3 other colonies from the Holy Cross Mts. are included: from Sowie Górki (set C), Marzysz and Zelejowa (see Text-figs 2-3, SG, MA, ZL). Uncut specimens from Laskowa (see Text-fig. 6.1-6.6) are referred to herein as *Phillipsastrea* cf. *jachowiczi*.

DIAGNOSIS: Astreoid to thamnasterioid *Phillipsastrea* with tendency towards expansion of peripheral septal segments and diffusion of their trabeculae; intercorallite walls usually discontinuous in longitudinal sections, composed of dispersed trabeculae connected by intraseptal dissepiments.

EXTERIORS (Text-fig. 6): The specimens from Laskowa come from the marly interval and they give a rare oportunity to study the exteriors of these massive phillipsastreid colonies. The upper parts of the colonies

feature \ species	*Ph. ussheri*	*Ph. falsa*	*Ph. ranciae*	*Ph.* cf. *ranciae*	*Ph. hennahii*	*M. ibergense* large	*M. ibergense* small
CO	1	1	1	1	1	1	1
MU	3.5-4	3.5-4	3.5	3.5	3.5	4	3.5-4
SC	1	1	1	1	1	1	1
IN1	0.6;0.9	0.3-0.9	0.9-1	0.7	0.8-0.9	0.5	0.4-1
IN2	0.2-0.3	0.2-0.5	0.3	0.3	0.3;0.8	0.4	0.3-0.7
CA	0	0-1	0	0	0	0	0
TB	1.5-2	0.2-2	0.5-2	0.5	1.5-2	1.5	0-1
TC	0	0-0.3	0.2-0.8	0.2	0.3;1	0	0-0.8
PP	0.6-0.8	0-0.8	0-0.9	0	0.8-1	1	0.8-1
DIC	6-6.1	7-10.7	5.5-7.6	8.3	9.8-10.5	14.9	6.4-10.4
L/T	0.76	0.58-0.98	0.61-0.91	0.95	0.69-0.73	0.84	0.4-0.88
N/D1	6.14-6.55	4.81-6.63	4.82-7.0	5.06	4.39-5.39	4.02	3.44-4.48
N/D2	1.9-2.07	1.2-1.91	1.63-2.04	1.45	1.21-1.26	1.3	1.53-2.16
#S1	11.6-12.4	11.7-14	10-12.4	12	12.3-12.7	19.4	13.7-16.5
TM	1.77-2.02	2.04-2.73	1.48-2.57	2.37	2.28-2.89	4.83	3.08-4.75
L1	0.67-0.77	0.69-1.25	0.49-0.96	1.13	0.79;1.06	2.03	0.8-2.09
L2	0.07-0.08	0-0.22	0.01-0.04	0.05	0.08;0.2	0.33	0.07-0.63
D1	0.22-0.31	0.13-0.36	0.23-0.33	0.3	0.25	0.36	0.22-0.45
D2	0.11-0.13	0.08-0.24	0.14-0.25	0.23	0.19-0.2	0.31	0.12-0.34
TW	1.73-1.8	1.9-3.45	1.61-2.77	2.36	2;3.08	4.7	3.0-3.93
W	0-1	0-2	0	1	0	0	0-2
Z	5-7	3.5-8.3	4.5-6	9	8	4.7	2.3-5.5
AZ	40-70	65-90	73-80	73	40;75	40	50-75
AW	0-15	0-35	0	35	0	0	0-35
TT	0.18-0.31	0.17-0.29	0.23-0.29	0.24	0.23;0.4	0.38	0.35-0.5
D/L	2.51-3.23	0.98-3.26	2.31-2.43	3.04	2.1-2.13	0.93	0.91-2.11
N	2	13	3	1	2	1	5
area	Devonshire	Ardennes + HCMts	Ardennes	Ardennes	Angara + Armenia	Harz	Harz + Russia

Ph. = Phillipsastrea, *M. = Medusaephyllum*

Table 5. Frasnian corals close to *Phillipsastrea hennahii*

are typically flat or only slightly convex (Text-fig. 6.4), whereas their bases may be either flat (Text-figs 6.2, 6.3) or distinctly conical, with an apical angle of about 90 degrees (Text-fig. 6.4). Holothecae, when observable, are with dominating transverse (growth) wrinkles (Text-fig. 6.2). The longitudinal striae are observed only in

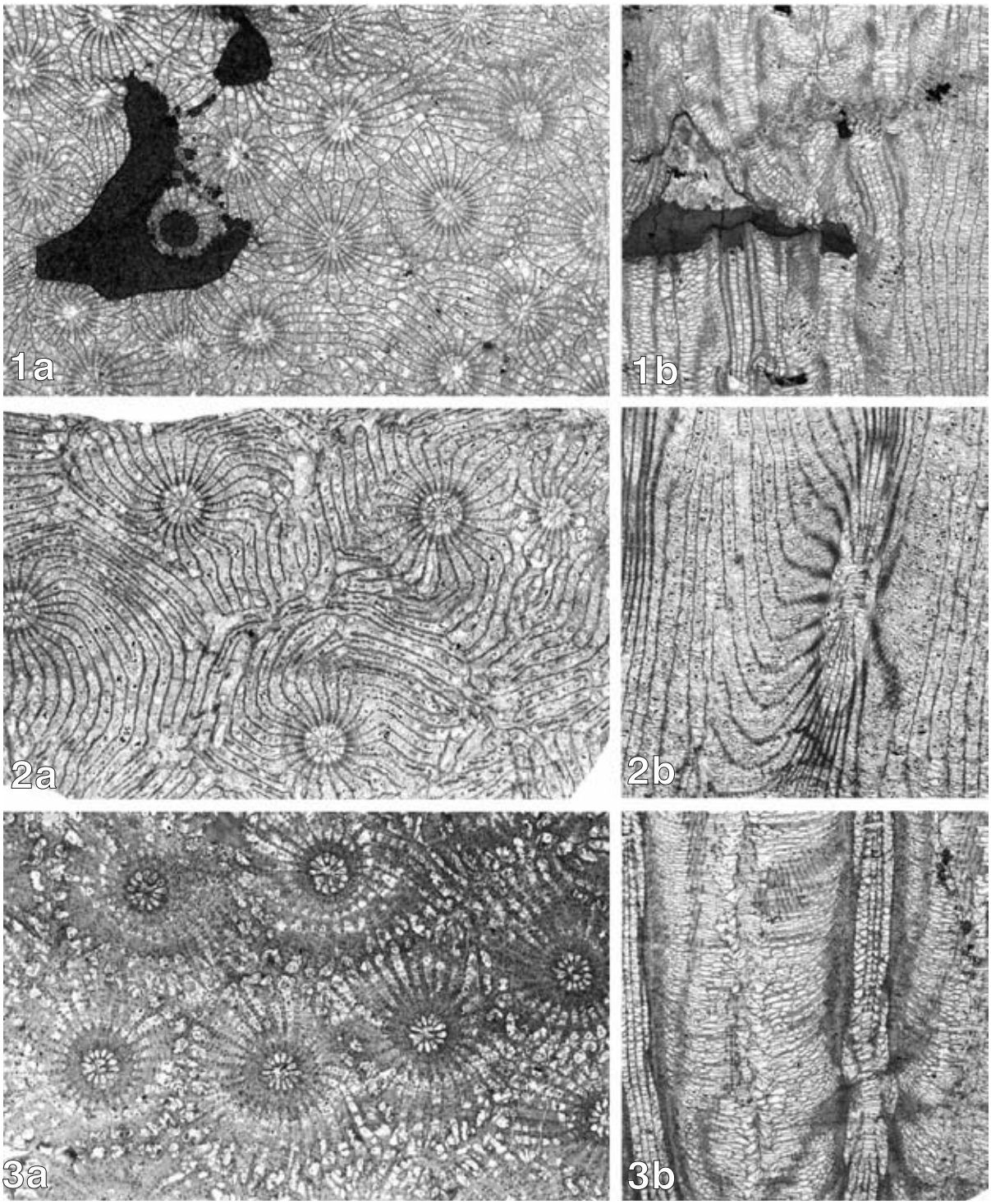

Fig. 7. Atypical colonies of *Phillipsastrea jachowiczi* sp. nov.; Laskowa Quarry, biolithites, Upper Givetian; magnified × 3; a – transverse, b – longitudinal sections; 1 – GIUS 421LA 251, a colony with very small corallites, and also with numerous intracolony voids; walls relatively well developed; 2 – GIUS 421LA 277, fragment of a colony with very rare horseshoe dissepiments and with intercorallite walls absent; 3 – GIUS 421LA 263, a colony with extremely strong septal expansion

slightly weathered specimens (Text-figs 6.1b, 6.3). The distal surfaces display strongly elevated horseshoe-pipes at the tabularium/dissepimentarium boundaries, and the intercorallite walls are weakly developed and inconspicuous (Text-figs 6.1a, 6.6). Denser packing of corallites and offsets can be observed at the colony margin (Text-fig. 6.5).

DESCRIPTION OF THE HOLOTYPE: GIUS 421LA 264 is a hemispherical colony or colony fragment, ca 120 mm × 180 mm × 110 mm in size (width × length × height). The intercorallite walls are weakly developed in transverse sections (Text-fig. 5.2a); in places thamnasterioid confluence of septa can be seen between the neighbouring corallites. Quite commonly, septa in the intercorallite area may form elongated zones, with septal segments apparently unconnected with any particular tabularium. The septa are generally smooth, though occasional carination is observed. The spindle-shaped septal expansion, so typical for the family Phillipsastreidae, is evident. Second order septa either do not enter the tabularia, or project only slightly into their lumina. In longitudinal sections (Text-fig. 5.2b), the tabularia show distally convex, occasionally mesa-shaped tabellae. The horseshoe dissepiments form a continuous series at the tabularium /dissepimentarium boundary; farther towards the corallite periphery, the dissepiments gradually change their orientation from steep, closer to the tabularium, to almost horizontal, within the intercorallite zones. Numerous discontinuities of walls are observed. The sections of septa within the intercorallite zones change slightly in orientation and thickness, giving a wavy appearance.

OTHER MATERIAL: Numerical data and scanned sections are presented at http://www.rugosa.wnoz.us.edu.pl/.

VARIABILITY IN *PHILLIPSASTREA JACHOWICZI* sp. nov. / QUINTILE ANALYSIS. The quintile analysis was performed for 33 colonies of *Ph. jachowiczi* sp.nov. from the Laskowa Quarry biolithites. The variability ranges for particular characters were divided into quintiles, corresponding to extremely low, moderately low, average, moderately high and extremely high values, and then the colonies were sorted to appropri-

	1st quintile outstanding low values	2nd quintile extreme low values	4th quintile extreme high values	5th quintile outstanding high values
IN2				LA263
CA			LA222	
PP	LA277	LA279		
DIC		LA251	LA168	
L/T		LA270 *ZL16*	LA250 LA252	
N/D2		LA168	LA251 LA272	
#S1		LA 06	LA256 LA267 LA269	
TM			LA220 LA256 LA269	
L1		LA251	LA269	
D1			LA263 LA266 LA267	
AZ		LA250 LA256 *ZL16*		
TT			LA268	
D/L		LA168 *SG07*	LA280	LA170

Table 6. Variability in *Phillipsastrea jachowiczi* sp. nov. – analysis of quintiles, paleophenon of Laskowa (N=33), with three other colonies (*italicised*) added

GIUS + ID number	extreme quintiles (1st or 5th)	medium quintiles (2nd or 4th)	"atypicality index" (ax5 + bx1)
	a	b	c
421LA 263	1	1	**6**
421LA 170	1		**5**
421LA 277	1		**5**
421LA 251		3	**3**
421LA 256		3	**3**
421LA 269		3	**3**
394ZL 16		2	**2**
421LA 168		2	**2**
421LA 250		2	**2**
421LA 267		2	**2**
360SG 07		1	**1**
421LA 06		1	**1**
421LA 220		1	**1**
421LA 222		1	**1**
421LA 252		1	**1**
421LA 266		1	**1**
421LA 268		1	**1**
421LA 270		1	**1**
421LA 272		1	**1**
421LA 279		1	**1**
421LA 280		1	**1**

Table 7. Variability in *Phillipsastrea jachowiczi* sp. nov. – summary of quintile analysis; Laskowa paleophenon, with three other colonies added

ate quintiles. The results of this classification are presented in Table 6, with the "average" quintile omitted for clarity. The characters with very low variability range are omitted from the analysis. Some other characters show asymmetrical distribution, i.e. without extreme specimens (in the 2nd or 4th quintile). Usually colonies of 1st or 5th quintile are rare. Results of this analysis are summarized for particular colonies in Table 7; each colony is given a numerical index corresponding to its "atypicality", calculated as the number of occurrences of the colony in the 1st or 5th quintile multiplied by 5, plus the number of occurrences in the 2nd or 4th quintile. The numerical weight of atypicality has been chosen arbitrarily, to emphasise outstanding values for particular characters, as this may indicate taxonomically suspect specimens. These values were added for all colonies; the numbers thus obtained range from 0 to 6, and may be regarded as a guideline to what is typical and what is atypical in the sample studied.

REMARKS: *Ph. jachowiczi* sp.nov. closely resembles *Ph. hennahii*, but its septa and inter-corallite walls are more complicated then in the latter species; the two are hardly distinguishable in their numerical characters. *Ph. sobolewi* (RÓŻKOWSKA) possesses significantly larger corallites (both DIC and TM parameters), and has more septa. Separation of *Ph. jachowiczi* from the remaining species of the *hennahii* group (listed in Table 3) is mostly by its complicated septal and wall structures (see Text-fig. 4). The numerical characters of these species overlap to a high degree (Table 3). However, with the exception of *Ph. jachowiczi* sp.nov. and *Ph. hennahii*, the samples of most of the species studied are rather small.

DISTRIBUTION: *Ph. jachowiczi* sp.nov. is known from the Laskowa Quarry, set A (RACKI & *al*. 1985, *hermanni-cristatus* to *disparilis* zones) at Kostomłoty (Text-figs 2-3, LA), from Sowie Górki Quarry, set C (Text-figs 2-3, SG) at Miedzianka (RACKI 1993, fig. 3, p. 177, Jaźwica Member - of the Kowala Formation - equivalents, lowermost *asymmetricus* Zone), from loose blocks at Marzysz (Text-figs 2-3, MA), and from Zelejowa Hill (Text-figs 2-3, ZL), possibly from the same horizon as in Sowie Górki (RACKI 1993, fig. 3).

Phillipsastrea sobolewi (RÓŻKOWSKA, 1956)
(Text-fig. 8.1-8.2)

1904. *Phillipsastraea hennani* LONSDALE; SOBOLEV, p. 38; pl. 5, figs 1-3.
1956. *Pachyphyllum sobolewi* sp.n.; RÓŻKOWSKA, p. 317; figs 37-39.
2003. *Phillipsastrea sobolewi* (RÓŻKOWSKA); FEDOROWSKI, p. 106; pl. 48, fig. 2.

TYPES: The holotype is the colony illustrated by RÓŻKOWSKA (1956, figs 37-39). The exact provenance of this specimen was not indicated by her, although the two outcrops in question, i.e. the exposures of the Pokrzywianka beds in Skały and Włochy, are very close to each other and are equivalent both stratigraphically and palaeoecologically (cf. WRZOŁEK 2002, fig. 2, for location). In the recent revision of the Devonian Rugosa from the Holy Cross Mts. (FEDOROWSKI 2003), the holotype of *Ph. sobolewi* was re-illustrated photographically, and its provenance indicated as *hermanni-cristatus* Zone of Skały.

EMENDED DIAGNOSIS: Massive phillipsastreid, astreoid/thamnasterioid, with large corallites, i.e. DIC of about 20 mm; about 20 major septa; horseshoe dissepiments usually forming a continuous series; skeletal elements typically thin or only moderately thickened.

NEW MATERIAL: 7 colonies measured.

DESCRIPTION: The sample studied is small and rather uniform. The colonies are of astreoid / thamnasterioid type, with a weak and rarely moderate septal thickening, both in respect of maximum thickness attained and in the length of the thickened septal segment. The carination is insignificant; tabularial floors are usually convex, sometimes slightly concave (Text-fig. 8.2). The horseshoe dissepiments form typically a continuous series. The corallites are very large, with their DIC ranging from 18.2 to 24.3 mm. These are the largest corallites observed among all of the Givetian colonies studied; only a few of the largest corallites in *Ph. hennahii* (population from Laskowa) can attain this size. The number of septa is about 20, with mean values ranging between 18.6 and 21 per colony. The tabularia are about 5 mm in diameter. The major septa reach well into the tabularium, usually with only a small axial space left without septa. The minor septa are very short and do not occur in the tabularium. As may be expected for such large corallites, numerous series of internal dissepiments can be observed adaxially to the horseshoe dissepiment series, 2 to 4 series on average. The peripheral platforms are usually strongly reflexed, with AZ angle from 45 to 60º. Delicate carination is seen in some colonies, especially at the corallite periphery and at inter-corallite walls (compare Text-fig. 8.1c and 8.2c).

REMARKS: The exceptionally large corallites and the numerous septa make *Phillipsastrea sobolewi* a

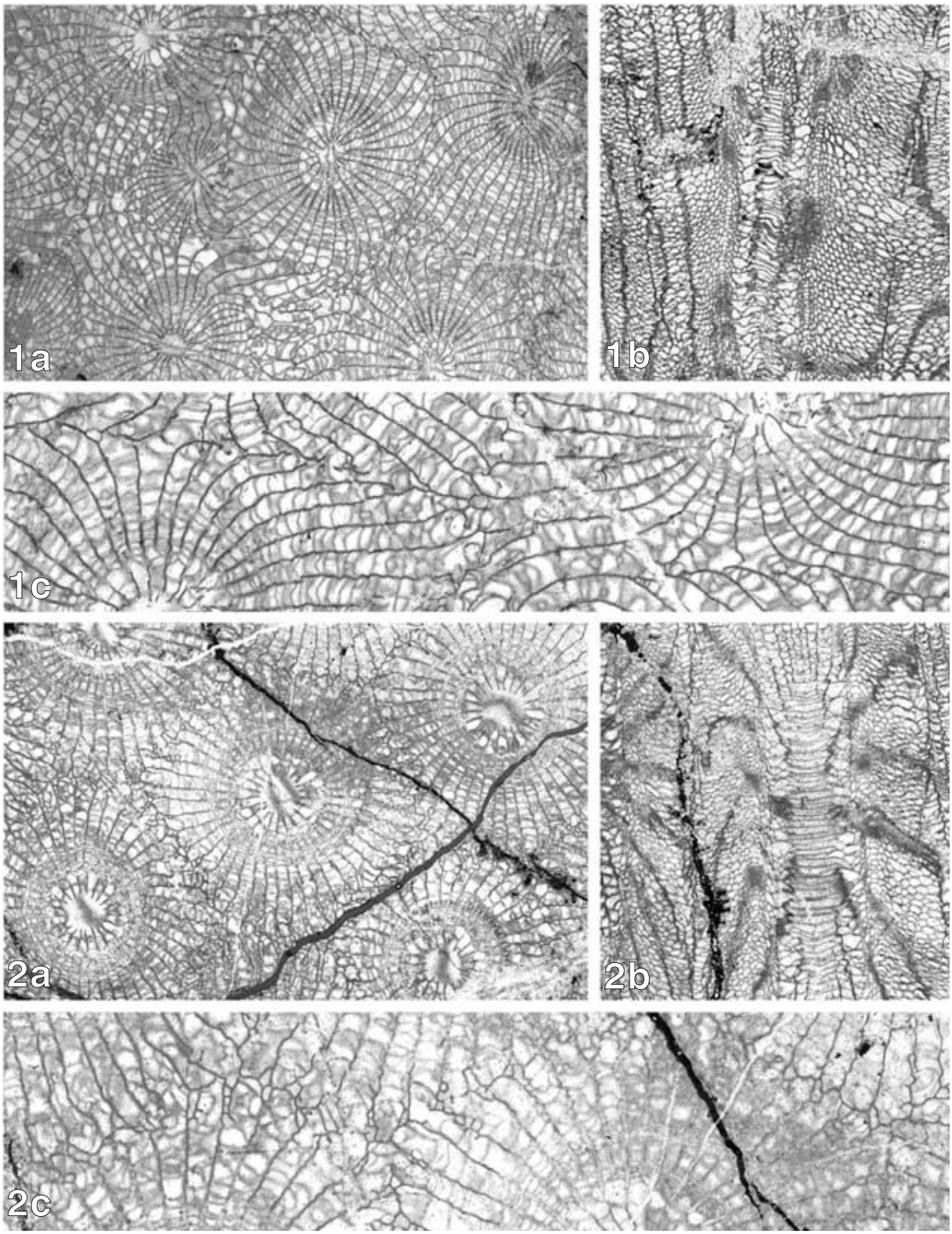

Fig. 8. *Phillipsastrea sobolewi* (Różkowska), topotypes from Włochy, Pokrzywianka beds, Middle Givetian, *varcus* Zone; a – transverse, b – longitudinal sections; magnified × 3, c – enlarged detail of transverse section; magnified × 6; 1 – GIUS1524PW 51, without septal carination; 2 – GIUS1524PW 52, with slightly carinated septa and inter-corallite walls

unique species among the massive phillipsastreids studied, at least in the Givetian or stratigraphically older material.

DISTRIBUTION: The species is known exlusively from its type location, i.e. Middle Givetian Pokrzywianka beds (Middle to Upper *varcus* zones according to MALEC & TURNAU 1997 and TURNAU & RACKI 1999) of Skały and Włochy, Łysogóry region of the Holy Cross Mountains, Poland (Text-figs 2-3, PK and PW).

IBERIAN SPECIES of the *Ph. hennahii* species group

Two morphotypes were distinguished among the eight colonies studied from the Cantabrian Mountains, northern Spain (Table 3, geography as "Spain" and illustrated in Text-fig. 9.2 and Text-fig. 9.1). They correspond to *Phillipsastrea torreana* (MILNE-EDWARDS & HAIME 1851), the lectotype of which was designated and illustrated by COEN-AUBERT (2002, pl. 4, figs 1-2; pp 30-31) and *Ph. "pradoana" sensu* PICKETT (1967, figs 12, 16) [*non Argutastrea pradoana* (HAIME in de VERNEUIL & BARRANDE 1855) of COEN-AUBERT (2002, p. 33, pl. 4, figs 3-4)]. Both morphotypes differ in the strong expansion of skeletal elements, and corallite size, which is larger in *Ph. "pradoana"*, but they may well represent a single species. More material is needed in order to give a final conclusion on this point.

Ph. torreana, as understood in this paper, is morphologically very close to *Ph. hennahii*, from which it differs only in a higher number of septa in some of its colonies, by somewhat larger tabularia and longer septa (see Table 3).

GONDWANAN SPECIES of the *Ph. hennahii* species group

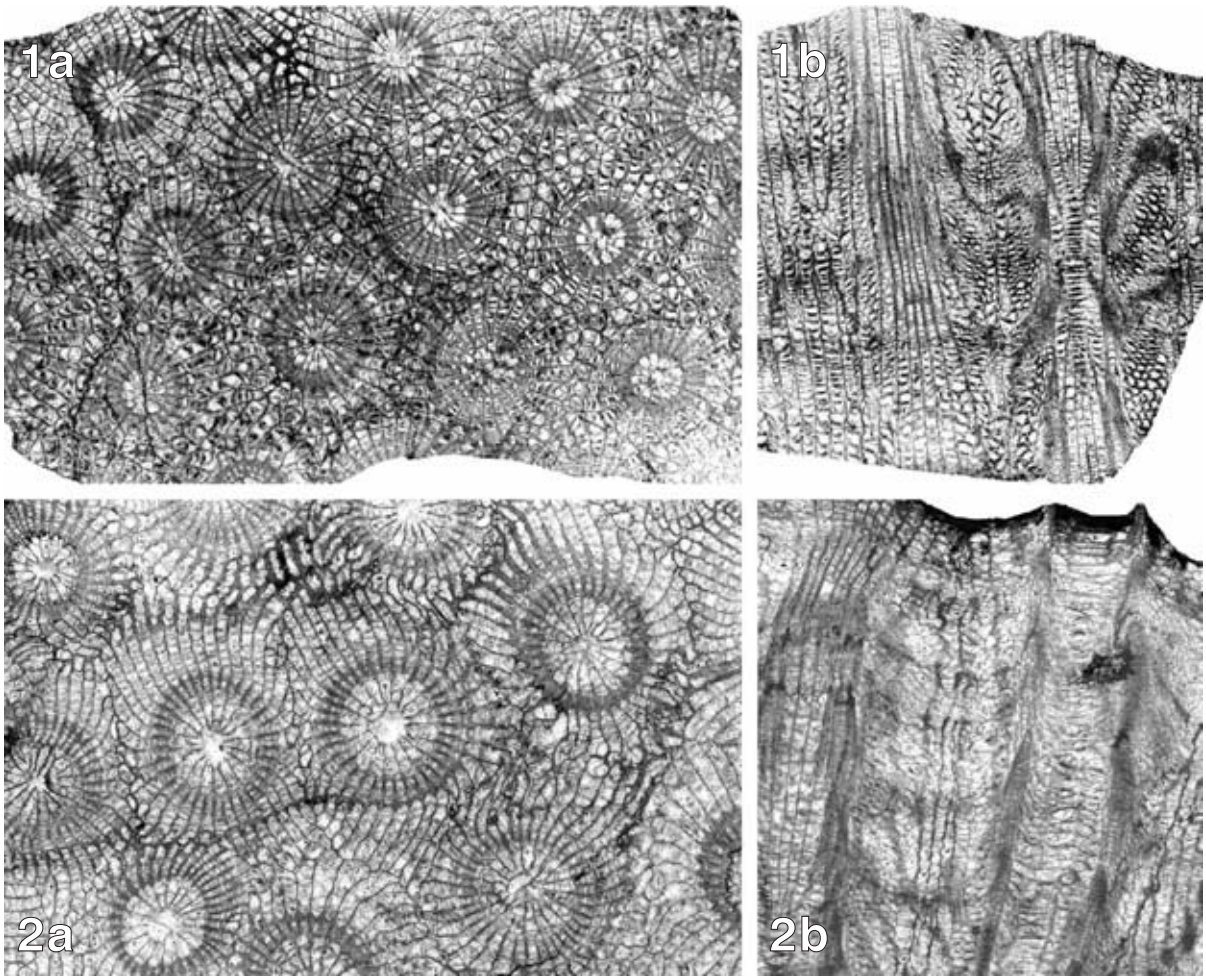

Fig. 9. Species of the genus *Phillipsastrea* from the Upper Givetian of the Cantabrian Mts, Spain; a – transverse, b – longitudinal sections; magnified × 3; 1 – *Phillipsastrea "pradoana"*, with smaller corallites, GIUS1530ES 03-03, Beberino, Portilla Formation; 2 – *Phillipsastrea torreana*, with larger corallites, GIUS1530ES 10-03, Peran, Candas Formation

Among five species of the group known from the Devonian of North Africa, three were described recently from the Upper Givetian by COEN-AUBERT (2002). These are: *Phillipsastrea weyeri*, *Ph. hollardi* (possible synonym of the former), and *Ph. tafilaltensis* (Table 3, Text-fig. 10). *Ph. weyeri* is very similar to *Ph.*

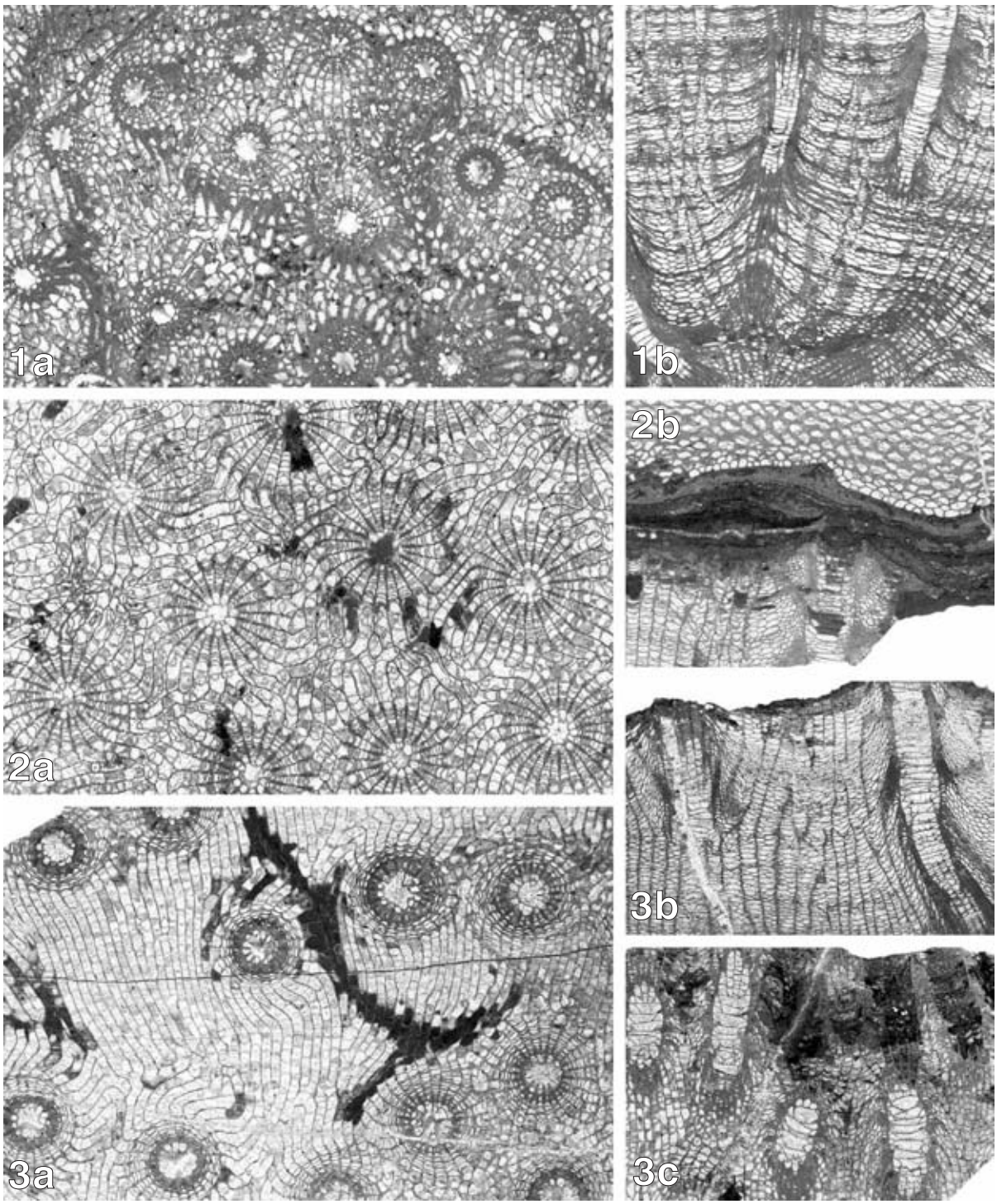

Fig. 10. Upper Givetian representatives of *Phillipsastrea* from Morocco, Ma'ader, Ait ou Amar, *disparilis* Zone; a – transverse, b, c – longitudinal sections; magnified × 3; 1 – *Phillipsastrea hollardi* COEN-AUBERT, GIUS2447MAA 01; 2 – *Ph. weyeri* COEN-AUBERT, MBK1578-3A; 3 (a, b, c) – *Ph. tafilaltensis* COEN-AUBERT, MBK1578-1a+b –less (as 1578-1a) and more densely packed (as 1578-1b) parts of this dimorphic colony were measured separately; 3b and 3c – longitudinal sections through loose and dense part of this colony respectively

hollardi (see Table 3) in its numerical characters (compare also Text-fig. 10.2 and 10.1); it differs from the latter species in possessing fewer horseshoe dissepiments, in a higher number of septa, and in a larger tabularium. *Ph. tafilaltensis* (Text-fig. 10.3) differs from the two other species in its more numerous horseshoe dissepiments; it is very similar to *Ph. hennahii* in its rather small-sized tabularium and low septal number.

Two additional African taxa which possibly belong to the *Ph. hennahii* group are *Pachyphyllum chenouensis*, reported from the Devonian of Algeria (SEMENOFF-TIAN-CHANSKY & *al*. 1962), and *Ph.* sp.nov. aff. *irregularis*, from the Upper Givetian or Lower Frasnian of Samra in Morocco (SCHRÖDER & WERNER 2000). Both species are treated further in the following section.

DUBIOUS SPECIES with affinity to *Ph. hennahii* species group

These are nine species represented by single specimens. Their numerical characters are given in Table 4, and they are briefly presented below:

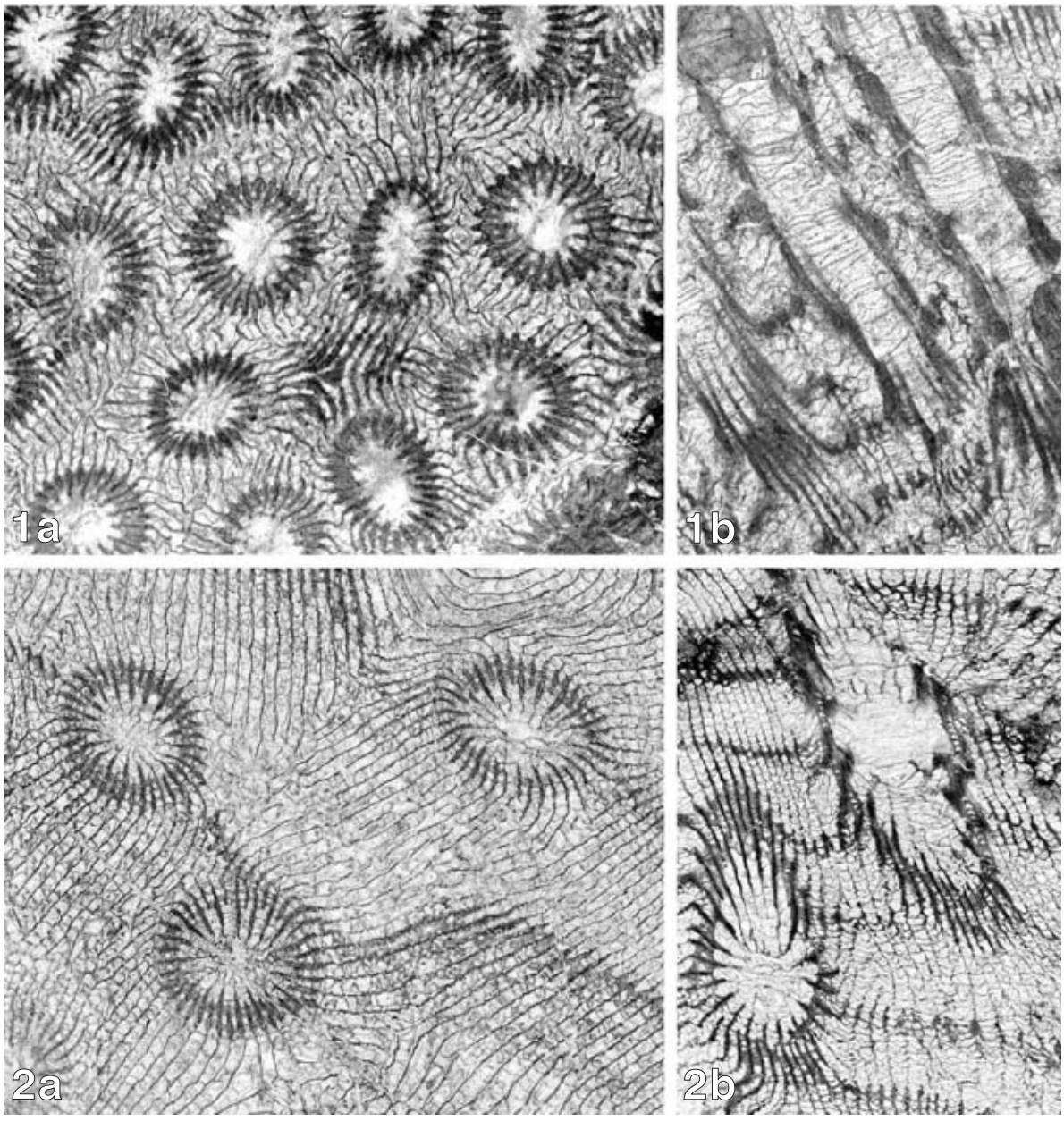

Fig. 11. *Medusaephyllum ibergense* ROEMER, Harz Mts., Rübeland, Iberg Limestone, Lower Frasnian at this location; a – transverse, b – longitudinal sections; magnified × 3; 1 – GIUS1529HZ 17I, variety with small corallites; 2 – GIUS1529HZ 17A, variety with large corallites

Ph. primitiva and *Ph. producta*, described by JIN & HE (1981, pl. 29, fig. 6 and pl. 31, fig. 6 respectively), both from the Lower Devonian of Guangxi (South China), are known to the author exclusively from illustrations that suggest their similarity to species of the *Ph. hennahii* group. Although this affinity is suggested by comparison of their numerical characters (Tables 3-4), *Ph. primitiva*, at least, is of distinctly aphroid aspect and most closely resembles the Late Frasnian *Medusaephyllum progressum* (RÓŻKOWSKA 1953).

Also very close to *Ph. hennahii* is *Phillipsastrea enbyskae*, described by SORAUF (1972, pl. 2: 3-5) from the Eifelian /? Givetian of Washington, western North America. However, the septa between the tabularia in *Ph. enbyskae* are reduced.

Frechastraea pentagoniformis (see TSYGANKO 1981, pl. 30, figs 1-2), from the Givetian of the Polar Urals should be included in *Phillipsastrea*, as suggested by its relatively common horseshoe dissepiments (PP of 0.3). In contrast to the other species of the *Ph. hennahii* group it is markedly thamnasterioid in habit rather than astreoid / thamnasterioid.

Pachyphyllum giveticum IVANIYA in ZHELTONOGOVA & IVANIYA 1961, from the Givetian of Gornyi Altai, Russia, possesses a large septal number for a moderately large tabularium; otherwise it is identical to *Ph. hennahii.*

Pachyphyllum intermedium IVANIYA 1953, from the Lower Frasnian of Kuzbass, Russia (measured in IVANIYA in ZHELTONOGOVA & IVANIYA 1961), has a large tabularium and distinct septal reduction within dissepimentaria (aphroid colony), which easily distinguishes it from all of the other species. It should possibly be placed in *Phillipsastrea*.

Pachyphyllum chenouensis SEMENOFF-TIAN-CHANSKY & *al*., 1962, from the Devonian (Givetian or Frasnian) of Algeria has moderately large corallites, characterised by very large tabularia and septal numbers; it should be placed in *Phillipsastrea.*

Phillipsastrea sp.nov. aff. *irregularis* (WEBSTER & FENTON 1924), described by SCHRÖDER & WERNER (2000) from the Upper Givetian / Lower Frasnian of Morocco is quite similar to *P. chenouensis*, with the exception of septal carinae, which are present on some of its septa.

Phillipsastrea xinhuanense JIANG 1982, described from the Frasnian of Hunan, China, is a typical *Ph. hennahii* in respect of its numerical characters; it differs in its atypical (distinctly longer) major septa.

FRASNIAN SPECIES close to *Ph. hennahii*

Besides the Frasnian corals referred to *Ph. hennahii* (Siberia and Armenia) and/or listed as "dubious" (*Ph. intermedia*, *Ph. xinhuanense* and possibly *Ph. chenouensis*), there is one other possibly related species, namely *Medusaephyllum ibergense*, described by ROEMER from the Harz Mts., Germany. Based on the Early Frasnian colonies of this species from my own collection from the Harz Mts. (this material comes from Rübeland, thus it is not strictly topotypical; the type material of Roemer's species comes actually from the Winterberg Quarry, and is possibly Late Frasnian), it is suggested that ROEMER's original material is polyspecific (confirming the opinion of BIRENHEIDE 1978, p. 117). The material may be split into two species; one with small and the other with very large corallites. Both forms are characterised by thickened horseshoe dissepiments (see Table 5; Text-fig. 11). Re-study of ROEMER's type material is needed (as indicated by MCLEAN 1994a, p. 53), to better understand these possible evolutionary links between the Givetian and Late Frasnian massive phillipsastreids.

Morphologically close to *Ph. hennahii* are the Upper Frasnian *Phillipsastrea ussheri* SCRUTTON, 1968 from Devonshire and *Ph. ranciae* COEN-AUBERT, 1987 (*Ph.* cf. *ranciae* including) from the Ardennes. Both the latter species are characterised by small corallites and a low septal number, and may appear consepcific.

Phillipsastrea falsa COEN-AUBERT, 1987
(Text-fig. 12.1-3)

1987. *Phillipsastrea hennahi falsa* ssp.n.; COEN-AUBERT, p. 47; pl. 1, figs 1-4) (*cum synonyma*).

MATERIAL: Four colonies from the Holy Cross Mts., Poland; nine colonies from the Ardennes (Table 5, Text-fig. 12).

REMARKS: The material with a mixed astreoid/thamnasterioid aspect coming from the Holy Cross Mts. is rare but morphologically diverse. Its variability lies in septal thickening and carination, and in corallite sizes (Table 5; Text-fig. 12 – compare Text-fig. 12.1 and 12.2). The material from the Ardennes is represented by a larger number of colonies and is more uniform in respect of its numerical characters (e. g. Text-fig. 12.3; Table 5).

Ph. falsa shows a high degree of overlap of the variability ranges of its particular numerical characters with *Ph. hennahii*; only the number of horseshoe dissepiments is slightly higher than in the latter species. This was the reason for treating this taxon as a subspecies of *Ph. hennahii* in the original description. In view of the disjunct stratigraphical distribution of these two taxa, *Ph. falsa* is elevated herein to specific rank.

OCCURRENCE: In the Holy Cross Mts., *Ph. falsa* occurs in the marly-detrital limestones cropping out in

the fields of the village of Janczyce (Text-fig. 2, JN), in the marly-detrital unit of the road-cutting section in Kowala (Text-figs 2-3, KD, see details in RACKI 1993, text-figs 3, 42, p. 178), in detrital limestones of set G in Kowala Quarry (Text-figs 2-3, KK; see RACKI 1993, figs 3, 8B, 42, p. 178), and in the western Wietrznia Quarry (Text-figs 2-

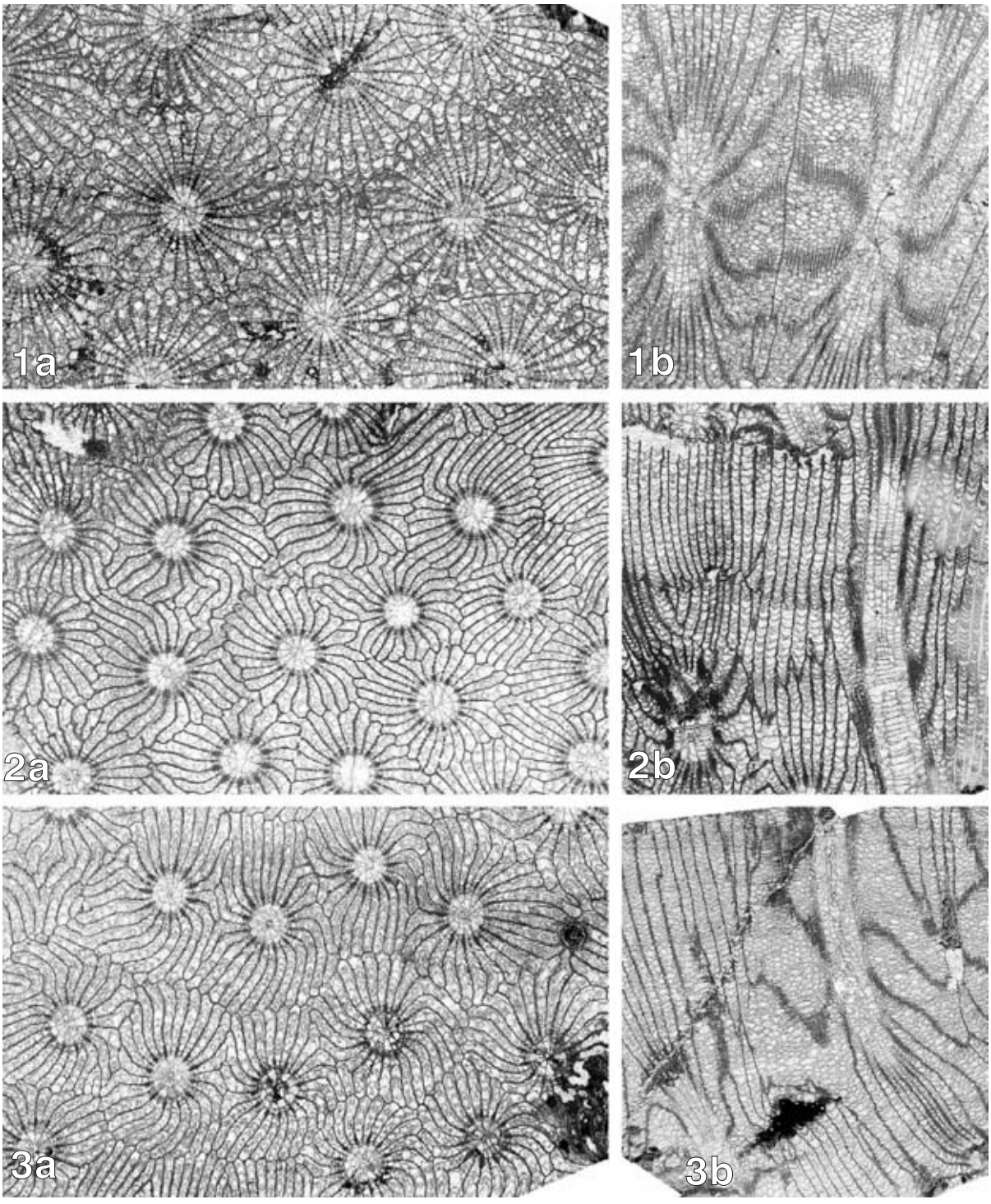

Fig. 12. *Phillipsastrea falsa* COEN-AUBERT, Upper Frasnian; a – transverse, b – longitudinal sections; magnified × 3; 1, 2 – material from the Holy Cross Mts.; 1 – GIUS 379JN 34-01, Janczyce, eastern Holy Cross Mts., colony with strongly carinate septa; 2 – GIUS 388KK101, Kowala Quarry, set G, colony with small corallites and smooth septa; 3 – specimen from the Ardennes, Upper Frasnian of the railway-cutting at Neuville; GIUS 389F 61, very similar to the specimen from Kowala, shown above

3, W; see RACKI 1993, fig. 3, pp 172-3), where it was collected as a loose block, derived from detrital limestones of set D, thus of either Middle or Late Frasnian age.

CONCLUSIONS

1) The *Phillipsastrea hennahii* species group is characterized by astreoid/thamnasterioid colonies, common occurrence of horseshoe dissepiments, and everted dissepimentaria.

2) The *Phillipsastrea hennahii* species group is represented by seven Givetian species (Tables 2, 3; Text-figs 4-10), inhabiting southern marginal seas of Euramerica (Devonshire, England; Rhenish area, Germany; Holy Cross Mountains, Poland), the Iberian microcontinent and northern Gondwana; a few occurrences are recorded in the Frasnian of Russia: Kuznetsk Basin and Siberia.

3) Predecessors of the *Phillipsastrea hennahii* species group should possibly be sought for among the "dubious" species, similar to *Ph. hennahii* (Table 4), from the Emsian of south China and the Eifelian / Givetian of western North America.

4) The Early Frasnian *Medusaephyllum ibergense* from the Harz Mountains (Text-fig. 11) may represent a descendant of the *Phillipsastrea hennahii* species group.

5) The Late Frasnian species, *Ph. falsa* (Text-fig. 12), *Ph. ussheri* and *Ph. ranciae*, are very similar to *Ph. hennahii*. Because of a significant stratigraphical hiatus between them (Givetian *Ph. hennahii* and Late Frasnian *Ph. falsa*), they are regarded as members of a younger species group, probably representing the astreoid/thamnasterioid end-members of the predominantly astreoid *Ph. ananas* species group.

6) In the Holy Cross Mts., the *Phillipsastrea hennahii* species group is represented by the Middle Givetian *Ph. sobolewi* (RÓŻKOWSKA), with very large corallites and simple septal structure (Text-fig. 8), and by the Late Givetian *Phillipsastrea jachowiczi* sp.nov., with smaller corallites, but with complicated septal and wall structure (Text-figs 4-7).

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