Middle Carboniferous to Early Permian bryozoans from Spitsbergen

HANS ARNE NAKREM

Nakrem, H.A. 1994. Middle Carboniferous to Early Permian bryozoans from Spitsbergen. *Acta Palaeontologica Polonica* **39**, 1, 45–116.

Bryozoans from the Nordenskiöldbreen Formation (Middle Carboniferous Moscovian through Early Permian Sakmarian) and the Gipshuken Formation (late Sakmarian – late Artinskian), from central Spitsbergen, Svalbard, are represented by 36 species (22 genera). One species is new: *Hinaclema svalbardensis* of the order Trepostomata. The bryozoan fauna is typical Boreal and resembles those from the Timan-Pechora region (western Siberia) and the Urals. Similarity indices based on generic composition show that the Boreal fauna became more endemic by the late Early Permian, clearly separated from the Tethyan faunas. Several species have stratigraphic ranges in Spitsbergen longer than elsewhere.

Key words: Bryozoa, Carboniferous, Permian, biostratigraphy, biogeography, Spitsbergen, Svalbard.

Hans Arne Nakrem, Paleontologisk Museum, Universitetet i Oslo, Sars' gate 1, N-0562 Oslo, Norway.

Introduction

Bryozoans have been previously described from the ?Kungurian-Late Permian Tempelfjorden Group of Svalbard (e.g. Morozova & Kruchinina 1986; Nakrem 1991a). Only summary distributions have been outlined for the Middle Carboniferous-Early Permian Gipsdalen Group (Nakrem 1991a; Nakrem *et al.* 1992). A single occurrence of *Archimedes* was, however, reported by Czarniecki (1964) from southern Spitsbergen, and *Streblascopora fasciculata* (Bassler 1929) from Polakkfjellet by Małecki (1977), both records from strata equivalent to the Tyrrellfjellet Member in the present study (see Fig. 1A).

Most previous descriptions have been based on material from Spitsbergen, the largest island in the Svalbard Archipelago which comprises all islands situated in the area 74–81°N, 10–35°E. In older usage, prior to the

Svalbard Treaty of 1920, Spitsbergen was named Vestspitsbergen, and the island group was named Spitsbergen.

The study of Late Palaeozoic bryozoans from Svalbard of which the present contribution is a part of was initiated when bryozoan remains were found in cutting samples (IKU Petroleum Research, Trondheim; in-house data) from the south-western Barents Sea. Subsequent shallow drillings in 1987–1988 provided additional material which will be described and published at a later stage. The aim of the bryozoan project is to describe the faunal composition, and to access its possible biostratigraphic value for dating on-shore sections in Svalbard as well as subsurface rocks in the Barents Sea. The bryozoan faunas of Svalbard also have important palaeobiogeographic implications, as they act as faunal links between the rich faunas known from the Timan-Pechora Basin (Nikiforova 1938; Morozova & Kruchinina 1986) in the east and the Sverdrup Basin (Morozova & Kruchinina 1986) and the Wandel Sea Basin (Ross & Ross 1962; Madsen & Håkansson 1989) in the west. All these basins were included in the Franklinian Shelf in the bryozoan palaeobiogeographic reconstructions by Ross (1981) and Ross & Ross (1990) (Fig. 2).

Geological framework

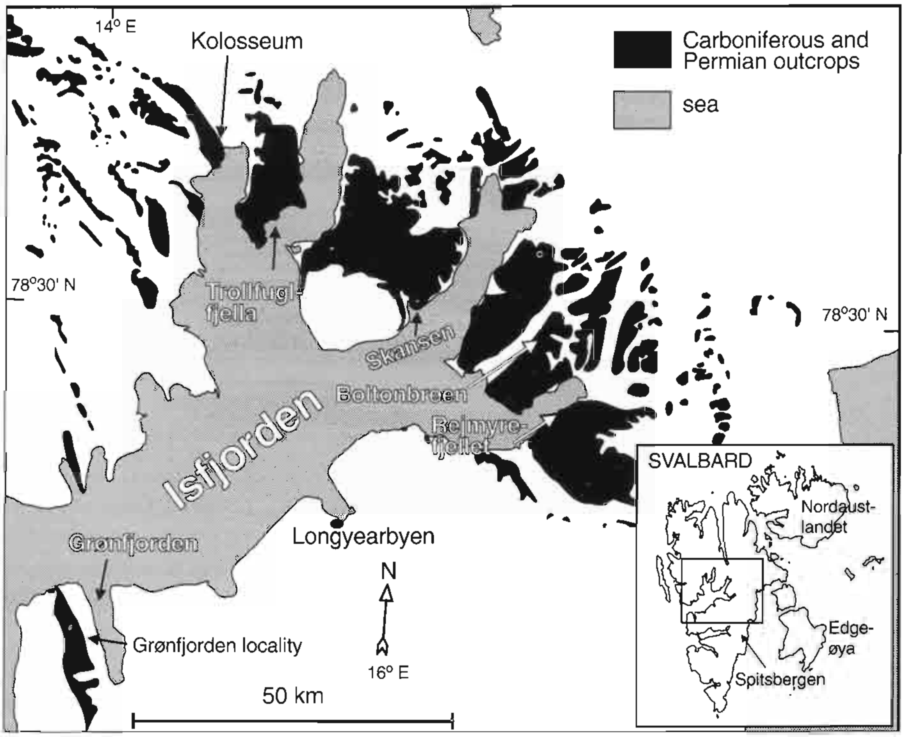
Lithostratigraphy. — The Late Palaeozoic rocks of Svalbard are divided into two major lithostratigraphic units: the Carboniferous – Early Permian Gipsdalen Group and the ?Kungurian – Late Permian Tempelfjorden Group (Cutbill & Challinor 1965). In the investigated area of western and central Spitsbergen, the Gipsdalen Group is represented by the Nordenskiöldbreen and the Gipshuken formations. The Nordenskiöldbreen Formation is divided into several members of which the upper Kapitol and Cadellfjellet (lateral equivalents) and the Tyrrellfjellet members (Cutbill & Challinor 1965) were collected for bryozoans (Fig. 1A).

In Late Carboniferous through Early Permian time Svalbard was situated in a sub-tropical position and drifted northwards from 25°N to 35°N. Deposition of dominantly carbonates took place under warm and humid, and later arid, conditions. The Nordenskiöldbreen Formation consists mainly of limestones and dolomites with less common clastics; the overlying Gipshuken Formation, deposited under evaporitic conditions is made up of anhydrite, dolomite, intraformational breccias and less common limestone intervals (Steel & Worsley 1984; Worsley *et al.* 1986; Keilen 1992).

Biostratigraphy. — A comprehensive re-investigation of the fusulinid faunas in the Nordenskiöldbreen Formation has been carried out recently, and new age determinations have been proposed for different parts of this formation (Nilsson 1988; Nilsson & Davydov in press). Conodonts occur sparsely in the Late Palaeozoic rocks of Svalbard (Nakrem 1991b), but a conodont based zonation is still to be completed. Palynomorphs have also

		STAGE	GROUP	FORMATION	MEMBER
PERMIAN	LATE	TATARIAN			
			?	?	?
		KAZANIAN-UFIMIAN	TEMPEL-FJORDEN	KAPP STAROSTIN	HOVTINDEN-SVENSKEGGA
	EARLY	KUNGURIAN			VØRINGEN
		ARTINSKIAN	GIPS-DALEN	GIPSHUKEN	
		SAKMARIAN			
		ASSELIAN		NORDEN-SKIÖLD-BREEN	TYRRELL-FJELLET
CARBONIF.	LATE	GZHELIAN			
		KASIMOVIAN			KAPITOL/ CADELL-FJELLET
	MID.	MOSCOVIAN			

A



B

Fig. 1. ❑A. Lithostratigraphic units and their ages, based on Cutbill & Challinor (1965), Nakrem *et al.* (1992), and Nilsson & Davydov (in press). ❑B. Locality map, western Spitsbergen, indicating sampling localities, Carboniferous and Permian outcrops based on Winsnes (1988). Inset map of Svalbard with framed locality map.

been described from the Permian of Svalbard (Mangerud & Konieczny 1993). The Gipshuken Formation contains few age diagnostic fossils, although smaller foraminifera, brachiopods, palynomorphs and a single conodont occurrence have been recorded (Nakrem *et al.* 1992). A biostratigraphic review of the Permian (and latest Carboniferous) of Svalbard is given in Nakrem *et al.* (1992).

Bryozoan samples were collected from the same sections as those for fusulinids, conodonts and palynomorphs, and the age of these samples is therefore precisely known. Fusulinid and conodont co-occurrences with the described bryozoans are noted where possible in the systematic section, and in the distribution charts. Sampled intervals range from Middle Carboniferous Moscovian through Early Permian ?late Artinskian.

Material and methods

Field work was carried out in western and central Spitsbergen during IKU Petroleum Research expeditions in 1985 and 1986. Bryozoan samples (with personal sample codes used in the systematic description of bryozoan taxa) were collected from Kolosseum (KOL), Trollfuglfjella (TRO), Skansen (SKA), Gipsvika (GIP) and Rejmyrefjellet (REF) (Fig. 1B). All material was collected by the author, except where noted in the systematic description. Additional specimens from Grønfjorden and Boltonbreen (BOLT-B2) have been selected from the collections of the Paleontologisk Museum in Oslo. Material was collected from 45 horizons, most of them with bryozoans visible during field inspections. Some intervals without visible bryozoans were also collected from which few bryozoan identifications could be made during laboratory sectioning.

Most bryozoan samples were collected from limestone beds, in which dolomitization and silicification have commonly taken place. In many samples, chemical alteration hinders observation (preservation) of microscopic details (Fig. 3). Physical damage, e.g. abrasion due to extensive transportation is seldom observed, although most delicate fenestrate colonies are preserved as small fragments.

Laboratory techniques include thin sectioning and preparation of acetate peels, with identifications in most cases made from acetate peels. Dolomitized and partly silicified bryozoans were usually identified from petrographic thin sections. Some distinctive genera were also identified from hand specimens, e.g. *Coscinium* and *Archimedes*.

Bryozoans are not very common in the investigated successions; when present they are usually fragmented and embedded in solid limestone or dolomite. It was not possible to obtain isolated specimens for accurate external investigation. 36 species, belonging to 22 genera are described in the systematic section, many of which are placed in open nomenclature due to insufficient material or poor preservation. The general diversity is moderate and few specimens of each taxa were found sufficiently well

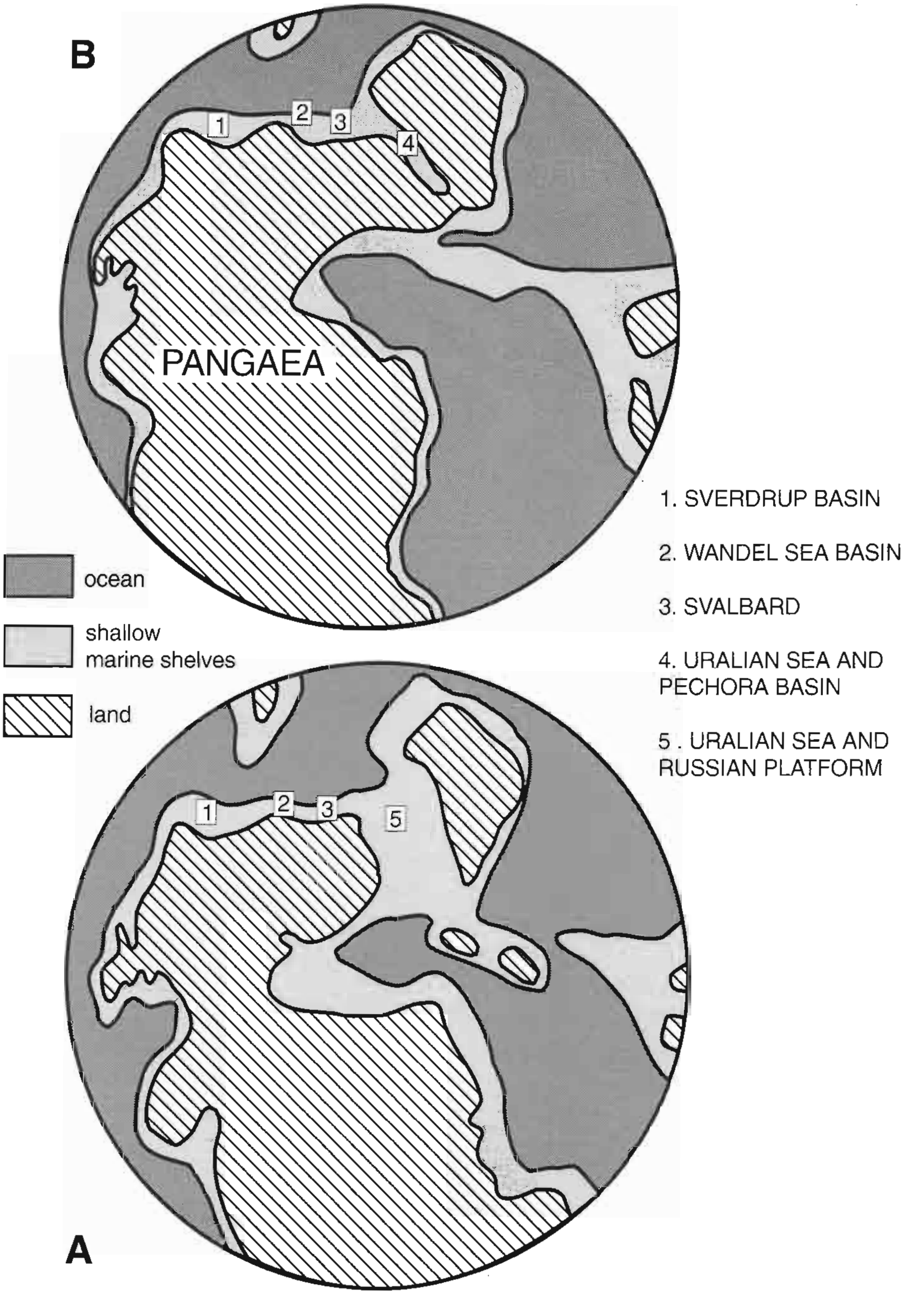


Fig. 2. Simplified palaeogeographical maps for Late Carboniferous (A) and late Early Permian (B); based on Ross & Ross (1990) with Svalbard and surrounding palaeobasins indicated.

preserved for treatment. Some additional indeterminate species are drawn in the distribution charts (Fig. 4).

All described and illustrated specimens are in the collections of the Paleontologisk Museum, Oslo (abbreviated PMO).

Faunal dynamics

Morozova & Kruchinina (1986) presented a biostratigraphic scheme for the Late Palaeozoic of Arctic Canada (mainly Ellesmere Island), Svalbard, Timan-Pechora/Polar Urals and Novaya Zemlya in which the correlative value of bryozoans was outlined. Time equivalent bryozoan faunas of northern affinity are also known from eastern North Greenland (Ross & Ross 1962; Madsen & Håkansson 1989). Except for the Timan-Pechora and Polar Urals faunas, the mentioned investigations are relatively fragmentary, and more studies must take place in order to obtain a useful database of bryozoan occurrences and stratigraphic ranges. Considering this, the investigated Spitsbergen faunas are best compared with Russian faunas of Late Carboniferous to Early Permian age (Alekseeva *et al.* 1986; Morozova & Kruchinina 1986). The bryozoans occur together with brachiopods, corals, echinoderms (crinoid debris) and fusulinids in varying amounts. Palaeoaplysinid (Skaug *et al.* 1982), and phylloidal algal bioherms are developed at irregular intervals, and these bioherms seem to house very few bryozoans. Studied bryozoan growth forms represent characteristic Late Palaeozoic types, and can be compared with those discussed by Stach (1936), Duncan (1969), and McKinney & Gault (1980); see Nakrem (1993) for review.

The Kapitol Member (Moscovian-Gzhelian) contains a bryozoan fauna with many species in common with the Moscovian-Gzhelian of the East European (Russian) Platform (Shul'ga-Nesterenko 1955; Morozova 1955), e.g. *Rhombotrypella rectangulata* Shul'ga-Nesterenko 1955, *R. dvinensis* Shul'ga-Nesterenko 1955, *Ascopora oblonga* (Nikiforova 1933), and *A. muromensis* Shul'ga-Nesterenko 1955. One species, *Rectifenestella submicroporata* (Shul'ga-Nesterenko 1952), previously known from the Early Permian of the East European Platform and Timan-Pechora (Morozova & Kruchinina 1986), and from the Late Permian of Caucasia and China (Morozova 1970), is also present in this part of the succession in Spitsbergen. This record significantly extends the stratigraphic range of this species. The fauna is characterized by delicate, minute fenestrates with thin branches and dissepiments, and finely branched trepostomes and cryptostomes. Although the zoaria are fragmented, there is little sign of abrasion, except in *Archimedes* where meshwork flanges are denuded, and it is concluded that the individual colonies have not been transported over extensive distances. Moreover, thick ramose and encrusting trepostomes and cystoporates (e.g. *Tabulipora* and *Fistulipora*) adapted to high energy waters are absent in this part, thus suggesting that the depositional environment was different from time equivalent conditions in eastern North Greenland (Ross & Ross 1962; Madsen & Håkansson 1989). The

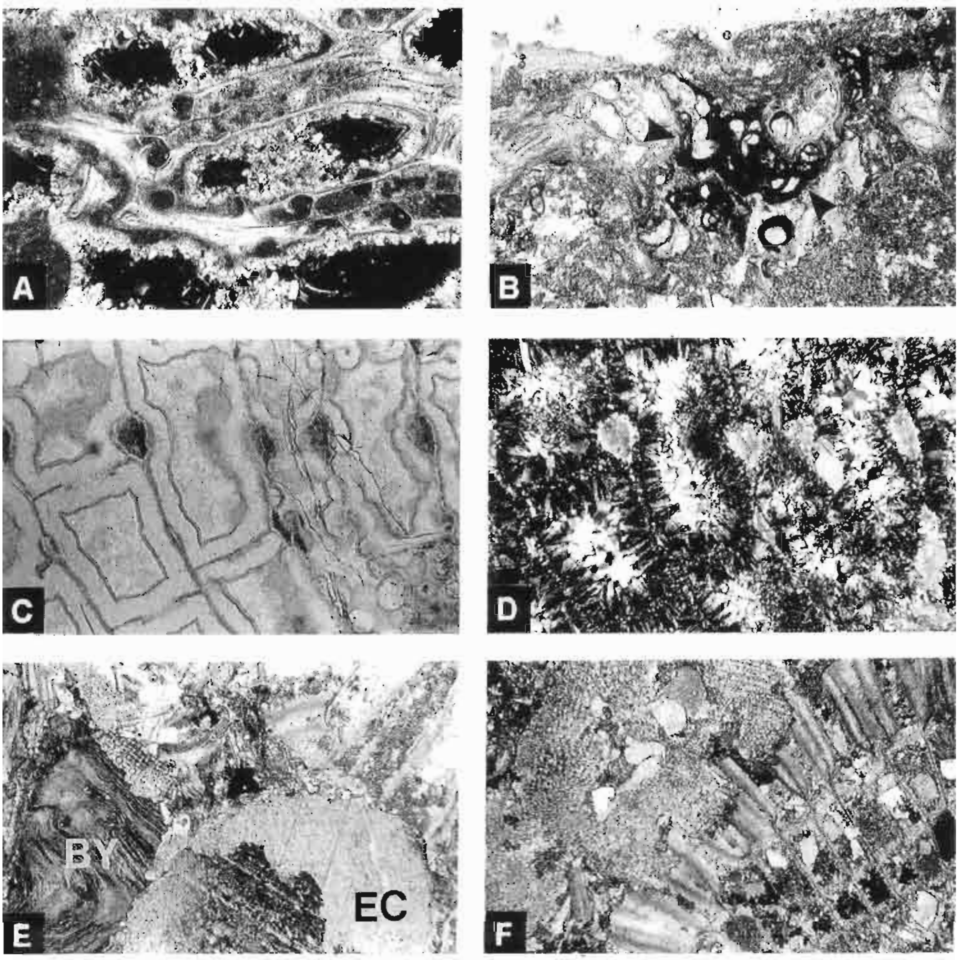


Fig. 3. Sample preservation and biotic interactions. ❑A. *Flexifenestella* cf. *grandis* (Shul'ga-Nesterenko 1936) with initial dolomite crystal growth in primary pores (fenestrules). Major part of fenestrules with preserved porosity. Crossed polars, × 25. Boltonbreen, Tyrrellfjellet Member, latest Gzhelian, BOLT-B2, PMO A42078. ❑B. Tubiphytes algae (black, arrow) growing on fenestrate fragments. Plane polarized light, × 25. Trollfuglfjella, Kapitol Member, Moscovian, TRO-2–40.0m, PMO A42930. ❑C–D. Silicified colony of *Tabulipora*; plane polarized light (C) and crossed polars (D). Trollfuglfjella, Tyrrellfjellet Member, Asselian, TRO-2–98.0m, PMO A42165; both × 40. ❑E–F. Grain contact leading to pressure dissolution and stylolite formation (EC – echinoderm, BY – bryozoan), crossed polars, × 25. E – Trollfuglfjella, Tyrrellfjellet Member, Asselian, TRO-2–60.0m, PMO A42014; F – Trollfuglfjella, Tyrrellfjellet Member, Asselian, TRO-2–60.0m, PMO A42013.

bryozoan fauna reflects a normal-marine environment with moderate to low water energy.

The lowermost part of the Tyrrellfjellet Member, of latest Gzhelian age as demonstrated by fusulinids (Nilsson & Davydov in press), contains a rich bryozoan fauna with 16 species of previously reported Late Carboniferous-Early Permian range, most of which are known from the Gzhelian of

Timan, the East European Platform and the Urals. The middle and upper part of the Tyrrellfjellet Member, of Asselian to early Sakmarian age as documented by fusulinids and conodonts (Nakrem *et al.* 1992) is characterized by a bryozoan fauna similar to the rich Asselian-Artinskian faunas described from Timan-Pechora by Nikiforova (1938) and Morozova & Kruchinina (1986). Characteristic species include *Coscinium cyclops* Keyserling 1846, *Ascopora sterlitamakensis* Nikiforova 1939, *Ascoporella grandis* (Kruchinina 1973), and *Rectifenestella* cf. *ornata* (Shul'ga-Nesterenko 1939). Some species, e.g. *Ascopora muromensis* and *Rhombotrypella dvinensis* known from the Moscovian and Kasimovian of the Urals (Morozova 1955) extend into the Early Permian of Spitsbergen.

The bituminous fusulinid rich layers (Brucebyen Beds; Cutbill & Challinor 1965) contain a low diversity bryozoan fauna with some fenestrates and delicate *Rhombotrypella* zoaria present. It has been suggested (Skaug *et al.* 1982) that these layers represent sedimentation in a quiet lagoonal environment under low oxic conditions not favouring bryozoan growth.

The upper part of the Tyrrellfjellet Member contains a normal-marine fauna including a rich bryozoan fauna with relatively thick ramose species (*Ascoporella* and *Tabulipora*), delicate fenestrates, as well as finely branched *Ascopora* and *Rhabdomeson*. Fenestrated specimens of *Coscinium* (bilaminate/adeoniform growth) are also common in these deposits. The bryozoan growth forms encountered reflect an environment with stronger currents, but with deposition still below storm wave base.

The basal, slightly dolomitized beds of the Gipshuken Formation, of late Sakmarian age, contain rare specimens of *Hinaclema svalbardensis* sp. n., *Rhombopora* sp. A, and ?*Ascoporella* sp. A. Identifiable bryozoans were also found in non-dolomitized horizons near the top of the formation and include *Hinaclema svalbardensis* sp. n. and *Polypora voluminosa* Trizna & Klautsan 1961, the latter with a previously reported Artinskian distribution (Morozova & Kruchinina 1986). The genus *Hinaclema* was previously only known from the Early Carboniferous (Schastlivtseva 1991). Silicified zoaria of fenestellids and polyporids were freed from carbonate matrix during acetic acid processing for conodonts of some limestone intervals. This part of the succession is characterized by evaporitic sedimentation under shallow water conditions with few open marine incursions. Bryozoans are extremely rare in the anhydritic layers (observed as leached voids), but fenestrates are locally present in horizons deposited under episodes of more normal marine conditions. The marine incursions contain *Hinaclema svalbardensis* sp. n., a trepostome bryozoan which is believed to have encrusted ?flexible algal or similar stems in shallow water. The host substrate decayed shortly after burial, and the internal void did not collapse but was subsequently infilled with sediment preserving the bryozoan colonies with a hollow central part.

Stratigraphic distribution of individual taxa are sketched in Fig. 4, where two range charts are presented. Fig. 4A shows the distribution of bryozoans in western-central sections (Nordfjorden Block development;

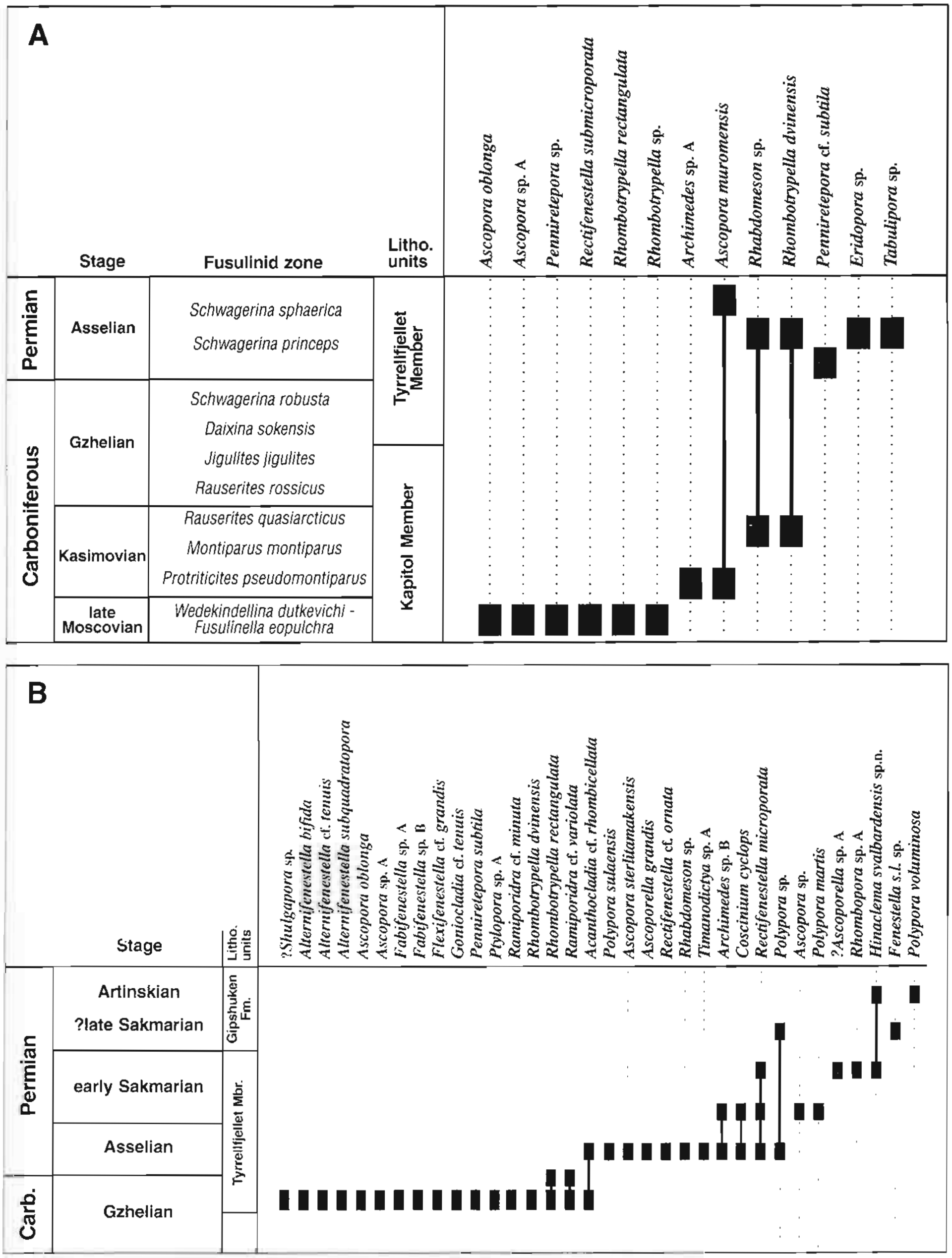


Fig. 4. Range-charts showing stratigraphic distribution of bryozoans. Black boxes indicate actual occurrence; solid lines denote inferred range. ❑A. Western sections located along the western margin of the Nordfjorden Block. ❑B. Central to eastern sections within the Billefjorden Trough.

Cutbill & Challinor 1965) where extensive fusulinid datings exists (Nilsson 1988; Nilsson & Davydov in press). Fig. 4B shows the distribution in central-eastern sections (Billefjorden Trough development; Cutbill & Challinor 1965) where bryozoans have been more extensively collected, but are less precisely dated.

As has previously been demonstrated, e.g. by Bancroft (1987) for the Carboniferous, bryozoans may be of biostratigraphic value, but many taxa have long ranges and may also show strong provincialism (Ross 1981; Ross & Ross 1990). Some Spitsbergen bryozoans have different stratigraphic ranges compared with the Urals and Timan-Pechora successions, and the present descriptions extend the ranges of some species. With some exceptions, the bryozoans, however, generally are in accordance with the age determinations of the investigated rocks previously documented by other fossil groups, e.g. brachiopods, conodonts and fusulinids (Nakrem *et al.* 1992).

Palaeobiogeography

Occurrences of bryozoan taxa in Spitsbergen are compared with time equivalent intervals elsewhere recorded in Ross (1981) and Ross & Ross (1990). As was concluded by Ross (1981) and Morozova & Kruchinina (1986) the bryozoans of present day western Arctic constituted a subtropical to boreal faunal province (Franklinian Shelf, including the Sverdrup Basin, the Wandel Sea Basin, and the Svalbard Platform) in the Late Palaeozoic (Fig. 2), with internal faunal similarities, but significant differences compared with Tethyan faunas. The degree of provinciality increased at the later Permian stages when the Boreal faunas diminished and Tethyan faunas increased significantly in diversity. Typical Early Permian Boreal genera include *Coscinium*, *Ascoporella* and *Timanodictya* as well as some goniocladiids. Similarity indices (Sørensen/Dice's index, see Fig. 5) have been calculated between the different provinces tabulated in Ross & Ross (1990) using the IBM-PC package 'MVSP Plus' written by W.L. Kovach. As was expected, the present day Arctic faunas (including Spitsbergen) are more similar to the Timan-Pechora faunas than the Urals faunas through the Asselian and Sakmarian (Fig. 5). An interesting feature is the placement of the Patagonian Shelf (western Argentina) in the Arctic/Uralian cluster. This can be explained in the bi-polarity of faunas distributed in boreal/temperate waters and reflects the high-latitudinal placement of both provinces. A similar bi-polarity was reported by Ustritskii (1974) where he found great similarities between mainly brachiopod faunas from Boreal (Siberia, Svalbard, Arctic Canada, and Alaska) and Notal (mainly Australian) regions. The internal similarities in the Boreal cluster is however significantly weaker (typically 40–50%) than the internal similarities in the different Tethyan sub-provinces (typically 80–100% within and 50–55% between). Province 4 (American shelves) and 5 (Angaran shelves) (Fig. 5) are clearly separated from both the Boreal and the Tethyan provinces. In the Artinskian-Kungurian (including data from

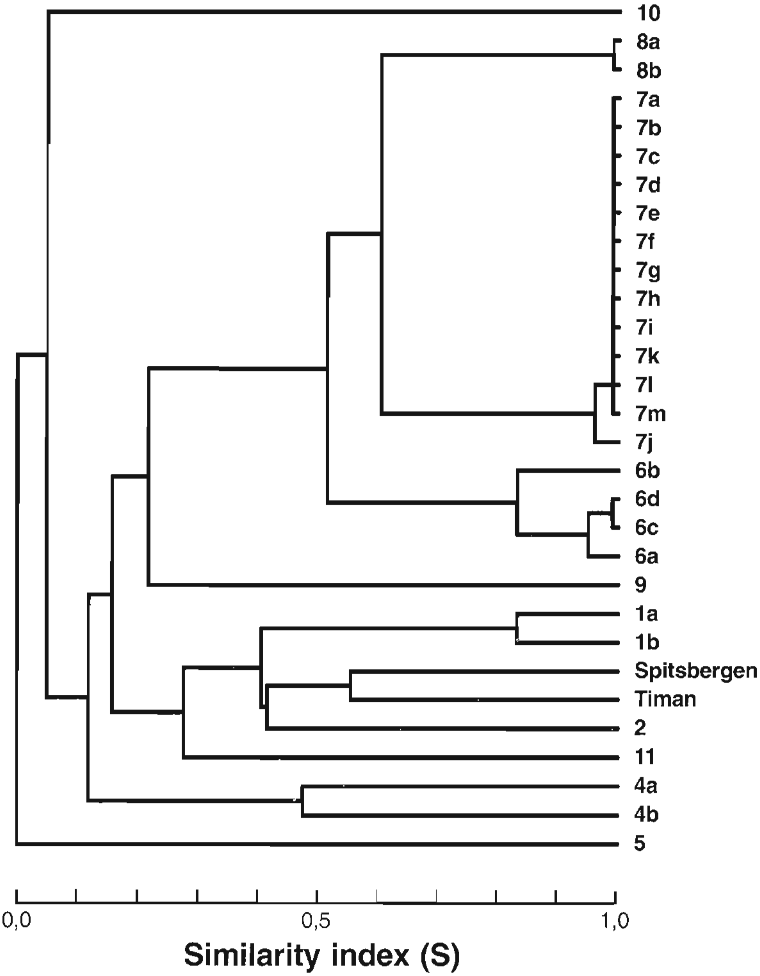


Fig. 5. Cluster diagram drawn from similarity matrices of Asselian-Sakmarian faunas, and formulae used (Dice's index of similarity). Geographic regions are numbered and refer to Ross & Ross (1990). 1a – Russian Platform, including Moscow Basin, Voronez basin, and Ural Shelf, 1b – Donetz Basin, 2 – Franklinian Shelf and adjacent regions, 4 – American shelves, 5 – Angaran shelves, 6 – Northern Tethys, 7 – Central Tethys, 8 – Southern Tethys, 9 – Tasman geosyncline, 10 – North American Cordillera, eastern part, 11 – Patagonian Shelf. $S = 2C_{ji}/(N_i+N_j)$; S – similarity between samples *i* and *j*, C_{ij} – number of species present in both samples ('match'), N_i – number of species present in sample *i*, N_j – number of species present in sample *j*.

Nakrem in press) the general trend did not change much. The Spitsbergen faunas cluster with other present day Arctic faunas, and the Timan-Pechora cluster with the Urals. Still these provinces are distinctly different from the Tethyan provinces. At this time the Uralian sea-way between the northern realm and the Tethys sea became closed off and the warm water adapted fauna diminished in diversity in the Boreal province (Ross & Ross 1990). Faunal migration also declined due to this physical barrier. The

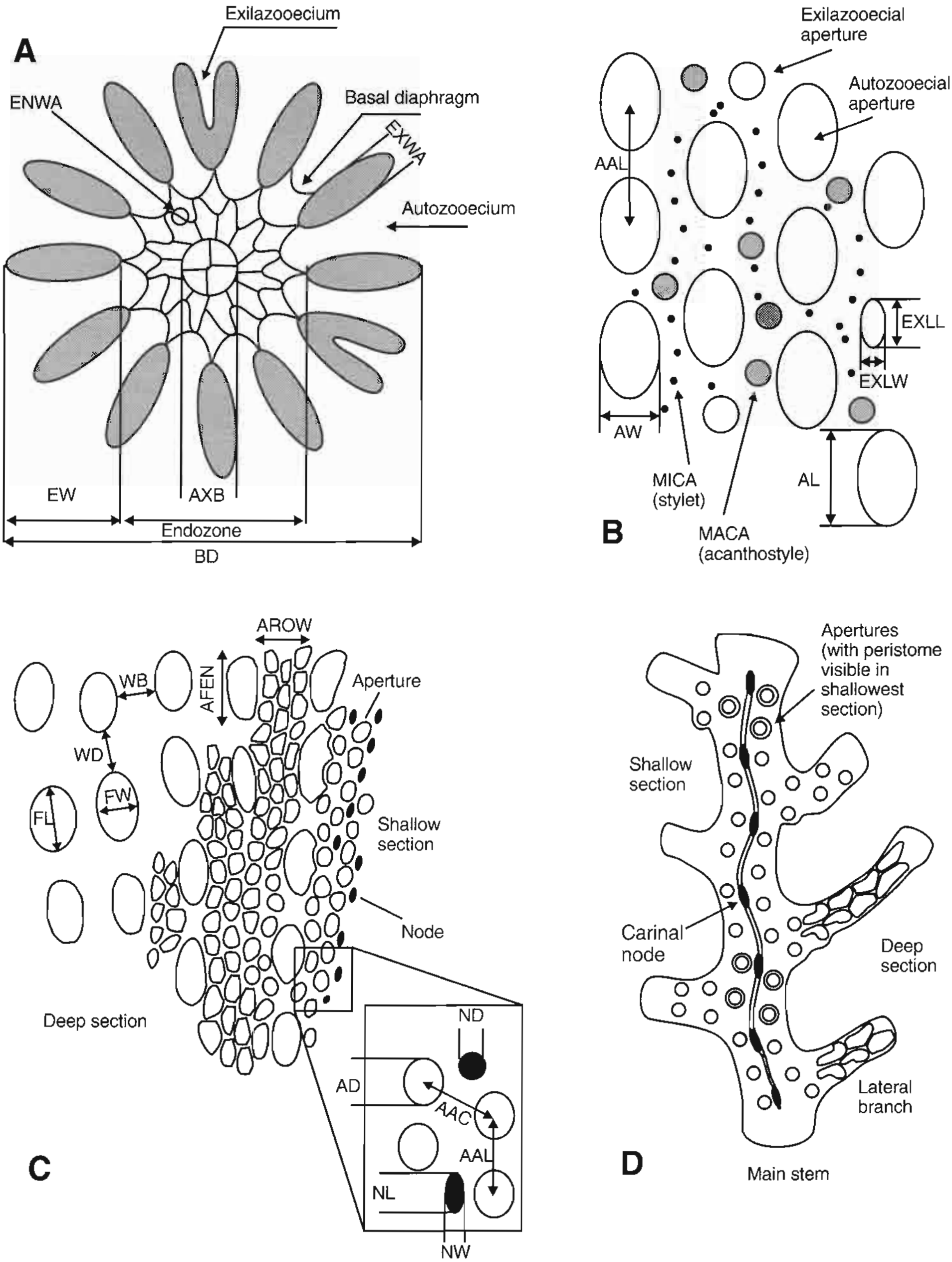


Fig. 6. Measured characters in ramose bryozoans (transverse section, A), ramose bryozoans (tangential section, B), fenestrate bryozoans (C), pinnate bryozoans (D).

present records of Early Permian bryozoans from Spitsbergen have thus provided an important faunal link between faunas from the Urals and Timan-Pechora, and those from more western Arctic localities, mainly North Greenland and Arctic Canada.

Taxonomy

Taxonomic procedures and character measurements. — In the descriptions of ramose trepostomes and rhabdomesid cryptostomes the following measurements have been taken (Fig. 6A–B):

BD	branch diameter in (sub)cylindrical forms,
EW	exozone width,
AL	autozooecial aperture length,
AW	autozooecial aperture width,
AAL	distance between autozooecial aperture centers along colony,
AAL/2	number of autozooecial apertures per 2 mm along colony surface,
AAC/2	number of autozooecial apertures per 2 mm diagonally or across colony surface,
DIA/1	diaphragms per 1 mm in autozooecial tubes,
EXWA	exozonal wall thickness,
ENWA	endozonal wall thickness,
MACA	diameter of large acanthostyles,
MACA/A	Large acanthostyles per autozooecial aperture (from tangential section),
MICA	diameter of small stylets in cryptostomes,
MICA/A	small stylets per autozooecial aperture (from tangential section),
EXLL	length of ovate or irregular exilazooecia,
EXLW	width of ovate or irregular exilazooecia,
SQ/1	number of square endozonal autozooecial tubes per 1 mm in transverse, section (endozone), in *Rhombotrypella* only,
AXB	diameter of axial bundle of parallel autozooecial tubes, in *Ascopora* and *Ascoporella* only.

In meshwork and pinnate fenestrated bryozoans (order Fenestrata and some cystoporates) the following measurements have been taken (Fig. 6C–D):

FL	length of fenestrule opening,
FW	width of fenestrule opening,
AD	aperture diameter,
AAL	distance between apertural centers along branch,
AAC	distance between apertural centers diagonally across branch at closest point,
WB	width of branch (not measured at branch bifurcation),
TB	thickness of branch (measured in obverse-reverse direction),
WD	width of dissepiment,
NL	length of oval carinal nodes on obverse surface,
NW	width of oval carinal nodes on obverse surface,
ND	diameter of circular nodes,
SNB	distance between nodes along obverse branch surface,
LAT/10	lateral branches (pinnae) per 10 mm along main stem (in *Penniretepora* and *Acanthocladia* only).

To provide data for comparison with older, especially Russian literature, the classical 'micrometric formula' (Miller 1961; Tavener-Smith 1966) has been calculated for each species:

BR10	branches per 10 mm across colony,
DS10	dissepiments or fenestrules per 10 mm along colony,
A5	apertures per 5 mm along branch,
AFEN	number of apertures per fenestrule (family Fenestellidae),
AROW	number of apertural rows across branch (family Polyporidae),
N1	carinal nodes per 1 mm along branch.

In the systematic description, the micrometric formula is denoted as BR10/DS10/A5/AFEN for fenestellids, and BR10/DS10/A5/AROW for polyporids.

Due to low numbers of specimens available of many fenestrates, all measurements advocated in Snyder (1991) and Hageman (1991) could not be taken. Basic statistics for most characters in each species are presented in Measurements; arithmetic mean (AVG), sample standard deviation (STDS), coefficient of variance (CV=STDS*100/AVG), minimum (MIN) and maximum (MAX) values observed and number of observations (n). Not all characters are tabulated for some species, usually due to insufficient amount of or poorly preserved material. Statistical calculations tabulated were obtained using the PC spreadsheet software Quattro Pro 4.0 from Borland.

Order Cystoporata Astrova 1964
Suborder Fistuliporina Astrova 1964
Family Fistuliporidae Ulrich 1882
Genus *Eridopora* Ulrich 1882
Type species: *Eridopora macrostoma* Ulrich 1882, Chesterian of Kentucky.

Eridopora sp.

Fig. 7A–B.

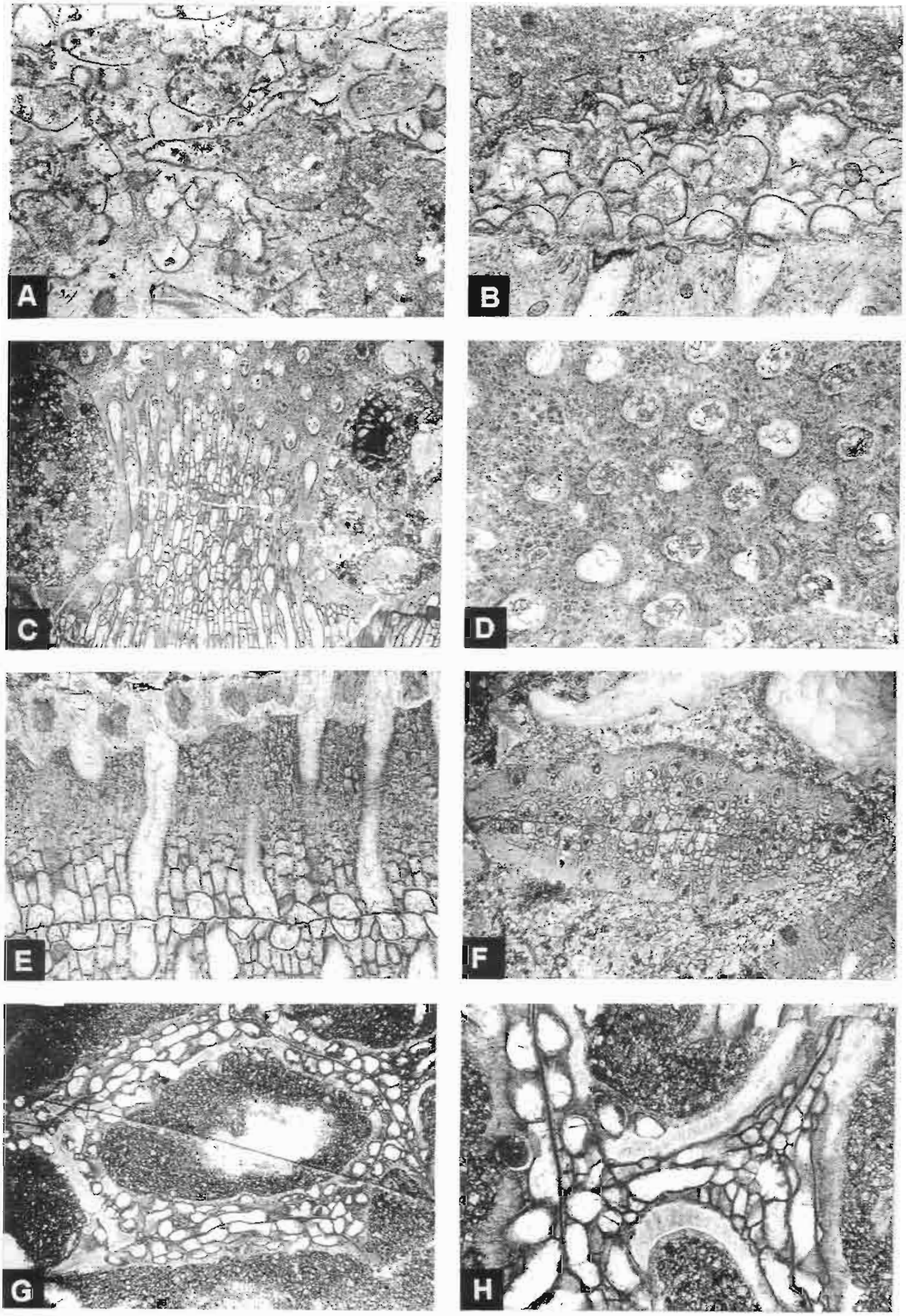
Remarks. — Identification is based on an incompletely preserved zoarium; sheet-like encrusting with large elongated zooecial apertures. Lunaria are long and overhanging. Specific assignment is impossible due to incomplete preservation of important taxonomic features.

Material. — SKA-2–132.0m (PMO A41932, A41989–991).

Stratigraphic occurrence in Spitsbergen. — Asselian, middle part of the Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — The genus *Eridopora* is most common in the Late Carboniferous in North America and Russia (Utgaard *in* Boardman *et al.* 1983), although it ranges through the Artinskian (Ross & Ross 1990).

Fig. 7. ❑A, B. *Eridopora* sp.; Skansen, Tyrrellfjellet Member, Asselian. A. Tangential section, SKA-2–132.0m, PMO A41991, × 25. B. Transverse section showing *Eridopora* sp. encrusting a specimen of *Coscinium*, SKA-2–132.0m, PMO A41989, × 25. ❑C–F. *Coscinium cyclops* Keyserling 1846; Gipsvika, Tyrrellfjellet Member, late Asselian, GIP-1–20.0m, petrographic thin sections. C. Oblique shallow to deep tangential section, PMO A42179, × 10. D. Shallow tangential section displaying lunaria, PMO A42179, × 25. E. Longitudinal section, partly silicified, PMO A42180/1, × 25. F. Transverse section, PMO A42180/2, × 10. ❑G–H. *Gonio-*



cladia cf. *tenuis* Shul'ga-Nesterenko 1933; Rejmyrefjellet,Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0, PMO A42119, petrographic thin section. G. Mesh in median tangential section, × 10. H. Enlarged part showing blister-like cysts between autozooecial tubes, × 25.

Family Hexagonellidae Crockford 1947

Genus *Coscinium* Keyserling 1846

Type species: *Coscinium cyclops* Keyserling 1846, Early Permian of Timan, Russia.

Coscinium cyclops Keyserling 1846

Fig. 7C–F.

Coscinium cyclops sp. n.; Keyserling 1846: p. 191.

Coscinium cyclops Keyserling; Stuckenberg 1895: p. 172, Pl. 24: 2a, c.

Coscinium cyclops Keyserling; Nikiforova 1938: p. 191 [273], Pls 2: 7–10, 3: 1–4.

Coscinium cyclops Keyserling; Utgaard *in* Boardman *et al.* 1983: p. 411, Fig. 197: 1a–f.

Coscinotrypa cyclops (Keyserling); Morozova & Kruchinina 1986: p. 37, Pls 5: 3, 6: 2.

Description. — Colonies with reticulate fronds with oval and circular fenestrules and anastomosing branches with zooecia opening on both sides of branches. The branches are ovate in cross section being bifoliate compressed perpendicular to branch surfaces. Width of branches varies between 2.7 and 3.1 mm, thickness average 2.0 mm. Branch spacing measured from center to center 4.5–5.0 mm (about 2.1 per 10 mm). The fenestrules varies greatly in size being 1.7–3.6 mm long and 1.3–2.7 mm wide, oval or more circular. Autozooecial tubes originate in low angles from a median lamina (mesotheca) being 0.018–0.020 mm thick. Vesicular, blister-like tissue is developed between autozooecial tubes. Massive stereom is developed near colony surface. Apertures are ovate in outline being 0.23–0.26 mm long and 0.16–0.19 mm wide. The apertures carry a weakly developed lunarium. There are about 3.7 apertures along colony per 2 mm and 5.2 diagonally. Distance between apertural centers longitudinally is about 0.55 mm. Maculae devoid of apertures, about 1.1 × 0.5 mm in size, are rarely developed adjacent to some fenestrules.

Remarks. — One specimen was found to be completely overgrown by an indeterminate species of *Eridopora* (Fig. 7B).

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	2.100	0.089	4.26	2.00	2.20	6
AAL/2	3.650	0.399	10.93	3.20	4.30	12
AAD/2	5.217	0.413	7.92	4.50	5.70	12
WB	2.833	0.145	5.13	2.68	3.05	7
TB	2.020	0.340	16.82	1.77	2.73	7
FL	3.059	0.565	18.46	1.68	3.64	9
FW	2.150	0.368	17.14	1.34	2.70	9
AL	0.245	0.008	3.26	0.23	0.26	12
AW	0.178	0.009	5.26	0.16	0.19	12
AAL	0.551	0.018	3.23	0.52	0.58	12

Comparison. — *C. cyclops* is roughly similar to *C. cyclops pobreinae* Nikiforova 1939, from the Sakmarian-Artinskian of the Urals (Bashkiria) which has generally larger apertures (0.27 mm × 0.18–0.22 mm) and more widely spaced branches (1.5 per 10 mm). *C. keyserlingi* Stuckenberg 1895 has larger fenestrules (4.5 mm long and 3.8 mm wide) and apertures of varying size (Nikiforova 1938).

Material. — GIP-1–1.0m (PMO 138.125), GIP-1–5.0m (PMO A42176–178), GIP-1–14.0m (PMO 138.055–056), GIP-1–20.0m (PMO A42179–180), GIP-1–30.0m (PMO 138.072–073), SKA-2–132.0m (PMO A41932).

Stratigraphic occurrence in Spitsbergen. — Asselian-early Sakmarian, within and below the *Eoparafusulina paralinearis* fusulinid zone (Nilsson & Davydov in press) and associated with *Sweetognathus inornatus*; middle-upper part of the Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — Asselian (Nenets Horizon) – Artinskian of Timan (Morozova & Kruchinina 1986).

Family Goniocladiidae Waagen & Pichl 1885

Genus *Goniocladia* Etheridge 1876

Type species: *Carinella cellulifera* Etheridge 1873, Early Carboniferous of Scotland.

Goniocladia cf. *tenuis* Shul'ga-Nesterenko 1933

Fig. 7G–H.

cf. *Goniocladia tenuis* sp. n.; Shul'ga-Nesterenko 1933: p. 49, Pl. 1: 1–3, 5–7, 10, Text-figs 4–5.

cf. *Goniocladia tenuis* Shul'ga-Nesterenko; Shul'ga-Nesterenko 1941: p. 183, Pls 49: 3–8, 47: 3–6.

cf. *Goniocladia tenuis* Shul'ga-Nesterenko; Alekseeva *et al.* 1986: Pl. 100: 1.

cf. *Goniocladia* cf. *tenuis* Shul'ga-Nesterenko; Fengsheng 1986: p. 229, Pl. 10: 7.

Description. — Reticulate colony with hexagonal fenestrules formed by anastomosis of branches. Fenestrules measure 3.6–4.1 mm in length and 1.8–2.3 mm in width. The branches are about 0.70 mm wide and 0.95 mm thick (perpendicular to colony surface). Branch spacing about 2.5 mm (4 branches across per 10 mm and 2 fenestrules along colony per 10 mm). Apertures are developed in 2–3 rows on each side of median keel, being circular (0.13 mm in diameter) or slightly oval, 0.14 × 0.12 mm. Aperture spacing measured from center to center 0.45–0.50 mm (10–11 apertures per 5 mm) along the branches.

Remarks. — Lack of sufficient material prevented a more precise identification and measurements are thus not tabulated. Typically most goniocladiids in the present study are partially silicified and microscopic details are usually obscured or destroyed.

Comparison. — The few measurements permit an identification very close to *G. tenuis*. Branch dimensions (width and thickness) and aperture size distinguish this species from other Early Permian species; e.g. *G. pulchra* Shul'ga-Nesterenko 1933 (branches 0.94–1.05 mm wide and 1.46–1.92 mm thick) and *G. cyclopora* Shul'ga-Nesterenko 1933 (branches 1.05–1.22 mm wide and 1.57–1.85 mm thick).

Material. — REF-0–25.0 m (PMO A42119 and A42187).

Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and

Streptognathodus excelsus and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.
Occurrence outside Spitsbergen. — *G. tenuis* was originally described from the Saraninian (late Artinskian) of the Urals (Alekseeva *et al.* 1986).

Genus *Ramiporidra* Nikiforova 1938
Type species: *Ramipora uralica* Stuckenberg 1895, Early Permian of the Urals.

Ramiporidra cf. *minuta* (Shul'ga-Nesterenko 1933)

Fig. 8A.

cf. *Ramipora minuta* sp. n.; Shul'ga-Nesterenko 1933: p. 57, Pl. 8: 6, 9, 11, 14, 15.
cf. *Ramiporidra minuta* (Shul'ga-Nesterenko); Shul'ga-Nesterenko 1941: p. 213, Pl. 58: 2–5.

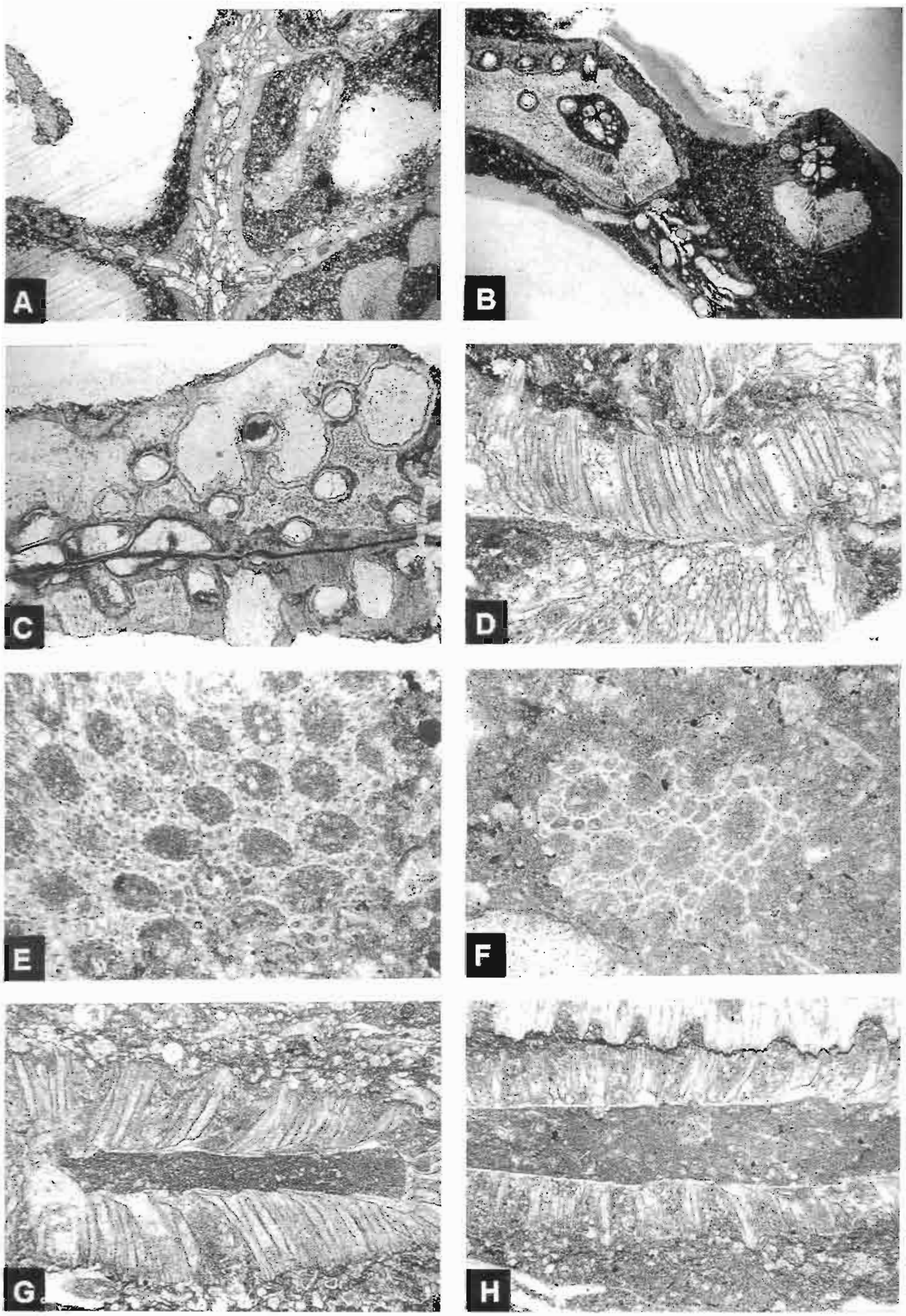
Description. — Delicate species of *Ramiporidra* with narrow main stem (0.54–0.78 mm wide) and secondary branches (0.45–0.51 mm wide). Secondary branches branch off from main stem at angles between 65° and 75°. Distance between points of branching varies between 2.0 and 4.0 mm (2.5–3.3 per 10 mm). There are between 12 and 16 apertures, 0.08–0.09 mm in diameter per 5 mm along main stem. Apertural rows on each side of keel number 3–4 on the main stem, 2–3 on lateral branches.
Remarks. — Lack of sufficient well preserved material for study prevented a more precise identification and measurements are thus not tabulated.
Comparison. — This species is distinguished from all other Early Permian species of *Ramiporidra* by its very narrow branches (0.81 mm). *R. variolata* (Shul'ga-Nesterenko 1933), *R. variolata sinensis* (Shul'ga-Nesterenko 1933), and *R. variolata cavernosa* (Shul'ga-Nesterenko 1933) have all main stems exceeding 1.47 mm (commonly 1.80–2.30 mm) in width.
Material. — REF-0–25.0m (PMO A42310).
Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.
Occurrence outside Spitsbergen. — *R. minuta* was originally described from the Gzhelian of the Urals (Shul'ga-Nesterenko 1933).

Ramiporidra cf. *variolata* (Shul'ga-Nesterenko 1933)

Fig. 8B–C.

cf. *Ramipora variolata* sp. n.; Shul'ga-Nesterenko 1933: p. 55, Pl. 7: 1–5, 7, 8, Text-fig. 33.
cf. *Ramipora variolata* Shul'ga-Nesterenko; Morozova & Kruchinina 1986: p. 40, Pl. 7: 4a–c.

Fig. 8. ❑A. *Ramiporidra* cf. *minuta* (Shul'ga-Nesterenko 1933) in deep tangential section. Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42310, × 10. ❑B–C. *Ramiporidra* cf. *variolata* (Shul'ga-Nesterenko 1933); Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian. B. Slightly silicified oblique transverse section, REF-0–25.0m, PMO A42204/1, × 10, petrographic thin section. C. Slightly silicified oblique longitudinal section, REF-1–36.0m, PMO A42181, × 25, petrographic thin section. ❑D–H. *Hinaclema svalbardensis* sp. n., petrographic thin sections. Rejmyrefjellet, Gipshuken Formation, late Artinskian, REF-4–15.0m. D. Irregular growth in longitudinal section, A42600/2, × 25. E. Shallow tangen-



tial section, holotype, A42600/1, × 40. F. Deep tangential section, holotype, A42600/1, × 40. G. Transverse/longitudinal section, A42600/3, × 25. H. Longitudinal section with well visible central part believed to represent decayed encrusting substrate, A42600/4, × 25.

Description. — Relatively robust colony of *Ramiporidra* with main stem being 1.7–2.2 mm wide. Secondary branches between 0.9 and 1.5 mm wide. Thickness of main stem about 2.2–2.3 mm whereas secondary branches are 2.0 mm thick. Secondary branches diverge from main stem at angles between 70° and 80°. Distance between branching points 2.7 to 3.6 mm (3.5–4 per 10 mm). Apertures are slightly oval (0.15–0.18 mm in diameter) with a weakly developed lunarium. A peristome is visible in apertures, being 0.036 mm wide. Zooecia originate from a 0.036–0.040 mm thick median lamina (mesotheca). Four to five rows of apertures are developed on each side of median keel. Apertural spacing 0.45–0.50 mm (10–11 per 5 mm) along both main stem and secondary branches.

Remarks. — Lack of sufficient well preserved material prevented a more precise identification and measurements are thus not tabulated.

Comparison. — Measured characters in the investigated specimens match well with the original description by Shul'ga-Nesterenko (1933). *R. simplex* Morozova 1955, described from the Gzhelian of Donbass (Morozova 1955) is intermediate between *R. minuta* and *R. variolata* regarding robustness. *R. uralica* (Stuckenberg 1895) is distinguished from the mentioned species in having thicker, and generally more robust main stem and secondary branches, and also in having greater number of apertural rows on each side of the median keel (5–6).

Material. — REF-0–25.0m (PMO A42204), REF-1–36.0m (PMO A42181–184).

Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — *R. variolata* is known from the Gzhelian of the Urals (Shul'ga-Nesterenko 1933) and the Belcher Channel Formation (Asselian-Sakmarian) of Ellesmere Island (Canadian Arctic) (Morozova & Kruchinina 1986).

Order Trepostomata Ulrich 1882

Family Crustoporidae Dunaeva & Morozova 1967

Genus *Hinaclema* Sakagami & Sugimura 1987

Type species: *Hinaclema hinaensis* Sakagami & Sugimura 1987, Viséan of southwest Japan.

Remarks. — The genus *Hinaclema* was first described from the Early Carboniferous (Viséan) of Japan, and subsequently reported from the Viséan of Uzbekistan (Schastlivtseva 1991). The genus was removed from the family Heterotrypidae Ulrich 1890, and placed in the family Crustoporidae Dunaeva & Morozova 1967 by Schastlivtseva (1991). The current material closely resembles the descriptions of *Hinaclema* both by Sakagami & Sugimura (1987) and Schastlivtseva (1991). Diagnostic characters include lamellar or multilamellar encrusting zoarium with hollow axial area, thin endozone and absence of diaphragms in auto- and exilazooecial tubes (Sakagami & Sugimura 1987).

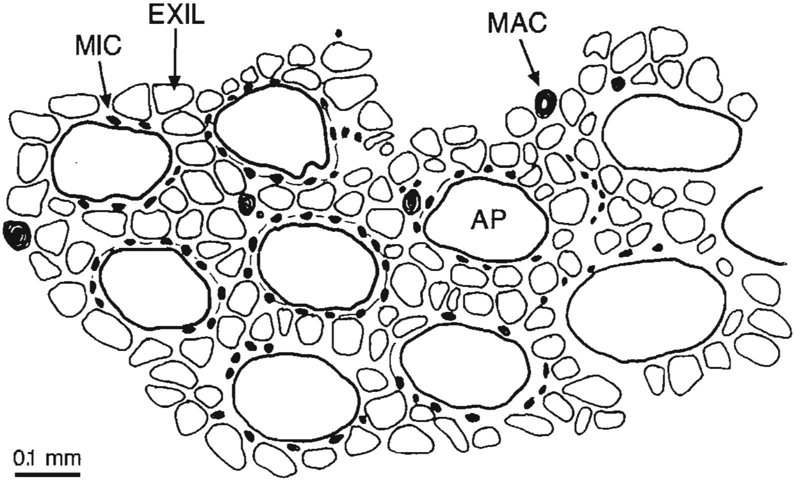


Fig. 9. Line drawing of *Hinaclema svalbardensis* sp. n. in shallow tangential section. Abbreviations: MIC – micro acanthostyle, MAC – macro (large) acanthostyle, EXIL – exilazooecial aperture, AP – autozooecial aperture.

Hinaclema svalbardensis sp. n.

Figs 8D–H, 9.

?*Hinaclema* sp.; Nakrem 1993: Fig. 2d.

Holotype: REF-4–15.0m, PMO A42600/1 (petrographic thin section); REF-4–15.0m, PMO 138.126 and PMO A42600/2–4.

Type locality: Rejmyrefjellet, Spitsbergen.

Type horizon: Gipshuken Formation, 15 metres below the top of the formation, late Artinskian.

Etymology: Species named after the Svalbard island group.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BT	0.776	0.359	46.24	0.31	1.10	7
AL	0.252	0.028	10.94	0.21	0.30	19
AW	0.206	0.047	22.96	0.14	0.25	19
AAC	0.273	0.040	14.54	0.21	0.32	24
AAL/2	6.904	0.489	7.09	6.50	8.00	23
EXLL	0.052	0.005	10.15	0.04	0.06	18
EXLW	0.052	0.005	10.15	0.04	0.06	18
MACA	0.055	0.012	22.15	0.04	0.07	19
MICA	0.010	0.002	19.06	0.01	0.01	12
MACA/A	3.400	0.940	27.66	2.00	5.00	20
MICA/A	14.333	1.435	10.01	11.00	16.00	12
EXWA	0.031	0.003	10.67	0.03	0.04	15
ENWA	0.018	0.001	5.86	0.02	0.02	10

Material. — REF-2–4.0m (PMO 138.124), REF-4–15.0m (petrographic thin sections PMO A42600/1–4, rock specimen 138.126).

Diagnosis. — Zoarium encrusting, less than 0.45 mm in thickness; autozooecial apertures indented with acanthostyles and ovate in outline, bordered by a chain of small acanthostyles and scattered larger acanthostyles; abundant exilazooecia; autozooecial and exilazooecial tubes devoid of diaphragms; zooecial walls evenly thickened approaching zoarium surface.

Description. — Zoarium encrusting, with thickness of encrusting layer 0.38–0.45 mm. The endozone is indistinguishable from the exozone. The autozooecial tubes meet zoarial surface at 80–90 in longitudinal section; proximal (endozonal) portion of tubes sometimes are oriented parallel to zoarial growth direction. Diaphragms are not observed in autozooecial or exilazooecial tubes. Zooecial walls are evenly thickened (not beaded); a dark central zone is visible in deep tangential section. The zooecial apertures are oval, 0.21–0.23 mm long and 0.14 mm wide. Distance between centers of adjacent apertures 0.21–0.29 mm (7–9 per 2 mm). Abundant exilazooecia, 0.043–0.071 mm diameter, are developed between autozooecia. 11–16 small acanthostyles (0.007–0.014 mm in diameter) are developed around each autozooecial aperture. Scattered larger acanthostyles (diameter 0.035–0.057 mm; 0.071 mm in shallowest section) are also developed, usually 2–3 per autozooecial aperture.

Remarks. — The zoaria are preserved as 'hollow tubes', and it is believed that they lived encrusted to quickly-decayed (algae?) thread- or ribbonlike plants.

Comparison. — Apertural dimensions separate the new species from *H. sakagamii* Schastlivtseva 1991 (0.30–0.45 mm across) and *H. hinaensis* (0.18–0.32 mm across). Acanthostyles in *H. hinaensis* have greater diameters than the Spitsbergen species.

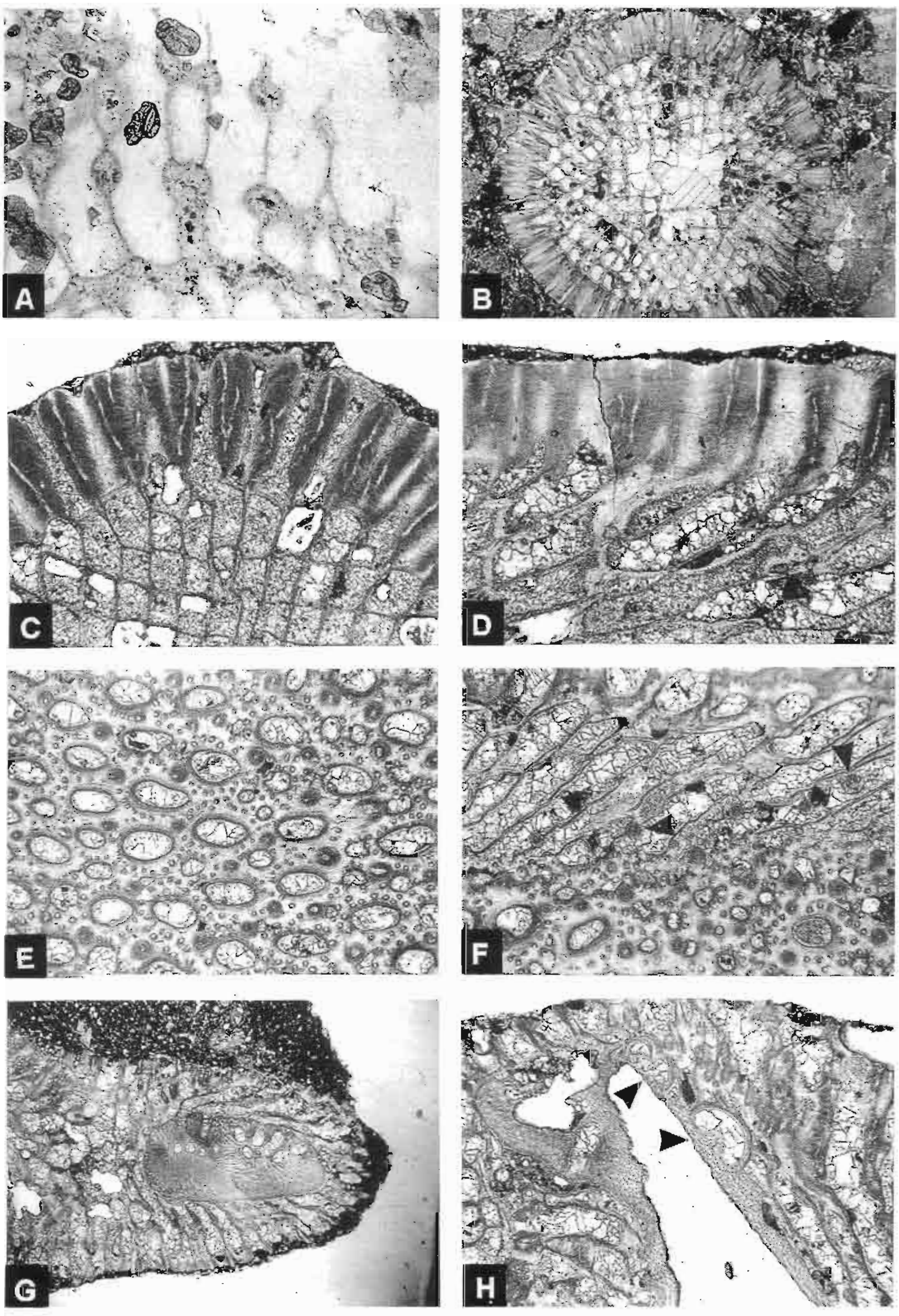
Stratigraphic occurrence in Spitsbergen. — Sakmarian-late Artinskian, associated with the conodonts *Sweetognathus inornatus* and *Neostreptognathodus* cf. *pequopensis*, upper part of the Tyrrellfjellet Member, and upper part of the Gipshuken Formation.

Family Stenoporidae Waagen & Wentzel 1886

Genus *Tabulipora* Young 1883

Type species: *Cellepora urii* Fleming 1828, Early Carboniferous of Scotland.

Fig. 10. ❑A. *Tabulipora* sp., silicified exozone with beaded zooecial walls. Trollfuglfjella, Tyrrellfjellet Member, Asselian, TRO-2–98.0m, PMO A42165, × 25, petrographic thin section. ❑B–H. *Rhombotrypella dvinensis* Shul'ga-Nesterenko 1955; Trollfuglfjella, Tyrrellfjellet Member, Asselian (B) and Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian (C–H). B. Transverse section showing partly recrystallized endozone with square zooecial tubes, TRO-2–60.0m, PMO A42013, × 10, petrographic thin section. C. Transverse section of exozone showing evenly thickened zooecial walls, REF-0–25.0m, PMO A42121, × 25. D. Longitudinal section of exozone, REF-0–25.0m, PMO A42121, × 25. E. Tangential section, REF-0–25.0m, PMO A42121, × 25. F. Regenerated growth with protruding acanthostyles trapped in subsequent growth cycle (arrow), REF-0–25.0m, PMO A42189, × 25. G. Fragment of polyporid overgrown



by *Rhombotrypella dvinensis*, REF-0–25.0m, PMO A42189, × 10. H. Unknown substrate (silicified) encrusted by foraminifers (arrow) and *Rhombotrypella dvinensis*, REF-0–25.0m, PMO A42189, × 25.

Tabulipora sp. indet.

Fig. 10A.

Remarks. — A thick (7–8 mm) colony apparently with multilaminar or encrusting growth is assigned to *Tabulipora*. Observations and quantifications of important taxonomic features could not be carried out due to the complete silicification of the colony. The specimen is assigned to the genus because of beaded exozonal walls, abundant complete and perforated diaphragms in exozone and polygonal pattern in endozonal zooecial tubes.

Material. — TRO-2–98.0m (PMO A42165–166).

Stratigraphic occurrence in Spitsbergen. — Middle Asselian, *Schwagerina princeps* fusulinid zone (Nilsson & Davydov in press), middle part of the Tyrrellfjellet Member.

Genus *Rhombotrypella* Nikiforova 1933.

Type species: *Rhombotrypella astragaloides* Nikiforova 1933, Middle Carboniferous of the Donetz Basin, Ukraine.

Rhombotrypella dvinensis Shul'ga-Nesterenko 1955

Fig. 10B–H.

Rhombotrypella dvinensis sp. n.; Shul'ga-Nesterenko 1955: p. 91, Pl. 11: 5–7.

Rhombotrypella dvinensis Shul'ga-Nesterenko; Morozova 1955: p. 20.

Description. — *Rhombotrypella* with moderately thick branches averaging 4.7 mm in diameter. The exozone shows great variation in width being 0.32–1.15 mm wide, and is clearly distinguished from the endozone. A single hook-like hemiseptum as well as 1 or 2 perforated diaphragms are commonly present in autozooecial tubes in exozone. Autozooecial apertures are ovate in outline, about 0.22 mm long and 0.13 mm wide. These apertures are arranged relatively regularly along branch with about 5.5 apertures along colony and 6.8 diagonally per 2 mm. The distance between apertural centers is about 0.37 mm. Exilazooecial apertures are irregularly distributed, with ovate or irregular outline being 0.03–0.09 mm in diameter. Three to five large acanthostyles with a diameter of about 0.10 mm are present around each autozooecial aperture. Small acanthostyles, observed as a chain on ridges between apertures are about 0.02 mm in diameter. Exozonal walls are about 0.13 mm thick; endozonal walls about 0.01 mm. Autozooecial tubes in transverse section are square in outline and number 4.4–5.6 per 1 mm.

Remarks. — Regenerated growth is well developed in one specimen where new calcified walls have grown around and encapsuled long protruding acanthostyles of previous growth stage/cycle (Fig. 10F). The same specimen has also overgrown and trapped a specimen of *Polypora* and an encrusting foraminifer (Fig. 10G–H).

Comparison. — *R. dvinensis* resembles the Artinskian *R. invulgata* Trizna 1948 in many characters, but is distinguished in having lower number of diaphragms (1–2 against 3–4) and in having smaller and more closely packed autozooecial apertures. The Gzhelian *R. subcomposita* Shul'ga-

Nesterenko 1955 has a larger colony diameter and significantly larger autozooecial apertures (0.20–0.30 mm in diameter).

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BD	4.705	0.443	9.42	3.90	5.50	20
EW	0.653	0.263	40.25	0.32	1.15	22
DIA/1	1.250	0.500	40.00	1.00	2.00	4
AL	0.221	0.017	7.68	0.19	0.25	36
AW	0.127	0.016	12.88	0.09	0.15	36
AAC	0.369	0.021	5.79	0.34	0.42	37
AAL/2	5.528	0.237	4.30	5.00	5.90	40
AAC/2	6.817	0.576	8.45	5.10	7.70	36
EXLL	0.066	0.015	23.13	0.03	0.09	39
EXLW	0.066	0.015	23.13	0.03	0.09	39
SQ/1	5.030	0.353	7.01	4.40	5.60	37
MACA	0.098	0.010	10.32	0.08	0.11	40
MICA	0.019	0.001	6.51	0.02	0.02	32
MACA/A	3.615	0.768	21.24	3.00	5.00	13
MICA/A	17.167	3.841	22.38	10.00	26.00	24
EXWA	0.129	0.015	11.33	0.10	0.16	36
ENWA	0.010	0.002	24.31	0.01	0.01	20

Material. — REF-0–25.0m (A42121, A42188, A42189, 138.064, 138.067, 138.068), TRO-2–60.0m (A41264, A42013, A42014, A42015), TRO-3–97.5m (A42597).

Stratigraphic occurrence in Spitsbergen. — Late Kasimovian (*Rauserites quasiarcticus* fusulinid zone) through middle Asselian (*Schwagerina princeps* fusulinid zone) (Nilsson & Davydov in press), Kapitol and Tyrrellfjellet members.

Occurrence outside Spitsbergen. — Kasimovian of the Urals (Shul'ga-Nesterenko 1955).

Rhombotrypella rectangulata Shul'ga-Nesterenko 1955

Fig. 11A–D.

Rhombotrypella rectangulata sp. n.; Shul'ga-Nesterenko 1955: p. 91, Pl. 12: 1–4.

Rhombotrypella rectangulata Shul'ga-Nesterenko; Morozova 1955: p. 20, Pl. 2: 3a–c.

Rhombotrypella rectangulata Shul'ga-Nesterenko; Goryunova & Kruchinina 1975: p. 147, Pl. 58: 7–9.

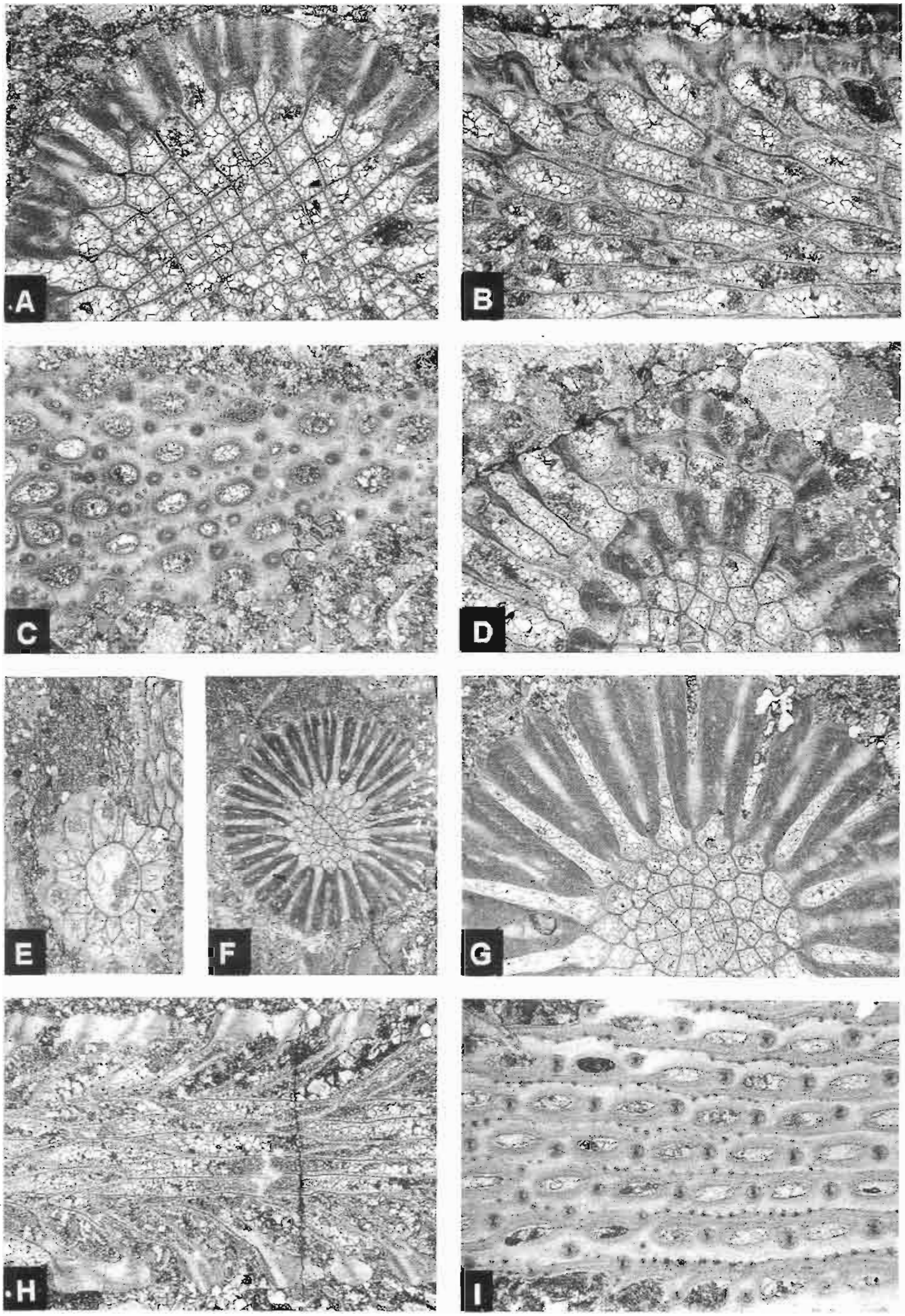
Description. — Finely branched *Rhombotrypella* with colony diameter averaging 2.9 mm. Exozone is clearly distinguished being about 0.51 mm wide and continued to increase in width as the colony expanded in diameter. A hook-like hemiseptum is present in the transition between endozone and exozone; diaphragms are not observed in autozooecial tubes. Autozooecial apertures ovate in outline, approximately 0.23 mm long and 0.15 mm wide. The apertures are arranged in rather regular rows with about 5.5 in 2 mm in all directions. Distance between apertural centers about 0.33 mm. Exilazooecial apertures circular or irregular in outline, about 0.05–0.10 mm in diameter. Exilazooecia are rare, not more than two in each autozooecial aperture. Three to four large acanthostyles, averaging 0.096 mm in diameter, are developed around each autozooecial aperture. Small acanthostyles, being about 0.02 mm in diameter are developed as a chain around each autozooecial aperture. Exozonal walls are 0.12–0.20 mm thick; endozonal walls about 0.02 mm. Autozooecial tubes in transverse section are square in outline in endozone numbering 5–6 per 1 mm.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BD	2.905	0.262	9.02	2.50	3.45	24
EW	0.513	0.187	36.45	0.21	0.81	26
DIA/1	–	–	–	–	–	–
AL	0.230	0.023	9.81	0.20	0.26	12
AW	0.149	0.016	10.49	0.13	0.18	12
AAC	0.328	0.023	6.97	0.29	0.35	12
AAL/2	5.528	0.407	7.36	5.00	6.10	18
AAC/2	5.528	0.407	7.36	5.00	6.10	18
EXLL	0.075	0.023	30.31	0.05	0.10	10
EXLW	0.075	0.023	30.31	0.05	0.10	10
SQ/1	5.609	0.262	4.67	5.00	6.00	34
MACA	0.096	0.017	17.25	0.07	0.11	14
MICA	0.020	0.001	6.86	0.02	0.02	8
MACA/A	3.500	0.707	20.20	3.00	4.00	2
MICA/A	22.500	1.871	8.31	20.00	25.00	6
EXWA	0.163	0.035	21.44	0.12	0.20	6
ENWA	0.018	0.001	6.52	0.02	0.02	11

Comparison. — The investigated specimens are similar to *Rhombotrypella rectangulata* as described by both Shul'ga-Nesterenko (1955) and Morozova (1955) in most measured characters. Zoarial dimensions are larger in *R. dvinensis* whereas autozooecial apertures are smaller and generally more closely packed in the latter species (see above). *R. arbuscula* (Eichwald 1860), known from the Artinskian and Kungurian of Timan and the Urals (Morozova & Kruchinina 1986) and from the Vøringen Member of the Kapp Starostin Formation of Spitsbergen (Nakrem in press) has generally thinner branches, narrower exozone as well as smaller and more closely packed zooecial apertures.

Fig. 11. ❑A–D. *Rhombotrypella rectangulata* Shul'ga-Nesterenko 1955. Kolosseum, Kapitol Member, Moscovian. A. Transverse section of exozone with evenly thickened zooecial walls, KOL-1–80.0m, PMO A42173, × 25. B. Oblique longitudinal section of exozone, KOL-1–80.0m, PMO A42171, × 25. C. Tangential section. Kolosseum, Kapitol Member, Moscovian, KOL-1–80.0m, PMO A42173, × 25. D. Regenerated growth/self overgrowth, KOL-1–80.0m, PMO A42171, × 25. ❑E. *Rhabdomeson* sp.; Skansen, Tyrrellfjellet Member, Asselian. SKA-2–132.0m, PMO A41990, × 25, petrographic thin section. ❑F–I. *Ascopora muromensis* Shul'ga-Nesterenko 1955; Kolosseum, Kapitol Member, Moscovian. F. Transverse section, TRO-2–40.0m,



PMO A42163, × 10. G. Transverse section with well visible bundle of parallel zooecial tubes, TRO-2–40.0m, PMO A42163, × 25.H. Longitudinal section, KOL-1–80.0m, PMO A42170, × 25. I. Tangential section, TRO-2–40.0m, PMO A41930, × 25.

Material. — KOL-1–80.0m (A42171, A42173, A42174), REF-0–25.0m (A42116, 138.063), TRO-1–29.0m (A42162).
Stratigraphic occurrence in Spitsbergen. — Moscovian, *Wedekindellina dutkevichi-Fusulinella eopulchra* fusulinid zone (Nilsson & Davydov in press), and late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.
Occurrence outside Spitsbergen. — Kasimovian and Gzhelian of the Urals (Shul'ga-Nesterenko 1955); Gzhelian of Timan (Morozova & Kruchinina 1986: table 5).

Order Cryptostomata Vine 1884
Suborder Rhabdomesina Astrova & Morozova 1956
Family Rhabdomesidae Vine 1884
Genus *Rhabdomeson* Young & Young 1874
Type species: *Millepora gracilis* Phillips 1841, Devonian of England.

Rhabdomeson sp.

Fig. 11E.
Remarks. — Specimens of *Rhabdomeson* were encountered in some randomly oriented sections, and identified due to the characteristic hollow central canal. Properly oriented sections have not been made, and specific identification is thus not possible.
Material. — GIP-1–14.0m (PMO A42104), SKA-2–132.0m (PMO A41990), TRO-2–60.0m (PMO A41264, A42013–015)
Stratigraphic occurrence in Spitsbergen. — Late Kasimovian-late Asselian (Kapitol and Tyrrellfjellet Members).
Occurrence outside Spitsbergen. — *Rhabdomeson* has a wide Middle Devonian-Late Permian range (Blake *in* Boardman *et al.* 1983).

Genus *Ascopora* Trautschold 1876
Type species: *Millepora rhombifera* Phillips 1836, Early Carboniferous of Yorkshire, England.
Remarks. — During the current study almost 50 specimens of *Ascopora* were thin sectioned/investigated, and different measurements were taken to discriminate the four species described below. Zoarial characters (branch diameter, exozone width and diameter of axial bundle) were found to vary continuously. To provide a useful distinction, apertural dimensions and packing of apertures were found to give the best results. Branch diameter and acanthostyle dimensions are more or less normal distributed when observing all specimens together, but discrimination is possible between each species. Measurements of stylet dimensions and endozone wall thickness are suspect due to recrystallization and subsequent loss of minute detail.

Ascopora muromensis Shul'ga-Nesterenko 1955

Fig. 11F–I.

Ascopora muromensis nom. nud.; Shul'ga-Nesterenko 1949: Pl. 7: 1–3.
Ascopora muromensis sp. n.; Shul'ga-Nesterenko 1955: p. 160, Pl. 26: 4–8.
Ascopora muromensis Shul'ga-Nesterenko; Morozova 1955: p. 57.

Description. — Cylindrical branching colony average 2.3 mm in diameter. Exozone up to 1.1 mm wide (average 0.75 mm), but also preserved narrower due to abrasion. Axial bundle with parallel zooecial tubes 0.50 mm in diameter with 4, rarely 5 parallel tubes as observed in longitudinal sections. Up to two hook-like hemisepta are present in exozonal zooecial tubes. Apertures oval, being 0.23–0.28 mm long and 0.07–0.14 mm wide. The apertures are arranged in distinct rows with a ridge between each row. There are about 4.8 apertures per 2 mm along colony and up to 7.7 (average 6.7) diagonally. The large acanthostyles have long pointed ends now preserved in surrounding sediment, their diameter average 0.11 mm. Usually there is one large acanthostyle between adjacent apertures, whereas in some areas there are two. Stylets with a diameter of 0.028–0.040 mm are developed in the ridges separating apertural rows.

Comparison. — *A. muromensis* is very similar to *A. magniseptata* Shul'ga-Nesterenko 1955 regarding many zoarial and zooecial dimensions, but is distinguished in the smaller number of distinct hemisepta developed. *A. muromensis* is distinguished from *A. sterlitamakensis* in having more closely packed zooecial apertures, and from *A. oblonga* in having thicker branches and more closely packed zooecial apertures.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BD	2.296	0.373	16.23	1.67	3.10	16
EW	0.750	0.286	38.10	0.45	1.10	7
AXB	0.499	0.068	13.66	0.36	0.56	11
AL	0.253	0.017	6.54	0.23	0.28	36
AW	0.111	0.025	22.86	0.07	0.14	36
AAL	0.421	0.043	10.20	0.35	0.48	29
AAL/2	4.768	0.223	4.67	4.40	5.10	34
AAC/2	6.688	0.529	7.91	6.00	7.70	41
MACA	0.105	0.010	9.84	0.09	0.12	38
MICA	0.034	0.003	8.99	0.03	0.04	17
EXWA	0.103	0.010	9.68	0.09	0.12	9
ENWA	0.011	0.002	15.86	0.008	0.013	8

Material. — KOL-1–80.0m (PMO A41814, A41853, A41863, A42170, A42172), KOL-3–169.0m (PMO A42281–283), TRO-2–40.0m (PMO A41924–925, A41927–931).

Stratigraphic occurrence in Spitsbergen. — Early Kasimovian, *Protriticites pseudomontiparus* fusulinid zone through late Asselian, *Schwagerina sphaerica* fusulinid zone (Nilsson & Davydov in press), Kapitol and Tyrrellfjellet members.

Occurrence outside Spitsbergen. — Moscovian-Kasimovian of the Urals (Morozova 1955).

Ascopora oblonga (Nikiforova 1933)

Fig. 12A–D.

Rhombopora dichotoma Ulrich var. *oblonga* var. n.; Nikiforova 1933: p. 27, Pls 6: 7–8, 7: 5–6.

Ascopora oblonga (Nikiforova); Morozova 1955: p. 56, Pl. 10: 4a–b.

Ascopora oblonga (Nikiforova); Goryunova & Kruchinina 1975: p. 151, Pl. 61: 4–6.

Description. — Delicate cylindrical dichotomically branching colonies averaging 1.9 mm in diameter. Exozone 0.49 mm wide. Axial bundle of parallel zooecia about 0.50 mm in diameter with 4, rarely 5 parallel zooecial tubes as observed from longitudinal sections. Two distinct proximal hemisepta are present in zooecial tubes in exozone. Apertures elongated oval, in some areas slit-like, about 0.28 mm long and 0.10 mm wide. There are about 4.2 apertures per 2 mm along colony and 6.5 diagonally. Distance between apertures longitudinally average 0.48 mm. Large acanthostyles 0.08–0.11 mm in diameter, stylets are present in ridges between apertural rows 0.018–0.030 mm in diameter. Zooecial wall in exozone is about 0.12 mm in thickness; endozonal wall about 0.011 mm.

Measurements. — (For abbreviations see pp. 57–58.)

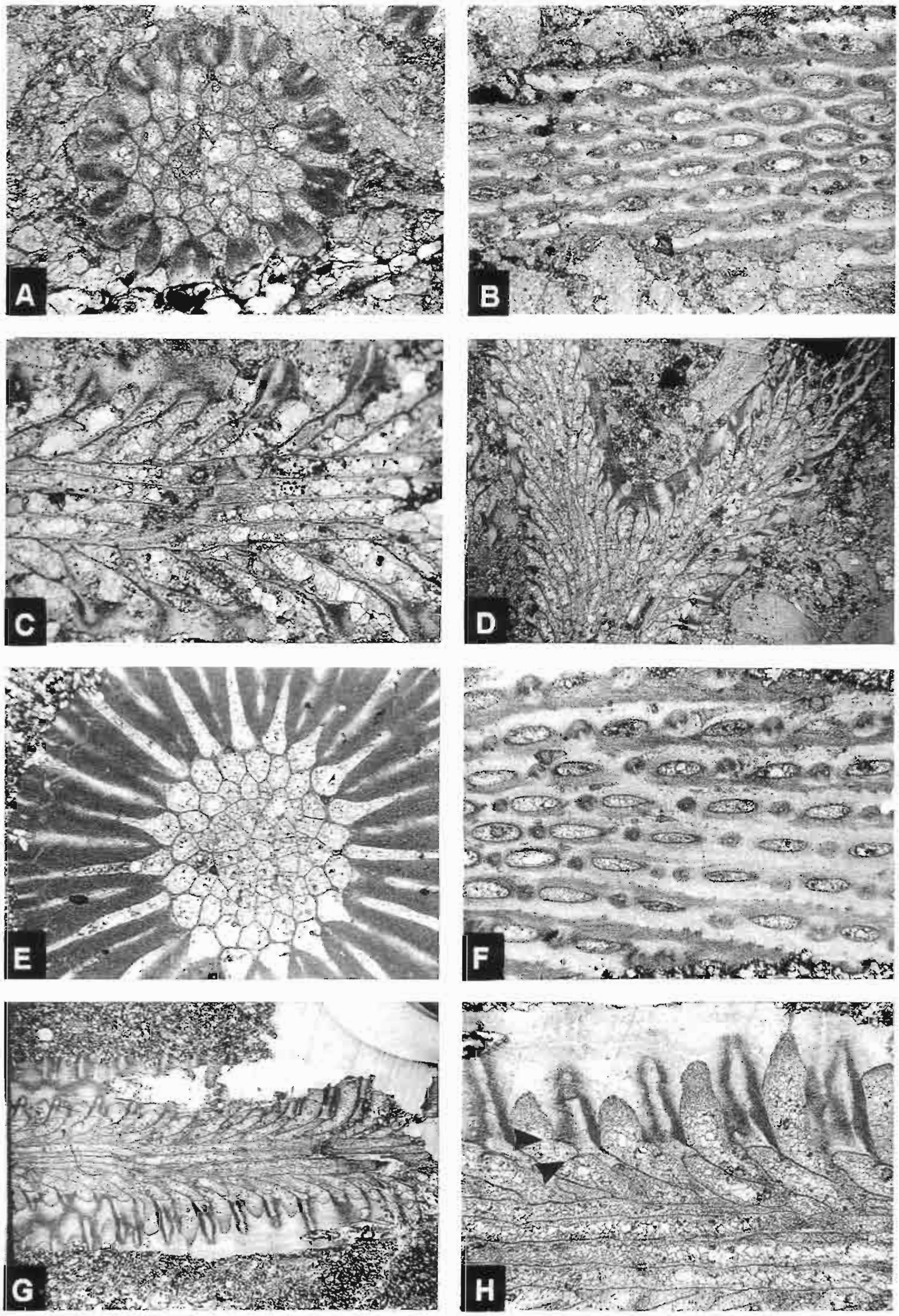
	AVG	STDS	CV	MIN	MAX	n
BD	1.871	0.317	16.92	1.45	2.33	10
EW	0.485	0.139	28.59	0.31	0.62	8
AXB	0.504	0.035	6.89	0.45	0.55	11
AL	0.281	0.030	10.61	0.25	0.33	24
AW	0.098	0.009	8.83	0.09	0.12	24
AAL	0.483	0.033	6.83	0.44	0.55	16
AAL/2	4.180	0.188	4.50	3.90	4.60	20
AAC/2	6.455	0.467	7.24	5.90	7.30	20
MACA	0.095	0.011	11.84	0.08	0.11	25
MICA	0.025	0.005	20.12	0.02	0.03	8
EXWA	0.119	0.017	14.14	0.09	0.13	7
ENWA	0.011	0.001	11.35	0.009	0.012	6

Comparison. — *A. oblonga* is distinguished from the other species of *Ascopora* in this study in the small branch diameter and the extremely elongated apertures.

Material. — KOL-1–28.3m (PMO A42167/1–2), REF-0–25.0m (PMO 138.069).

Stratigraphic occurrence in Spitsbergen. — Late Moscovian, *Wedekindellina dutkevichi – Fusulinella eopulchra* fusulinid zone (Nilsson & Davydov in press) and late Gzhelian, associated with *Schellwienia* aff. *arctica*

Fig. 12. ❑A–D. *Ascopora oblonga* (Nikiforova 1933); Kolosseum, Kapitol Member, Moscovian, KOL-1–28.3m. A. Transverse section, PMO A42167/1, × 25. B. Tangential section, PMO A42167/3, × 25. C. Longitudinal section, PMO A42167/1, × 25. D. Longitudinal section through region of bifurcation, PMO A42167/4, × 10. ❑E–H. *Ascopora sterlitamakensis* Nikiforova 1939; Gipsvika, Tyrrellfjellet Member, Asselian. E. Transverse section, GIP-1–9.0m,



PMO 138.047/2, × 25. F. Tangential section, GIP-1–1.0m, PMO 138.050, × 25. G. Longitudinal section, partly silicified, GIP-1–9.0m, PMO 138.047/1, × 10. H. Longitudinal section with 1–2 hemisepta visible in exozone (arrows), GIP-1–9.0m, PMO 138.047/1, × 25.

(Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — Podolsky Horizon (Moscovian) of the Urals (Morozova 1955).

Ascopora sterlitamakensis Nikiforova 1939

Fig. 12E–H.

Ascopora nodosa Fischer de Waldheim var. *sterlitamakensis* var. n.; Nikiforova 1939: p. 87 [98], Pl. 4: 7–8.

Ascopora sterlitamakensis Nikiforova; Morozova & Kruchinina 1986: p. 64, Pl. 22: 2a–b.

Description. — *Ascopora* with cylindrical bifurcating branches of varying diameter (1.8–3.3 mm). Exozone about 0.80 mm wide, axial bundle of parallel zooecial tubes 0.40–0.55 mm in diameter containing 4 parallel tubes as observed in longitudinal sections. Two proximal hemisepta are usually present in zooecial tubes in exozone. Apertures elongated oval, sometimes slit-like, about 0.25 mm long and 0.10 mm wide. The apertures are arranged in rows with ridges between; 3.3–4.0 per 2 mm along colony and 5.4–6.6 diagonally. Distance between apertural centers longitudinally average 0.52 mm. One, or rarely two large acanthostyles are present adjacent to each aperture. A chain of stylets, 0.02–0.04 mm in diameter, is present on the ridges between apertural rows. Zooecial wall in exozone is 0.090–0.16 mm in thickness; endozonal wall about 0.010 mm.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BD	2.448	0.519	21.21	1.80	3.30	11
EW	0.806	0.221	27.41	0.50	1.10	8
AXB	0.470	0.055	11.72	0.40	0.55	7
AL	0.253	0.042	16.67	0.20	0.33	24
AW	0.104	0.022	21.61	0.07	0.15	24
AAL	0.518	0.031	5.98	0.49	0.62	18
AAL/2	3.722	0.163	4.38	3.30	4.00	18
AAC/2	5.889	0.254	4.32	5.40	6.60	18
MACA	0.112	0.016	14.24	0.09	0.14	22
MICA	0.031	0.007	23.92	0.02	0.04	5
EXWA	0.134	0.027	20.16	0.09	0.16	5
ENWA	0.010	0.001	7.44	0.009	0.010	2

Comparison. — The present specimens are similar to the specimens of *A. sterlitamakensis* described by Nikiforova (1939) and Morozova & Kruchinina (1986) in most characters, although longitudinal distance apertures is slightly greater in the Spitsbergen specimens. *A. sterlitamakensis* differs from *A.* sp. A in having wider exozone and having larger acanthostyles, and from *A. muromensis* in having greater distance between apertures in all directions.

Material. — GIP-1–9.0m (PMO A42103, 138.047/1–2), GIP-1–1.0m (PMO 138.049–054).

Stratigraphic occurrence in Spitsbergen. — Asselian, below the *Eoparafusulina paralinearis* fusulinid zone (Nilsson & Davydov in press), middle part of the Tyrrellfjellet Member.
Occurrence outside Spitsbergen. — Sakmarian of Timan (Morozova & Kruchinina 1986).

Ascopora sp. A

Fig. 13A–B, D.
Description. — Relatively delicate bifurcating colony, with a diameter averaging 2.3 mm. Exozone shows great variation between 0.29 and 0.64 mm in width. Axial bundle of parallel zooecial tubes about 0.71 mm in diameter with 4 parallel tubes as observed in longitudinal section. Zooecial apertures strongly elongated oval, averaging 0.28 mm in length, 0.11 mm in width. In 2 mm there are 3.4–3.8 apertures along colony and 6.9–7.6 diagonally across colony. Distance between apertural centers along colony about 0.52 mm. A single large acanthostyle with a diameter about 0.08 mm is developed between each aperture. A chain of stylets is present on the ridges separating the individual apertural rows. 15–20 stylets with a diameter of about 0.025 mm surround each aperture. Exozone wall thickness varies between 0.08 and 0.10 mm; zooecial walls in the endozone measure about 0.011 mm. 1–2 hemisepta are present in exozonal part of zooecial tubes.
Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BD	2.284	0.448	19.59	1.82	2.82	7
EW	0.429	0.157	36.66	0.29	0.64	7
AXB	0.712	0.056	7.85	0.65	0.77	5
AL	0.284	0.033	11.54	0.23	0.31	17
AW	0.114	0.010	8.78	0.10	0.13	17
AAL	0.517	0.027	5.32	0.46	0.58	25
AAL/2	3.569	0.149	4.18	3.40	3.80	16
AAC/2	7.325	0.195	2.66	6.90	7.60	16
MACA	0.083	0.008	9.20	0.07	0.10	18
MICA	0.025	0.005	20.39	0.02	0.03	10
EXWA	0.090	0.006	7.03	0.08	0.10	6
ENWA	0.011	0.001	12.30	0.010	0.012	4

Comparison. — The relatively distant apertures longitudinally and more closely packing across colony distinguishes the present species from those described herein. In many characters *Ascopora* sp. A resembles *A. elanyensis* Trizna 1961 described from the Myachkovian-Podolskian (Bashkirian, Middle Carboniferous) of the Urals, which however has smaller apertures and narrower axial bundle. *Ascopora* sp. A is distinguished from both *A. muromensis* and *A. oblonga* in having longer distance between apertures longitudinally, but more closely spaced apertures diagonally.
Material. — REF-1–9.5m (PMO A42113), TRO-1–9.5m (PMO A42586–588).

Stratigraphic occurrence in Spitsbergen. — Late Moscovian *Wedekindellina dutkevichi – Fusulinella eopulchra* fusulinid zone (Nilsson & Davydov in press) and ?late Gzhelian-?early Asselian, associated with *Streptognathodus excelsus* and *S. elongatus*, lower part of the Kapitol Member and lowermost part of the Tyrrellfjellet Member.

Genus *Ascoporella* Kruchinina *in* Morozova & Kruchinina 1986

Type species: *Ascopora grandis* Kruchinina, Sakmarian of Timan, Russia.

Remarks. — *Ascoporella* differs from *Ascopora* in having thicker branches, larger number of parallel zooecial tubes in endozone (usually more than 10), beaded exozonal walls and less regularly arranged autozooecial apertures. As observed from the illustrations in Kruchinina (1973) and Morozova & Kruchinina (1986) all these features are not well visible in all the species assigned to this genus. *Ascopora pugnalis* Fengsheng 1986 and *Ascopora yangiana* Fengsheng 1986 from the Late Permian of China (Fengsheng 1986) fulfill most of the above mentioned features and should consequently be transferred to *Ascoporella*.

Ascoporella grandis (Kruchinina 1973)

Fig. 13E–H.

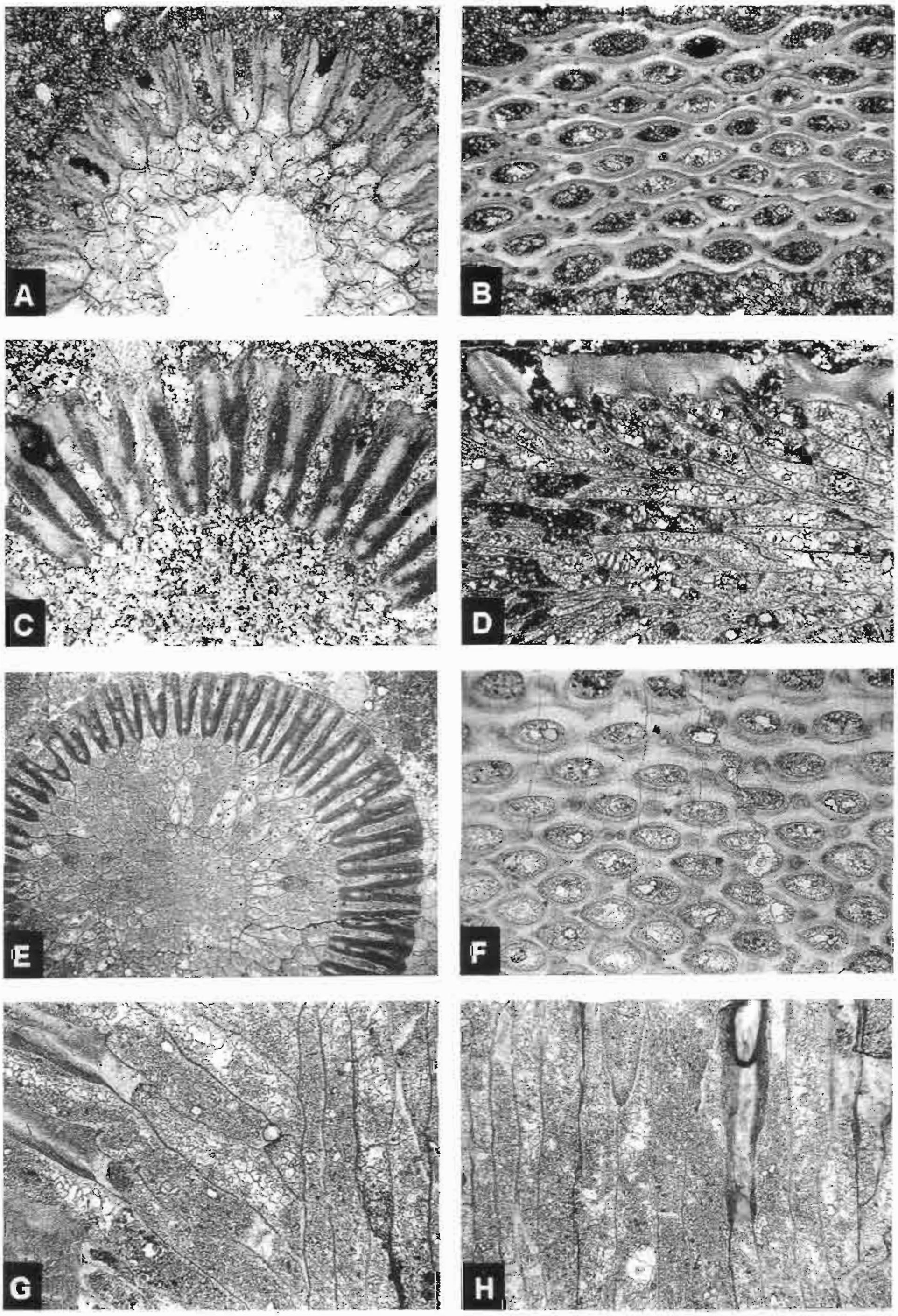
Ascopora grandis sp. n.; Kruchinina 1973: p. 95, Pl. 27: 6.

Ascoporella grandis (Kruchinina); Morozova & Kruchinina 1986: p. 65, Pl. 22: 1a–d.

Description. — Zoarium ramose with thick branches averaging 6.6 mm in diameter (slightly abraded). Exozone about 0.6 mm wide; endozone 5.3–5.5 mm in diameter. Axial bundle diameter 2.4 mm. The axial bundle comprises 11 parallel zooecial tubes as viewed in longitudinal section. Zooecial apertures elongated, about 0.26 mm long and 0.15 mm wide. There are 4 zooecial apertures in 2 mm along colony; 5–6 diagonally. There are 2–3 hemisepta present in exozonal zooecial tubes. One large acanthostyle is developed in the area between zooecial apertures; diameter 0.09–0.11 mm. Small, infrequent pores are also present in exozonal walls.

Remarks. — The described specimens compare well with the illustrations and descriptions given by Kruchinina (1973) and Morozova & Kruchinina (1986). It should be remarked that the axial bundle was described as containing 15–22 parallel zooecial tubes, but the illustrations given (Kruchinina 1973: Pl. 28: 1c, identical to Morozova & Kruchinina 1986: Pl. 22: 1c) display a maximum of 11 parallel zooecia. The number of parallel

Fig. 13. ❑A–B, D. *Ascopora* sp. A. A. Transverse section with silicified central part. Trollfuglfjella, Kapitol Member, Moscovian, TRO-1–9.5m, PMO A42588, × 25, petrographic thin section. B. Tangential section. Trollfuglfjella, Kapitol Member, Moscovian, TRO-1–9.5m, PMO A42587, × 25, petrographic thin section. D. Longitudinal section. Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-1–9.5m, PMO A42113, × 25. ❑C. ?*Ascoporella* sp. A, transverse section with central part completely dissolved. Rejmyrefjellet, upper part of Tyrrellfjellet Member, early Sakmarian, REF-2–4.0m, PMO 138.123, × 25. ❑E–H. *Ascoporella grandis* (Kruchinina 1973); Gipsvika, Tyrrellfjellet Member, late Asselian, GIP-1–14.0m. E. Transverse



section, PMO A42104/3, × 10. F. Tangential section, PMO 138.045, × 25. G. Longitudinal section showing part of axial bundle of parallel zooecial tubes and exozone with hemisepta, A42104/1, × 25. H. Axial bundle with 12 parallel tubes visible, PMO A42104/2, × 25.

zooecial tubes counted from these illustrations is actually lower than the minimum figure given in the generic diagnosis.

Comparison. — *A. grandis* is distinguished from *A. borealis* (Stuckenberg 1895) and *A. enormis* Kruchinina 1986 (both Artinskian species from Timan) in having smaller branch diameter, and fewer parallel zooecia in the axial bundle.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BD	6.425	0.171	2.66	6.20	6.60	4
EW	0.563	0.015	2.71	0.55	0.58	3
AXB	2.050	0.071	3.45	2.00	2.10	2
AL	0.257	0.010	3.84	0.24	0.27	12
AW	0.152	0.007	4.73	0.14	0.16	12
AAL	0.477	0.009	1.86	0.47	0.49	12
AAL/2	3.988	0.145	3.65	3.80	4.20	16
AAC/2	5.886	0.357	6.07	5.00	6.30	14
MACA	0.102	0.006	6.20	0.09	0.11	10
MICA	—	—	—	—	—	—
EXWA	0.134	0.010	7.27	0.12	0.15	7
ENWA	0.012	0.002	17.88	0.01	0.01	5

Material. — GIP-1–14.0m (PMO A42104, 138.045, 138.060).

Stratigraphic occurrence in Spitsbergen. — Late Asselian, below the *Eoparafusulina paralinearis* fusulinid zone (Nilsson & Davydov in press) and *Sweetognathus inornatus*, middle part of the Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — Sakmarian (Ilibei Horizon) of Timan (Morozova & Kruchinina 1986).

?*Ascoporella* sp. A

Figs 13C, 17A–C.

Description. — Moderately thick branches 2.4–5.1 mm in diameter. Exozone average 0.63 mm in width; it is, however, possibly abraded. Axial bundle of parallel zooecial about 0.87 mm in diameter with 6–7 zooecial tubes as observed in longitudinal section. Apertures are arranged in regular rows, elongated ovate in outline, being 0.25–0.30 mm long and 0.11–0.16 mm wide. There are 4.3 apertures per 2 mm along colony and 7 diagonally. Distance between apertural centers longitudinally 0.40–0.50 mm. A single large acanthostyle is present adjacent to each aperture, about 0.10 mm in diameter; stylets are 0.01–0.02 mm in diameter arranged on ridges between apertural rows. Exozonal walls about 0.08 mm thick; endozonal walls about 0.011 mm thick. Zooecial walls are in places beaded and display an annular growth pattern.

Remarks. — A number of moderately thick specimens have been assigned to ?*Ascoporella* sp. due to many features in common with *Ascoporella*. The generic assignment is questioned because the branches are significantly thinner than defined for *Ascoporella* by Kruchinina (*in* Morozova & Kruchinina 1986), and the axial bundle also contains a lower number of parallel zooecia than in *Ascoporella*. The mentioned features are, however, more similar to those in *Ascoporella* than *Ascopora*. No previously described species of *Ascoporella* match the measured characters in the current specimens.

Comparison. — Both zoarial and zooecial dimensions distinguish ?*Ascoporella* sp. from *Ascoporella grandis*. The apertures are more elongated, and also more closely distributed as counted in tangential sections. Axial bundle is narrower, and number of parallel tubes is smaller. Other previously described species of *Ascoporella* have significantly greater dimensions in most zoarial characters (Morozova & Kruchinina 1986).

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BD	3.503	0.907	25.89	2.40	5.10	17
EW	0.631	0.264	41.91	0.35	1.10	11
AXB	0.869	0.106	12.20	0.76	1.10	10
AL	0.276	0.017	6.03	0.25	0.30	38
AW	0.129	0.017	13.05	0.11	0.16	38
AAL	0.456	0.026	5.65	0.40	0.50	38
AAL/2	4.274	0.327	7.64	3.60	4.90	39
AAC/2	6.989	0.372	5.32	6.10	7.80	36
MACA	0.099	0.011	11.09	0.08	0.12	43
MICA	0.017	0.001	7.82	0.01	0.02	15
EXWA	0.077	0.011	13.84	0.07	0.10	22
ENWA	0.011	0.006	56.90	0.004	0.020	26

Material. — REF-2–4.0m (PMO 138.115, 138.117, 138.119, 138.122, 138.123, 138.124, A42300, A42302–304).

Stratigraphic occurrence in Spitsbergen. — ?Early Sakmarian, below *Sweetognathus inornatus*, uppermost part of the Tyrrellfjellet Member.

Family Rhomboporidae Simpson 1895

Genus *Rhombopora* Meek 1872

Type species: *Rhombopora lepidodendroides* Meek 1872, Virgilian of Nebraska.

Rhombopora sp. A

Fig. 14D–F.

Description. — Dichotomously branching zoaria commonly 1.5–1.6 mm in diameter (up to 1.8 prior to bifurcation) are assigned to *Rhombopora* sp. A. Exozone about 0.35 mm wide. Zooecia originate in a spiral growth pattern from a central axis. Some tubes carry up to 2 thin diaphragms. Apertures in a moderately well arranged linear pattern, being about 0.27 mm long and 0.15 mm wide. Zooecial tubes meet colony surface at low angles, and slightly deeper cut (polished) tangential sections will produce artificially larger, more elongated apertures, up to 0.36 mm long. There are about 3 apertures per 2 mm along colony and 5.2 diagonally. Distance between apertural centers 0.43–0.86 mm longitudinally. Large acanthostyles protrude well above colony surface, being 0.09–0.13 mm in diameter. There are usually 5–6 large acanthostyles around each aperture. 6–10 stylets, 0.018–0.040 mm in diameter are developed in exozonal walls around each aperture. Exozonal walls about 0.12 mm thick; endozonal walls about 0.016 mm thick.

Comparison. — *R. nikiforovae* Baranova 1960a, described from the late Sakmarian-early Artinskian of Timan has greater zoarium diameter (2.35 mm) than *R.* sp. A, and wider exozone (0.47–0.61 mm), the apertures are more elongated (0.22–0.31 mm long and 0.09–0.11 mm wide) and are also more widely spaced. *R.* sp. A is distinguished from *R. optima* Goryunova 1975, from the Artinskian of Pamir, which has thinner branches (1.00 mm in diameter) and extremely elongated apertures (0.43–0.50 mm long and 0.10–0.13 mm wide), 2 and 3 per 2 mm longitudinally and diagonally respectively.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BD	1.597	0.168	10.54	1.330	1.800	9
EW	0.354	0.030	8.60	0.310	0.400	7
AL	0.267	0.033	12.41	0.220	0.360	26
AW	0.153	0.031	20.08	0.110	0.240	26
AAL	0.640	0.126	19.62	0.430	0.820	16
AAL/2	3.050	0.463	15.17	2.500	4.000	22
AAC/2	5.205	0.502	9.65	4.700	6.200	20
MACA	0.108	0.013	11.78	0.090	0.130	25
MICA	0.029	0.007	25.28	0.018	0.040	22
EXWA	0.119	0.019	16.29	0.090	0.150	18
ENWA	0.016	0.002	9.46	0.014	0.020	14

Material. — REF-2–4.0m (PMO A42301/1–2, 138.118, 138.120).

Stratigraphic occurrence in Spitsbergen. — ?Early Sakmarian, below *Sweetognathus inornatus*, uppermost part of the Tyrrellfjellet Member.

Suborder Timanodictyina Morozova 1966

Family Timanodictyidae Morozova 1966

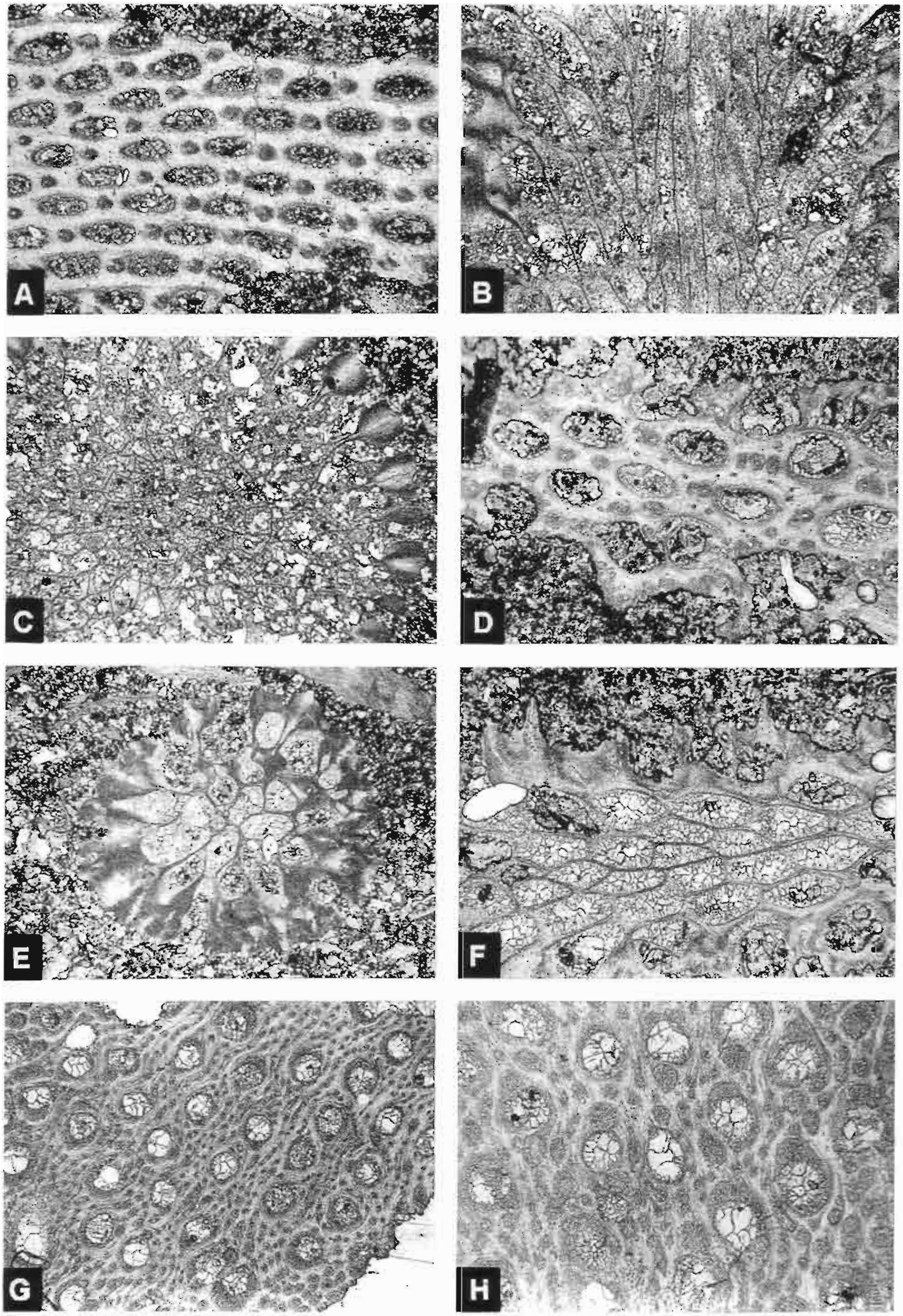
Genus *Timanodictya* Nikiforova 1938

Type species: *Coscinium dichotomum* Stuckenberg 1895, Early Permian of Timan, Russia.

Timanodictya sp. A

Figs 14G–H, 15A–D.

Fig. 14. ❑A–C. ?*Ascoporella* sp. A; Rejmyrefjellet, upper part of Tyrrellfjellet Member, early Sakmarian, REF-2–4.0m. A. Tangential section, PMO 138.122, × 25. B. Longitudinal section, PMO 138.124, × 25. C. Transverse section with partly abraded or leached outermost exozone and visible central bundle of zooecial tubes, PMO A42301/2, × 25. ❑D–F. *Rhombopora* sp. A; Rejmyrefjellet, upper part of Tyrrellfjellet Member, early Sakmarian, REF-2–4.0m. D. Tangential section, PMO 130.120, × 25. E. Transverse section, PMO 138.118, × 25. F. Longitudinal



section with protruding styles, PMO A42301/2, × 25. ❑G–H. *Timanodictya* sp. A, tangential sections. Gipsvika, Tyrrellfjellet Member, late Asselian, GIP-1–14.0m, PMO 138.057. G – × 25; H – with large (shallow) and smaller (deeper) tubercles, × 40.

Description. — A small fragment of *Timanodictya* was found attached to an unknown, now silicified substrate. The attachment portion gave rise to a superficially hollow colony, but development of a lateral bifoliate branch is also observed. Encrusting layer about 0.30–0.50 mm in thickness; bifoliate branch up to 0.9 mm in thickness. Encrusting lamina, and median lamina in lateral branch about 0.050–0.064 mm in thickness. Apertures, carrying a stellate peristome, are slightly ovate, about 0.16 mm long and 0.14 mm wide. Apertures arranged in oblique rows, about 4.5 per 2 mm along branch and 6–7 diagonally. Colony surface has a striated pattern of abundant stylets developed between apertures; 0.08–0.09 mm in diameter in shallowest tangential section and significantly smaller in deeper section. Larger stylets are developed adjacent to apertures. A single, significantly smaller aperture (?fossazooecium) was also observed, being 0.09 mm in diameter. Elevated monticules, about 1.0 × 0.55 mm are not common.

Comparison. — Zooecial dimensions and apertural spacing are most similar to those in *T. nikiforovae* Morozova 1966 of Late Permian age. Development and dimensions of stylets and capillaries account for similarity with *T. dichotoma* (Stuckenberg 1895) and *T. cylindrica* Nikiforova 1939 of Early Permian age. Limitations in the material available prevent a precise assignment, and measurements are subsequently not tabulated.

Material. — GIP-1–14.0m (PMO 138.057).

Stratigraphic occurrence in Spitsbergen. — Late Asselian (below the *Eoparafusulina paralinearis* fusulinid zone (Nilsson & Davydov in press) and *Sweetognathus inornatus*, middle part of the Tyrrellfjellet Member.

Order Fenestrata Elias & Condra 1957

Note: Morozova (1987) is followed in the subdivision of this order.

Family Fenestellidae King 1849

Genus *Flexifenestella* Morozova 1974

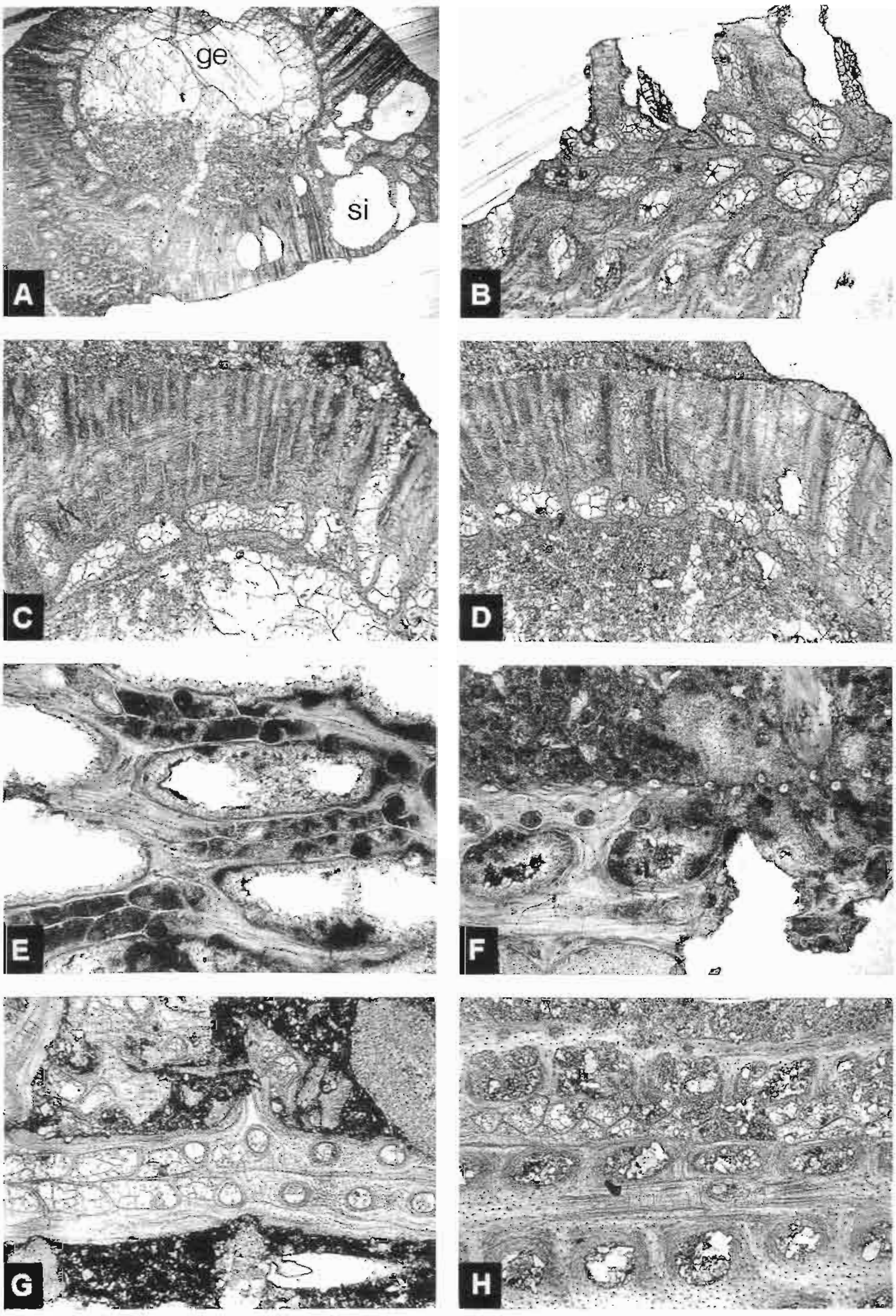
Type species: *Fenestella eichwaldi* Stuckenberg 1895, Early Permian of the Urals.

Flexifenestella cf. *grandis* (Shul'ga-Nesterenko 1936)

Fig. 15E.

cf. *Fenestella foraminosa* Eichwald var. *grandis* var. n.; Shul'ga-Nesterenko 1936: p. 250, Pl. 5: 2, Text-fig. 13.

Fig. 15. ❑A–D. *Timanodictya* sp. A, tangential sections. Gipsvika, Tyrrellfjellet Member, late Asselian, GIP-1–14.0m, PMO 138.057. A. Transverse section of complete zoarium encrusting a (now) dissolved substratum with a well developed geopetal crystal growth (ge) and local silicification (si), × 10. B. Longitudinal section of lateral branch, × 25. C. Oblique longitudinal of encrusting layer, × 25. D. Oblique transverse section of encrusting layer, × 25. ❑E. *Flexifenestella* cf. *grandis* (Shul'ga-Nesterenko 1936), deep tangential section. Boltonbreen, Tyrrellfjellet Member, latest Gzhelian, BOLT-B2, PMO A42078, × 25, petrographic thin section. ❑F. *Fabifenestella* sp. A, oblique shallow (top) to deep (bottom) tangential section with well visible row of carinal nodes (almost white). Boltonbreen, Tyrrellfjellet Member, latest Gzhelian, BOLT-B2, PMO A42077, × 25, petrographic thin section. ❑G. *Fabifenestella* sp. B, shallow to medium deep section. Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m,



PMO 138.071, × 25. ❑H. *Rectifenestella microporata* (Shul'ga-Nesterenko 1939), shallow (top) to deep, reversal (bottom) tangential section. Gipsvika, Tyrrellfjellet Member, late Asselian, GIP-1–20.0m, PMO 138.058/1, × 25.

cf. *Fenestella foraminosa* Eichwald var. *grandis* Shul'ga-Nesterenko; Shul'ga-Nesterenko 1939: p. 69, Pl. 12: 4.

cf. *Fenestella foraminosa* Eichwald var. *grandis* Shul'ga-Nesterenko; Shul'ga-Nesterenko 1941: p. 62, Pl. 7: 1.

cf. *Flexifenestella grandis* (Shul'ga-Nesterenko); Morozova 1974: Pl. 3: 3.

cf. *Flexifenestella grandis* (Shul'ga-Nesterenko); Alekseeva *et al.* 1986: Pl. 99: 1.

Description. — The fragment identified as *Flexifenestella* cf. *grandis* is characterized by a fenestrated colony with undulating, almost anastomosing branches, and short but wide dissepiments. There are 14–16 branches across colony and about 6 fenestrules along colony per 10 mm. Both branches and dissepiments are about 0.29 mm wide, but variation in branch width is larger. The branches carry about 2 circular nodes per 1 mm on a sinuous carina. The nodes are 0.06–0.07 mm in diameter with a distance of 0.40–0.70 mm between centers. Apertures are circular, 0.12–0.13 mm in diameter. Distance between apertural centers is 0.33 along branch and 0.27 diagonally across branch. There are 15–16 apertures along branch per 5 mm. Zooecial bases are rectangular to parallelogram shaped in median tangential section, sometimes with an outer single hemiseptum. Fenestrules have a pointed (sharp) outline, about 1.40 mm long and 0.40 mm wide, bordered by 4–5 apertures.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	14.767	0.668	4.53	14.00	15.70	6
DS10	6.200	0.361	5.82	5.80	6.50	3
A5	15.467	0.408	2.64	15.00	16.00	6
AFEN	4.500	0.577	12.83	4.00	5.00	4
WB	0.286	0.018	6.35	0.27	0.31	5
WD	0.288	0.052	18.01	0.22	0.36	6
FL	1.357	0.051	3.78	1.30	1.40	3
FW	0.400	0.010	2.50	0.39	0.41	3
AD	0.125	0.006	4.62	0.12	0.13	4
AAL	0.333	0.015	4.52	0.32	0.36	6
AAC	0.268	0.011	4.09	0.25	0.28	5
N1	2.000	0.500	25.00	1.50	2.50	3
SNB	0.550	0.129	23.47	0.40	0.70	4
NL	0.068	0.004	6.00	0.06	0.07	4
NW	0.068	0.004	6.00	0.06	0.07	4

Comparison. — *F. grandis* is separated from *F. foraminosa* (Eichwald 1860) in having more elongated fenestrules and more closely packed apertures. *F. eichwaldi* (Stuckenberg 1895), also from the Early Permian of Timan, has shorter distance between branch centers across colony, as well as more closely separated apertures.

Material. — BOLT-B2 (PMO A42078, collected by Carl E. Dons in 1980).

Stratigraphic occurrence in Spitsbergen. — Latest Gzhelian, *Palaeoaplysina* bioherm 2, lowermost part of Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — Sakmarian-Artinskian of Urals and the East European Platform (Alekseeva *et al.* 1986).

Genus *Fabifenestella* Morozova 1974.

Type species: *Fenestella praevirgosa* Shul'ga-Nesterenko 1951, Gzhelian of central Russia.

Fabifenestella sp. A

Fig. 15F.

Description. — A fragment of an intermediately robust zoarium with zooecial chambers with a moderately well developed superior hemiseptum is identified as *Fabifenestella* sp. A. The zoarium has 14–15 branches across and about 13 fenestrules along per 10 mm. The branches are straight, 0.30–0.36 mm wide; dissepiments are 0.16–0.18 mm wide. The branches carry a row of monoserial nodes 0.05–0.06 mm in diameter, about 0.17 mm spaced from center to center (6–7 per 1 mm). Apertures are circular, with a diameter between 0.10 and 0.11 mm. Distance between apertures is 0.29–0.31 along branch (about 17 per 5 mm); distance diagonally across branch could not be measured due to section obliqueness. Zooecial bases are fabiform in shallowest tangential section, elongated rectangular to slightly parallelogram shaped in deeper sections. Fenestrules are ovate to approaching rectangular shaped, about 0.62 mm long and 0.35 mm wide.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	14.300	0.447	3.13	14.00	15.00	5
DS10	13.060	0.089	0.68	13.00	13.20	5
A5	16.867	0.058	0.34	16.80	16.90	3
AFEN	2.750	0.289	10.50	2.50	3.00	4
WB	0.323	0.032	9.94	0.30	0.36	3
WD	0.170	0.010	5.88	0.16	0.18	3
FL	0.620	0.028	4.56	0.60	0.64	2
FW	0.345	0.021	6.15	0.33	0.36	2
AD	0.107	0.006	5.41	0.10	0.11	3
AAL	0.304	0.007	2.45	0.29	0.31	8
AAC	–	–	–	–	–	–
N1	6.367	0.153	2.40	6.20	6.50	3
SNB	0.167	0.008	4.52	0.16	0.18	7
NL	0.055	0.007	12.86	0.05	0.06	2
NW	0.055	0.007	12.86	0.05	0.06	2

Remarks. — The few measurements conducted on a single specimen do not justify assignment to a specific species, but the calculated meshwork formula is different from other described species of *Fabifenestella*.

Material. — BOLT-B2 (PMO A42077, collected by Carl E. Dons in 1980).

Stratigraphic occurrence in Spitsbergen. — Latest Gzhelian, *Palaeoaplysina* bioherm 2, lowermost part of Tyrrellfjellet Member.

Fabifenestella sp. B

Fig. 15G.

Remarks. — Small fragments of fenestellids with the typical generic characters of *Fabifenestella*, e.g., wide branches and straight dissepiments are observed in some samples. Closely spaced, larger, slightly ovate apertures (0.13–0.14 mm × 0.11–0.12 mm) distinguish this species from *F.* sp. A. Both branches and dissepiments are wider than in *F.* sp. A.

Material. — REF-0–25.0m (PMO A42204, 138.071).

Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.

Genus *Rectifenestella* Morozova 1974

Type species: *Fenestella medvedkensis* Shul'ga-Nesterenko 1951, Kasimovian of central Russia.

Rectifenestella microporata (Shul'ga-Nesterenko 1939)

Figs 15H, 16A–C.

Fenestella elegantissima Eichwald var. *microporata* var. n.; Shul'ga-Nesterenko 1939: p. 67, Text-fig. 21.

Fenestella elegantissima Eichwald var. *microporata* Shul'ga-Nesterenko var. n.; Shul'ga-Nesterenko 1941: p. 69, Pls 7: 3, 8: 3.

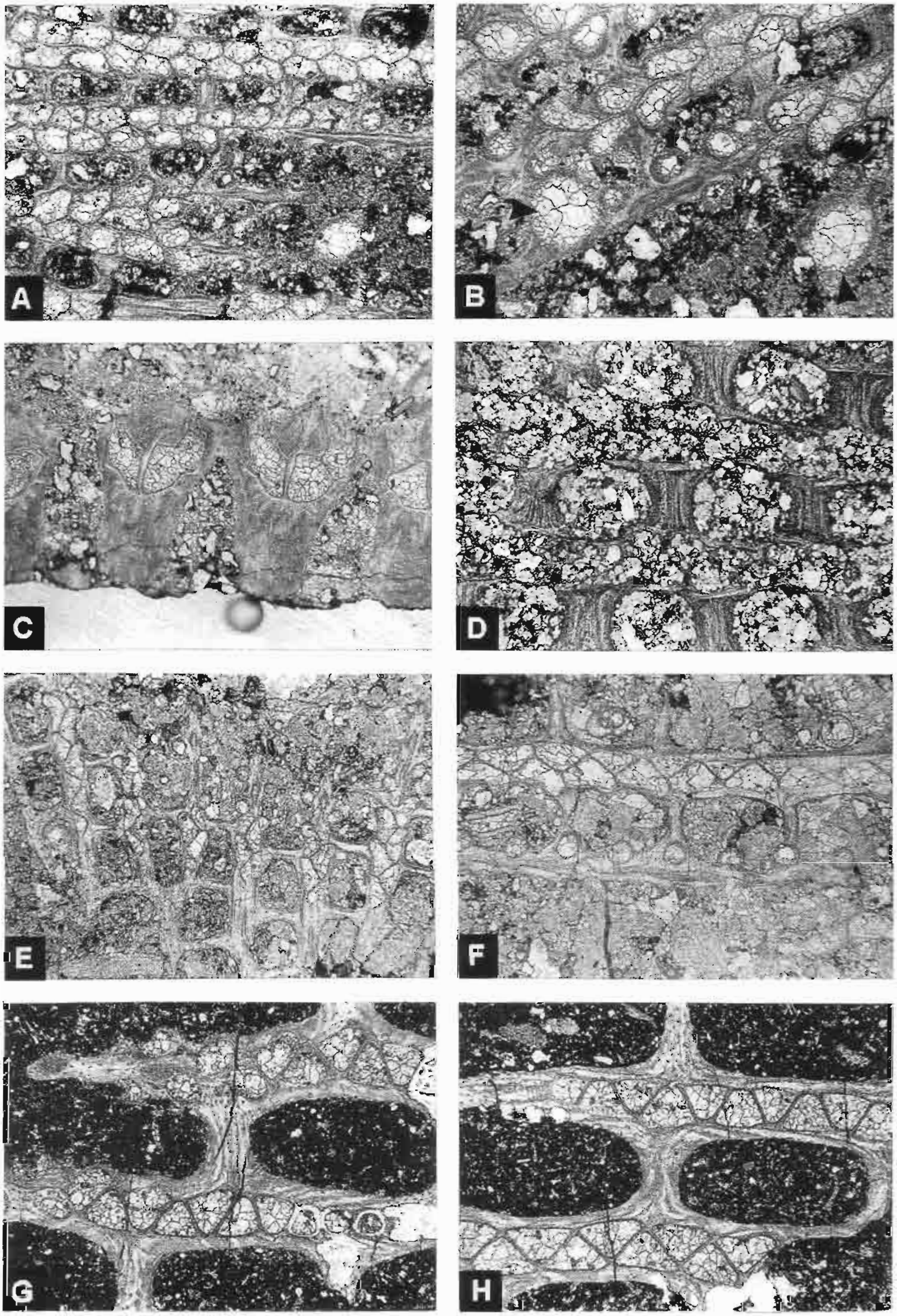
Fenestella elegantissima Eichwald var. *cornifera* Shul'ga-Nesterenko var. n.; Shul'ga-Nesterenko 1941: p. 71 [232], Pl. 9: 1–2.

Rectifenestella microporata (Shul'ga-Nesterenko); Morozova 1981: p. 65, Pls 15: 5, 29: 3.

Rectifenestella microporata (Shul'ga-Nesterenko); Morozova & Kruchinina 1986: p. 80, Pl. 28: 3.

Description. — Delicate meshwork with 20–24 small fenestrules along colony and 21–27 branches across colony per 10 mm. Branches about 0.22 mm wide with a straight low carina carrying about 4.5 nodes per 1 mm. Nodes are about 0.090 mm long and 0.075 mm wide being 0.18–0.29 mm apart. Dissepiments varying significantly in width, from 0.07 mm near colony reverse side up to 0.20 mm near obverse side. Fenestrules vary in size being smallest near obverse surface; about 0.35 mm long and 0.19 mm wide. Fenestrules near reverse side of colony almost circular, being 0.22–0.27 mm in diameter. The shape of branches and dissepiments in transverse sections thus accounts for cone-shaped fenestrules. Apertures

Fig. 16. ❑A–C: *Rectifenestella microporata* (Shul'ga-Nesterenko 1939); Gipsvika, Tyrrellfjellet Member, Asselian. A. Tangential section, GIP-1–5.0m, PMO A42107, × 25. B. Tangential section with ovicells (arrows), GIP-1–5.0m, PMO A42107, × 40. C. Transverse section, GIP-1–20.0m, PMO 138.058/2, × 40. ❑D. *Rectifenestella* cf. *ornata* (Shul'ga-Nesterenko 1939), poorly preserved deep tangential section. Gipsvika, Tyrrellfjellet Member, Asselian, GIP-1–1.0m, PMO 138.048, × 25. ❑E–F. *Rectifenestella submicroporata* (Shul'ga-Nesterenko 1952); Kolosseum, Kapitol Member, Moscovian, KOL-1–28.3m, PMO A42167/2. E. Tangential section close to colony origin, × 25. F. Shallow (bottom) to deep (top) tangential section, × 40. ❑G–H. *Alternifenestella bifida* (Eichwald 1860); Grønfjorden, Tyrrellfjellet Member, latest Gzhelian.



G. Shallow to deep tangential section with large nodes visible (lower right), PMO A42018, × 25, petrographic thin section. H. Deep tangential section with local silicification, PMO A42017, × 25, petrographic thin section.

circular in outline, about 0.10 mm in diameter. There are usually 22–23 apertures per 5 mm along branch. Distance between apertural centers along colony about 0.20 mm; diagonally across branch about 0.23 mm. 2–2.5 apertures border each fenestrule. Zooecial chambers pentagonal in outline in median tangential section.

Remarks. — The branches do not display the heavy calcified reverse side as was observed in the specimens from the Vøringen Member (Kapp Starostin Formation) (Nakrem in press).

Comparison. — *R. microporata* is distinguished from *R. submicroporata* (see below) in having larger apertures (0.10 mm against 0.07 mm in diameter) and wider and more widely spaced branches and dissepiments. *R.* cf. *ornata* (see below) has a looser meshwork with more robust branches and dissepiments.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	23.818	1.026	4.31	21.40	26.80	40
DS10	21.733	0.989	4.55	19.80	24.00	39
A5	22.508	1.385	6.15	20.90	25.80	36
AFEN	2.263	0.256	11.33	2.00	2.50	19
WB	0.224	0.042	18.92	0.17	0.31	35
WD	0.111	0.041	36.43	0.07	0.20	34
FL	0.350	0.024	6.90	0.26	0.38	37
FW	0.188	0.017	9.28	0.16	0.23	37
AD	0.101	0.011	11.17	0.08	0.12	16
AAL	0.227	0.021	9.19	0.18	0.26	28
AAC	0.195	0.022	11.52	0.16	0.23	22
N1	4.530	0.283	6.25	4.00	4.70	10
SNB	0.235	0.027	11.37	0.18	0.29	22
NL	0.090	0.018	20.29	0.07	0.11	4
NW	0.075	0.006	7.70	0.07	0.08	4

Material. — GIP-1–5.0m (PMO A42107), GIP-1–20.0m (PMO 138.058), REF-2–4.0m (PMO A42308).

Stratigraphic occurrence in Spitsbergen. — Late Asselian, below the *Eoparafusulina paralinearis* fusulinid zone (Nilsson & Davydov in press), early Sakmarian, associated with *Sweetognathus inornatus*, middle and upper part of the Tyrrellfjellet Member, and late Artinskian-early Kungurian (*Neostreptognathodus pequopensis-Sweetognathus whitei* conodont association, *Horridonia timanica* brachiopod zone), Vøringen Member of the Kapp Starostin Formation (Nakrem in press).

Occurrence outside Spitsbergen. — Sakmarian of the Urals and the Artinskian of Ellesmere Island (Morozova & Kruchinina 1986).

Rectifenestella cf. *ornata* (Shul'ga-Nesterenko 1939)

Fig. 16D.

cf. *Fenestella ornata* sp. n.; Shul'ga-Nesterenko 1939: p. 68, Pl. 11: 5.

cf. *Fenestella ornata* Shul'ga-Nesterenko; Shul'ga-Nesterenko 1941: p. 88, Pl. 14: 1.

cf. *Fenestella ornata* Shul'ga-Nesterenko; Trizna 1948: p. 162, Pl. 13: 1, 2.

cf. *Fenestella subornata* Shul'ga-Nesterenko; Shul'ga-Nesterenko 1952: p. 40, Pl. 6: 3, Text-fig. 19.

cf. *Rectifenestella ornata* Shul'ga-Nesterenko; Morozova & Kruchinina 1986: p. 79, Pls 27: 5, 28: 1.

cf. *Rectifenestella subornata* (Shul'ga-Nesterenko); Alekseeva *et al.* 1986: Pl. 96: 5.

cf. *Rectifenestella ornata* (Shul'ga-Nesterenko); Alekseeva *et al.* 1986: Pl. 96: 6.

Description. — Moderately loose meshwork with 14–16 branches across colony and 13–14 dissepiments along colony per 10 mm. Branches, about 0.31 mm wide carry a slightly sinuous carina with 2–3 elongated nodes per 1 mm. Nodes about 0.20 mm long and 0.11 mm wide; about 0.42 mm from center to center. Dissepiments about 0.23 mm wide. Fenestrules are 0.50 mm long and 0.35 mm wide. Apertures 0.14 mm in diameter, about 0.39 mm from center to center along branch and 0.27 mm diagonally. There are about 19 apertures per 5 mm along branch, with 2.5–3 bordering each fenestrule. Zooecial chambers are pentagonal in outline in median tangential section.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	15.190	0.605	3.98	14.00	16.20	10
DS10	13.530	0.258	1.91	13.20	14.00	10
A5	18.850	0.534	2.83	18.30	19.90	10
AFEN	2.750	0.354	12.86	2.50	3.00	2
WB	0.309	0.011	3.56	0.29	0.33	10
WD	0.229	0.018	7.83	0.21	0.26	10
FL	0.492	0.032	6.41	0.45	0.53	10
FW	0.350	0.040	11.43	0.29	0.40	10
AD	0.140	–	–	0.14	0.14	1
AAL	0.273	0.008	2.99	0.26	0.28	6
AAC	0.392	0.021	5.46	0.36	0.41	6
N1	2.500	0.408	16.33	2.00	3.00	4
SNB	0.419	0.023	5.45	0.38	0.46	10
NL	0.205	0.007	3.45	0.20	0.21	2
NW	0.110	0.028	25.71	0.09	0.13	2

Remarks. — Both zooecial characters and meshwork formulas of previously reported *R. ornata* and *R. subornata* resemble the Spitsbergen specimen (see p. 14 for explanations). For *R. ornata*Shul'ga-Nesterenko (1939): 15–16/13–14/18/2–3, Shul'ga-Nesterenko (1941): 14–16/13–14/18/2–3, and Morozova & Kruchinina (1986): 14–17/11–14/18–20/3–4. This work: 14–16/13–14/18–20/2–3. For *R. subornata* according to Shul'ga-Nesterenko (1951: Tab. 4, p. 48; *nomen nudum*): 16/13/20/3–4 and Shul'ga-Nesterenko (1952): 15/14/18/2–3.

The current specimen is, however, identified as *R.* cf. *ornata* due to insufficient material.

Comparison. — *R. ornata* is separated from other species of *Rectifenestella* in having large fenestrules producing a relatively loose meshwork. Number of zooecial chambers in a given linear distance is also greater.

Material. — GIP-1-1.0m (PMO 138.048).

Stratigraphic occurrence in Spitsbergen. — Asselian, below the *Eoparafusulina paralinearis* fusulinid zone (Nilsson & Davydov in press), middle part of the Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — *R. ornata* is recorded from the ?Sakmarian-Artinskian of the Urals and Timan (Shul'ga-Nesterenko 1941, Morozova & Kruchinina 1986).

Rectifenestella submicroporata (Shul'ga-Nesterenko 1952)

Fig. 16E–F.

Fenestella submicroporata sp. n.; Shul'ga-Nesterenko 1952: p. 35, Pl. 4: 2, Text-fig. 15.
Fenestella submicroporata Shul'ga-Nesterenko; Morozova 1970: p. 175, Pl. 36: 1.
Rectifenestella submicroporata (Shul'ga-Nesterenko); Alekseeva *et al.* 1986: Pl. 91: 5.

Description. — *Rectifenestella* with minute meshwork and narrow branches and dissepiments. There are 27–29 branches per 10 mm across colony and 25–27 dissepiments per 10 mm along colony. Branches about 0.14 mm wide carrying 5–5.5 small nodes (0.06 mm × 0.04 mm) per 1 mm. Distance between node centers about 0.19 mm. Dissepiments 0.05–0.06 mm wide. Fenestrules 0.32–0.35 mm long and 0.20–0.22 mm wide. Apertures circular in outline being 0.07 mm in diameter. There are about 26 apertures per 5 mm along branch; 2 bordering each fenestrule. Distance between apertural centers 0.18–0.20 mm both along and diagonally across branch. Zooecial chambers fabiform in shallow tangential section; pentagonal in median section.

Comparison. — *R. submicroporata* is distinguished from other species of *Rectifenestella* in the significantly minute meshwork and the very small apertural diameter.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	28.320	0.665	2.35	27.50	29.30	10
DS10	25.940	0.743	2.86	24.70	27.00	10
A5	26.190	0.233	0.89	25.70	26.50	10
AFEN	2.000	0.000	0.00	2.00	2.00	2
WB	0.140	0.011	7.53	0.12	0.15	10
WD	0.055	0.005	9.58	0.05	0.06	10
FL	0.339	0.010	2.94	0.32	0.35	14
FW	0.210	0.008	3.74	0.20	0.22	14
AD	0.073	0.001	0.98	0.07	0.07	2
AAL	0.191	0.008	4.16	0.18	0.20	12
AAC	0.190	0.009	4.49	0.18	0.20	12
N1	5.350	0.058	1.08	5.30	5.40	4
SNB	0.192	0.008	4.36	0.18	0.20	12
NL	0.055	0.005	9.21	0.05	0.06	3
NW	0.035	0.005	14.24	0.03	0.04	3

Material. — KOL-1–28.3m (PMO A42167/2).

Stratigraphic occurrence in Spitsbergen. — Late Moscovian, *Wedekindellina dutkevichi – Fusulinella eopulchra* fusulinid zone (Nilsson & Davydov in press), lower part of the Kapitol Member.
Occurrence outside Spitsbergen. — Asselian of the Urals (Shul'ga-Nesterenko 1952); Late Permian of Caucasia and China (Morozova 1970).

Genus *Alternifenestella* Termier & Termier 1971
(incl. *Mirandifenestella* Termier & Termier 1971)
Type species: *Fenestella minor* Nikiforova 1933, Middle Carboniferous of the Donetz Basin, Ukraine.

Alternifenestella bifida (Eichwald 1860)
Fig. 16G–H.

Fenestella bifida sp. n.; Eichwald 1860: p. 354, Pl. 23: 6.
Fenestella bifida Eichwald; Stuckenberg 1895: p. 144, Pl. 21: 7.
Fenestella bifida Eichwald; Nikiforova 1938: p. 78 [230], Pl. 14: 6–9, Text-fig. 40.
Fenestella bifida Eichwald; Shul'ga-Nesterenko 1939: p. 67, Pl. 11: 6–7.
Fenestella bifida Eichwald; Shul'ga-Nesterenko 1941: p. 119, Pls 26: 4, 28: 3–4.
Fenestella bifida Eichwald; Shul'ga-Nesterenko 1949: Pls 4: 11, 7: 6.
Alternifenestella bifida (Eichwald); Morozova & Kruchinina 1986: p. 83, Pl. 30: 4.

Description. — Relatively delicate meshwork with moderately thin branches and dissepiments. There are 10–13 branches across and 8–11 fenestrules along colony per 10 mm. Branches are about 0.38 mm wide carrying variably spaced (1.5–6 per 1 mm) small, elongated nodes. The nodes are variably elongated, average 0.12 mm long and 0.07 mm wide. Dissepiments average 0.24 mm in width. Apertures are circular (about 0.11 mm in diameter) or slightly ovate in outline (0.12 × 0.14 mm). There are 13–16 apertures per 5 mm along branch. Distance between apertural centers is about 0.35 mm along and about 0.30 mm diagonally across branch. Zooecial bases are ovate-fabiform in shallowest section, typically triangular to trapezoidal in median to deep tangential section. Three apertures border each fenestrule in average. Fenestrules, varying distinctly in size, averaging 0.83 mm in width and 0.43 mm in length are formed in an off-set alternating pattern. The branches frequently bifurcate, and some unusually small fenestrules (almost circular, 0.30–0.40 mm in diameter) are developed in such parts of the zoaria.
Comparison. — *A. bifida* was described in various Russian papers as having a meshwork formula of 10–12/6–12/14–18/3 which embraces several varieties of *A. bifida* described as *A. bifida tricosa* (Trizna 1939), *A. bifida crassiseptata* (Shul'ga-Nesterenko 1941) and *A. bifida cyclotriangulata* (Shul'ga-Nesterenko 1941). *A. bifida* is distinguished from other species in the current work in having large fenestrules and subsequently widely spaced branches and dissepiments.
Material. — BOLT-B2 (PMO A42080), Grønfjorden (PMO A42017–018), REF-0–25.0m (PMO A42122).
Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and

Streptognathodus excelsus and *S. elongatus*, lowermost part of the Tyrrellfjellet Member, and late Artinskian-early Kungurian (*Neostreptognathodus pequopensis-Sweetognathus whitei* conodont association, *Horridonia timanica* brachiopod zone), Vøringen Member of the Kapp Starostin Formation (Nakrem in press).

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	11.252	0.863	7.67	10.00	13.00	21
DS10	8.895	1.226	13.78	7.70	11.00	21
A5	14.158	0.790	5.58	12.90	16.00	33
AFEN	3.136	0.595	18.98	2.00	4.00	11
WB	0.375	0.032	8.66	0.30	0.43	24
WD	0.235	0.057	24.14	0.16	0.30	22
FL	0.834	0.170	20.44	0.65	1.15	14
FW	0.432	0.075	17.46	0.31	0.55	14
AD	0.115	0.022	19.16	0.09	0.14	8
AAL	0.351	0.017	4.92	0.32	0.38	26
AAC	0.298	0.023	7.71	0.27	0.34	16
N1	2.775	2.011	72.45	1.50	6.00	8
SNB	0.521	0.223	42.76	0.14	0.70	20
NL	0.122	0.064	52.85	0.06	0.20	5
NW	0.066	0.028	42.24	0.04	0.09	5

Occurrence outside Spitsbergen. — Sakmarian – Artinskian of the Urals and Timan (Shul'ga-Nesterenko 1941; Nikiforova 1938); Gerke Group (Ufimian) of Novaya Zemlya (Morozova & Kruchinina 1986).

Alternifenestella subquadratopora (Shul'ga-Nesterenko 1952)

Fig. 17A–B.

Fenestella subquadratopora sp. n.; Shul'ga-Nesterenko 1952: p. 47, Pl. 9: 5.

Fenestella subquadratopora Shul'ga-Nesterenko; Goryunova 1975: p. 84, Pls 19: 3, 20: 1.

Description. — Meshwork with frequently bifurcating branches and short, almost quadrate fenestrules. There are about 17–18 branches across and 18 fenestrules along colony per 10 mm. The branches carry two rows of apertures being 0.28 mm from center to center along branch and 0.25 mm diagonally across branch (17–19 per 5 mm longitudinally). The branches average 0.26 mm in width, they are commonly narrower closer to reverse side of colony. The apertures are circular, 0.07–0.08 mm in diameter. Zooecial chambers are oval or pisiform in shallowest section, pentagonal to trapezoidal in median to deeper tangential section. Elongated carinal nodes are developed in alternating rows being 0.13 mm from center to center. The nodes are 0.072 mm long and 0.036 mm wide, about 7 per 1 mm. Dissepiments are thin, usually 0.13 mm wide. Fenestrules are 0.42–0.46 mm long and 0.30–0.36 mm wide. 2 apertures border each fenestrule, often indenting the fenestrule giving rise to an irregular fenestrule outline.

Comparison. — *A. subquadratopora* is distinguished from *A. bifida* in that the latter has a much looser meshwork made up of larger fenestrules. *A. tenuiseptata* (Shul'ga-Nesterenko 1941) is distinguished in having greater distance between branches and dissepiments, 14–16 of both in 10 mm as described by Shul'ga-Nesterenko (1941).

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	17.487	0.707	4.04	16.40	18.70	15
DS10	17.808	0.396	2.23	16.80	18.30	12
A5	17.825	0.510	2.86	17.20	18.60	12
AFEN	2.000	0.000	0.00	2.00	2.00	2
WB	0.258	0.018	6.97	0.23	0.28	12
WD	0.134	0.008	5.91	0.12	0.15	12
FL	0.440	0.010	2.37	0.42	0.46	12
FW	0.327	0.022	6.82	0.30	0.36	12
AD	0.076	0.003	3.94	0.07	0.08	4
AAL	0.278	0.009	3.21	0.27	0.29	14
AAC	0.246	0.014	5.61	0.23	0.27	12
N1	7.000	0.000	0.00	7.00	7.00	2
SNB	0.133	0.007	5.07	0.12	0.14	10
NL	0.073	0.001	0.98	0.07	0.07	2
NW	0.037	0.001	1.94	0.04	0.04	2

Material. — REF-0–25.0m (PMO A42118).

Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — Sakmarian of the Urals (Shul'ga-Nesterenko 1952).

Alternifenestella cf. *tenuiseptata* (Shul'ga-Nesterenko 1941)

Fig. 17C–D.

cf. *Fenestella tenuiseptata* sp. n.; Shul'ga-Nesterenko 1941: p. 115 [235], Pl. 26: 1.

cf. *Alternifenestella tenuiseptata* (Shul'ga-Nesterenko); Morozova 1981: p. 70, Pl. 17: 2.

Description. — Zoarium with frequently branching branches giving rise to great variation in branch spacing (14–21 per 10 mm across colony). The inter-zoarial variation is great (CV 10.40) whereas intra-zoarial variation is significantly smaller (CV 2.69–6.48). The same variation is observed in dissepiment spacing (12–17 along colony per 10 mm) with high inter-zoarial variation and clearly smaller intra-zoarial variation. The branches, being about 0.23 mm wide, carry apertures in two rows, 18–23 per 5 mm along colony. The apertures are circular (diameter 0.08–0.09 mm) or slightly ovate (0.11 × 0.09 mm). The distance between apertural centers is 0.25 mm longitudinally and 0.20 mm diagonally across branch. Zooecial chambers are triangular to trapezoidal in median to deep tangential section. Circular and slightly elongated nodes are present on branch carina; 3–4 per 1 mm, about 0.06–0.08 mm in diameter. Dissepiments are thin, about 0.13 mm wide. Fenestrules, being about 0.59 mm long and 0.36 mm wide, are bordered by 2.5–4 apertures.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	17.582	1.829	10.40	14.00	21.70	28
DS10	13.800	1.402	10.16	11.60	16.50	30
A5	20.228	1.538	7.60	18.30	22.80	29
AFEN	3.000	0.522	17.41	2.50	4.00	12
WB	0.234	0.030	12.89	0.18	0.29	29
WD	0.129	0.035	26.78	0.08	0.18	30
FL	0.592	0.082	13.93	0.49	0.76	31
FW	0.362	0.036	10.02	0.29	0.44	31
AD	0.094	0.009	9.34	0.08	0.11	9
AAL	0.252	0.018	7.32	0.21	0.28	25
AAC	0.200	0.013	6.55	0.17	0.22	22
N1	3.600	0.458	12.73	3.10	4.00	5
SNB	0.301	0.025	8.21	0.25	0.33	10
NL	0.082	0.031	38.35	0.05	0.11	4
NW	0.064	0.011	17.45	0.05	0.07	4

Comparison. — The present specimens compare fairly well with the original description given by Shul'ga-Nesterenko (1941) who gave the micrometric formula as 14–16/14–15/19–20/3–4. Morozova (1981) identified her specimens with a micrometric formula of 16–20/12–15/18–20/2–2.5. The close spacing of the zooecial apertures distinguishes *A. tenuiseptata* from *A. pulcherrima* (Shul'ga-Nesterenko 1936) (18–19 against 14–15 per 5 mm).

Material. — REF-0–25.0m (PMO A42117, A42203, A42205).

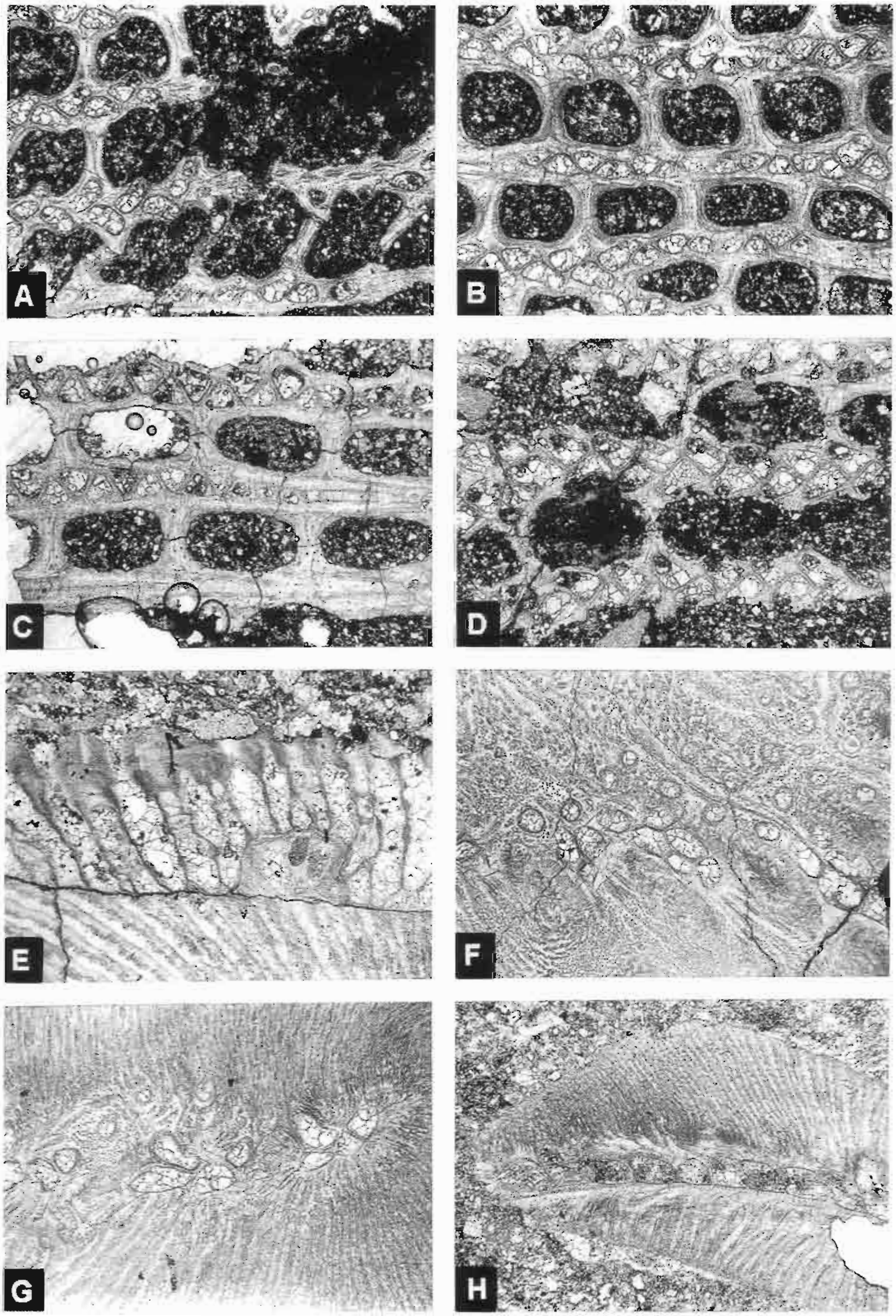
Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.

Occurrence outside Spitsbergen. — *A. tenuiseptata* is known from the Sakmarian – Artinskian of the Urals (Shul'ga-Nesterenko 1941) and the Siberian Far East (Morozova 1981).

Genus *Archimedes* Owen 1842, SD Hall 1857

Type species: *Fenestella wortheni* Hall 1857, Mississippian of Warsaw, Illinois.

Fig. 17. ❑A–B. *Alternifenestella subquadratopora* (Shul'ga-Nesterenko 1952); Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42118, ×25. A. Shallow tangential section with nodes present. B. Deeper tangential section. ❑C–D. *Alternifenestella* cf. *tenuiseptata* (Shul'ga-Nesterenko 1941); Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42205, ×25. C. Deep tangential section. D. Shallow tangential section of partly leached colony. ❑E–G. *Archimedes* sp. A; Kolosseum, Kapitol Member, Moscovian, KOL-1–80.0m. E. Abraded colony surface encrusted by indetermined trepostome (?*Tabulipora*), PMO



A42168/1, × 25. F. Tangential section, PMO A42168/2, × 25. G. Oblique transverse section, PMO A42168/2, ×25. ❑H. *Archimedes* sp. B, oblique longitudinal section of meshwork flange. Gipsvika, Tyrrellfjellet Member, late Asselian, GIP-1–14.0m, PMO 138.046, × 25.

Archimedes sp. A

Fig. 17E–G.

Description. — Investigated material consists of a denuded zoarium with abraded volutions being 8–9 mm apart. Angle between central axial screw and volutions is about 60. Preserved portion of zoarium has a meshwork with 17–22 branches across and 10–11 fenestrules along colony per 10 mm. The branches are 0.35–0.39 mm wide, slightly sinuous with great variation in spacing due to sections being taken close to central axial portion of zoarium. Nodes are present on branch carina (although few could be measured), being 0.07 mm in diameter, 0.30–0.35 from center to center. Apertures are circular, 0.09–0.10 mm in diameter, being 0.23–0.26 mm from center to center longitudinally and 0.27–0.31 mm diagonally across branch. There are about 17 apertures per 5 mm along branch. Zooecial chambers are elongated or parallelogram shaped, with a distinct hemiseptum. Fenestrules, 0.48–0.50 mm long and 0.25–0.29 mm wide bordered by 3 apertures, are regularly arranged, usually in a diverging pattern.

Remarks. — The description is based on denuded specimens without the delicate meshwork preserved. Typical measurements thus originate from zoarial portions close to the coiled central axial support where branch morphology is believed to be more robust than more distally. Hemisepta, as being observed in zooecia in the current specimen (in meshwork attached to central axis) are generally regarded as being absent in *Archimedes* (Snyder 1991).

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	18.510	1.574	8.51	17.20	22.00	10
DS10	10.900	0.365	3.35	10.40	11.50	7
A5	17.333	0.510	2.94	16.50	18.00	9
AFEN	3.000	0.000	0.00	3.00	3.00	2
WB	0.366	0.015	4.14	0.35	0.39	5
WD	0.368	0.016	4.47	0.35	0.39	5
FL	0.490	0.010	2.04	0.48	0.50	3
FW	0.270	0.020	7.41	0.25	0.29	3
AD	0.093	0.006	6.19	0.09	0.10	3
AAL	0.286	0.013	4.42	0.27	0.31	10
AAC	0.244	0.008	3.46	0.23	0.26	10
N1	3.000	0.000	0.00	3.00	3.00	2
SNB	0.327	0.025	7.70	0.30	0.35	3
NL	0.070	0.000	0.00	0.07	0.07	2
NW	0.070	0.000	0.00	0.07	0.07	2

Comparison. — The current species is most similar to *A. stuckenbergi* Nikiforova 1938 as based on meshwork characters, but is distinguished in having more closely spaced volutions (8–9 mm apart, against 12–14 mm in *A. stuckenbergi*). *A.* cf. *magnus* Condra & Elias 1944, described from the

Treskelodden Formation of southern Spitsbergen (Czarniecki 1964) has more closely spaced volutions (6.7–7.7 mm apart) and smaller fenestrule dimensions. *A. arcticus* (Toula 1875) has similar meshwork characters, but zooecial characters are unknown (Toula 1875). It should be noted that the latter species was described from the Early Permian of the Barentz Island situated close to the northern coast of Novaya Zemlya, not the Barents Island belonging to the Svalbard island group as was believed by Condra & Elias (1944: p. 178).

Material. — KOL-1–80.0m (PMO A41853, A42168).

Stratigraphic occurrence in Spitsbergen. — Early Kasimovian, *Protriticites pseudomontiparus* fusulinid zone (Nilsson & Davydov in press), lower part of the Kapitol Member.

Archimedes sp. B

Figs 17H, 18A–C.

Description. — The description is based on internal characters observed from a broken off meshwork fragment (GIP-1–30.0m, PMO A42108), and zoarial characters (axial screw and volution dimensions) from a denuded axial portion (GIP-1–14.0m, PMO 138.046). Distance between mesh volutions has been calculated to be 7–8 mm, with volutions departing from axial screw at angles between 65 and 70. The meshwork consists of regular straight branches, elongated fenestrules and moderately thin dissepiments. There are 20–23 branches across and 14–15 fenestrules along colony per 10 mm. The branches are about 0.26 mm wide, carrying 4 elongated (average 0.09 × 0.06 mm) nodes per 1 mm (0.22–0.26 mm between node centers). Obverse side of branches are wide (up to 0.32 mm); near reverse side, the branches are about 0.22 mm wide; striated or pierced by minute capillaries. Apertures are circular, 0.08–0.10 mm in diameter, numbering commonly 20–23 per 5 mm along branches. Distance between apertural centers both longitudinally and diagonally across branch is 0.21–0.23 mm. Zooecial chambers are irregular oval or pisiform in shallow section; pentagonal in median to deep tangential section. Hemisepta are not observed. Dissepiments are 0.14–0.15 mm wide. Fenestrules are elongated oval, average 0.49 mm long and 0.23 mm wide bordered by 2.5–3 apertures. Near reverse side of colony the fenestrules are oval or almost circular, about 0.51 × 0.33 mm.

Comparison. — The meshwork formula of the current species is similar to that of *A. timanicus* Condra & Elias 1944, which was erected as a new species by Condra & Elias (1944) to embrace some (but not all) specimens described as *A. keyserlingi* Stuckenberg 1875, by Stuckenberg (1895) and Nikiforova (1938). Distance between volutions is, however, smaller than in previously described species of *Archimedes*, as is also the case in the other species known from Spitsbergen (see above).

Material. — GIP-1–14.0m (PMO 138.046), GIP-1–30.0m (PMO A42108).

Stratigraphic occurrence in Spitsbergen. — Late Asselian-early Sakmarian, within and below the *Eoparafusulina paralinearis* fusulinid zone

(Nilsson & Davydov in press) and associated with *Sweetognathus inornatus*; middle-upper part of the Tyrrellfjellet Member.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	21.814	0.770	3.53	20.60	23.00	14
DS10	14.633	0.235	1.60	14.40	15.00	12
A5	20.975	1.110	5.29	19.60	23.30	12
AFEN	2.750	0.274	9.96	2.50	3.00	6
WB	0.259	0.026	10.20	0.22	0.32	12
WD	0.147	0.005	3.29	0.14	0.15	10
FL	0.487	0.013	2.60	0.47	0.50	14
FW	0.231	0.017	7.55	0.20	0.25	14
AD	0.090	0.007	7.86	0.08	0.10	5
AAL	0.220	0.007	3.03	0.21	0.23	10
AAC	0.220	0.007	3.03	0.21	0.23	10
N1	4.120	0.239	5.79	3.90	4.50	5
SNB	0.242	0.016	6.79	0.22	0.26	5
NL	0.090	0.000	0.00	0.09	0.09	5
NW	0.058	0.008	14.43	0.05	0.07	5

Genus *Ptylopora* M'Coy 1844

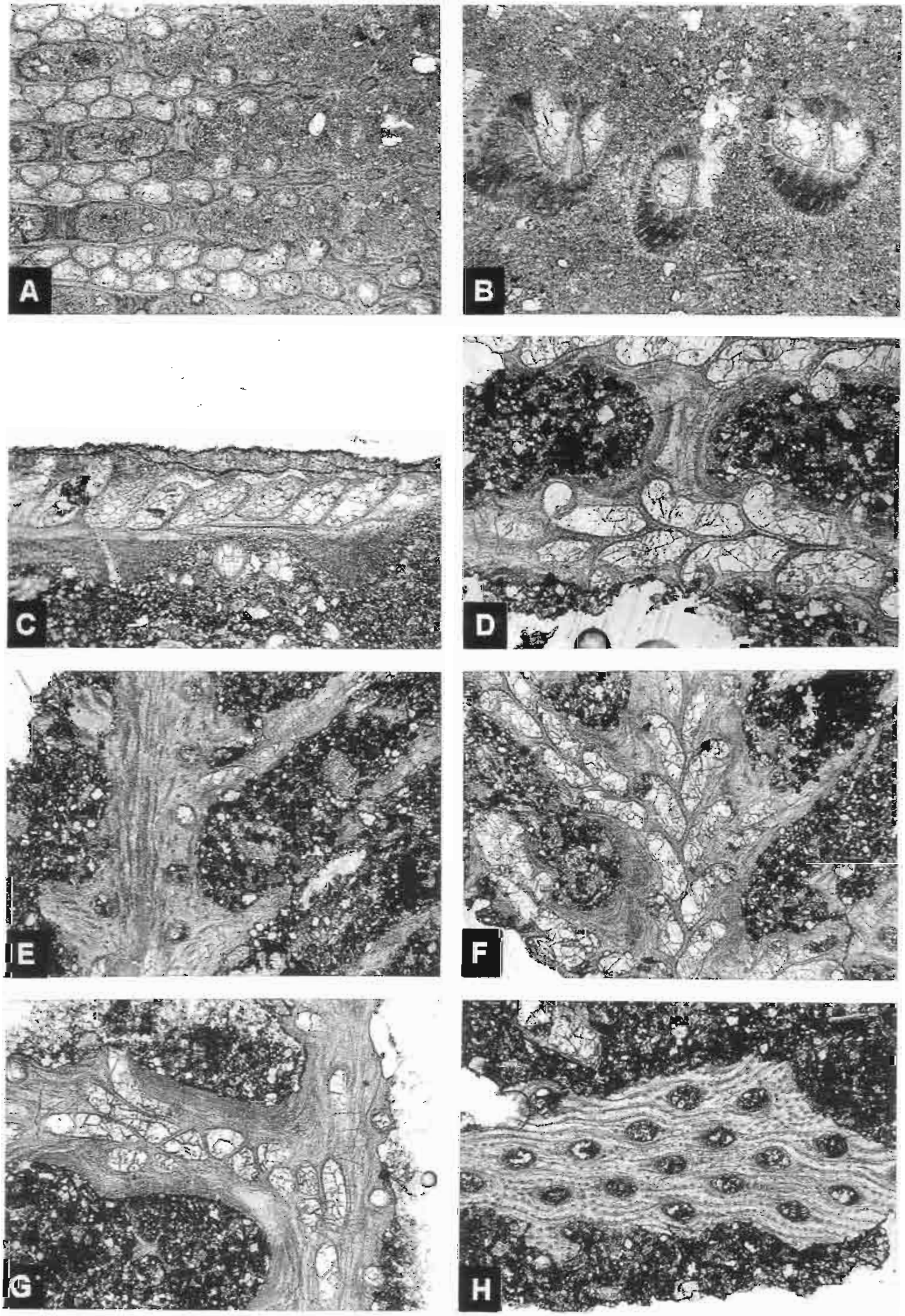
Type species: *Ptylopora pluma* M'Coy 1844, Viséan of Ireland.

Ptylopora sp. A

Figs 18D–F, 19D.

Description. — The zoarium consists of a moderately strong main stem to which lateral branches forming a meshwork is attached. The main stem is 0.63–0.71 mm wide, carrying apertures in two rows. Aperture diameter 0.10–0.11 mm. There are 14–15 apertures longitudinally per 5 mm. Distance between apertural centers average 0.35 mm along and 0.45 mm diagonally across branch. Zooecial bases are oval to fabiform in median tangential section with a single hemiseptum present. Elongated, indistinct carinal nodes, 0.18 mm × 0.09 mm are present; 1.5–2 per 1 mm. Lateral branches are 0.34–0.40 mm wide connected by dissepiments being 0.23–0.25 mm wide. There are about 14 lateral branches and 7–8 dissepiments per 10 mm. Fenestrules are about 1.13 mm long and 0.37 mm wide, bordered by 4 apertures. Apertures with diameter 0.10–0.11 mm are placed 0.31–0.40 mm from center to center along and 0.25–0.33 mm

Fig. 18. ❑A–C. *Archimedes* sp. B; Gipsvika, Tyrrellfjellet Member, early Sakmarian, GIP-1-30.0, PMO A42108. A. Tangential section, × 25. B. Transverse section, × 40. C. Longitudinal section, × 25. ❑D–F. *Ptylopora* sp. A; Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42311. D. Median tangential section of lateral meshwork branch, × 40. E. Shallow tangential section of main stem, × 25. F. Deep tangential section of main stem, × 25. ❑G. *Penniretepora subtila* (Shul'ga-Nesterenko 1941), shallow to median deep tangential section. Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42208, × 25.



❑H. *Acanthocladia* cf. *rhombicellata* Shul'ga-Nesterenko 1955, shallow tangential section of main stem. Rejmyrefjellet, Tyrrellfjellet Member, early Asselian, REF-1–36.0m, PMO A42114, × 25.

diagonally across lateral branches. Lateral branches also carry indistinct nodes 0.07 mm in diameter, 2.5–3 per 1 mm.

Measurements. — (For abbreviations see pp. 57–58.)

		AVG	STDS	CV	MIN	MAX	n
Meshwork	BR10	13.978	0.244	1.74	13.40	14.30	9
	DS10	7.567	0.404	5.34	7.20	8.00	3
	AFEN	4.000	0.000	0.00	4.00	4.00	2
	FL	1.130	0.037	3.31	1.09	1.18	4
	FW	0.373	0.019	5.08	0.36	0.40	4
Main stem	WB	0.673	0.030	4.48	0.63	0.71	8
	AD	0.105	0.007	6.73	0.10	0.11	2
	AAL	0.346	0.014	4.06	0.32	0.37	15
	AAC	0.452	0.022	4.82	0.43	0.49	15
	A5	14.560	0.313	2.15	14.10	15.00	10
	N1	1.600	0.141	8.84	1.50	1.70	2
	SNB	0.620	0.028	4.56	0.60	0.64	2
	NL	0.180	–	–	0.18	0.18	1
	NW	0.090	–	–	0.09	0.09	1
Lateral branches	WB	0.364	0.018	4.86	0.34	0.40	8
	AD	0.105	0.007	6.73	0.10	0.11	2
	AAL	0.345	0.027	7.90	0.31	0.40	15
	AAC	0.293	0.026	8.80	0.25	0.33	15
	A5	14.550	0.392	2.70	14.00	15.00	10
	N1	2.733	0.252	9.21	2.50	3.00	3
	SNB	0.363	0.035	9.67	0.33	0.40	3
	NL	0.105	0.007	6.73	0.10	0.11	2
	NW	0.070	0.000	0.00	0.07	0.07	2

Remarks. — The identification of *Ptylopora* is based on a fairly large (9 mm high, 7 mm wide) zoarium with both main stem and lateral meshwork preserved. The genus is distinguished in having a robust main stem being wider than lateral branches which are of uniform width, while *Ptiloporella* Hall 1885 has lateral branches of significantly varying width.

Comparison. — *Ptylopora* sp. A is distinguished from *P. pluma*, well known from the Carboniferous of Ireland and UK (Bancroft 1985) which has stronger main stem (up to 2.80 mm wide), larger apertures (up to 0.18–0.19 mm in diameter) and more widely spaced nodes (2.5–4 per 1 mm). In other zoarial characters, the Spitsbergen specimen falls within the variation of the specimens re-described by Bancroft (1985).

Material. — REF-0–25.0m (PMO A42311).

Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.

Genus *Penniretepora* d'Orbigny 1849

Type species: *Retepora pluma* Phillips 1836, Early Carboniferous of Yorkshire, England.

Penniretepora subtila (Shul'ga-Nesterenko 1941)

Figs 18G, 19E.

Pinnatopora subtila sp. n.; Shul'ga-Nesterenko 1941: p. 174 [241], Pl. 46: 2, Text-fig. 137.
Penniretepora subtila (Shul'ga-Nesterenko); Alekseeva *et al.* 1986: Pl. 97: 3.

Description. — Pinnate colony with 2 rows of apertures both on main stem and lateral branches. The main stem is 0.66–0.69 mm wide with paired lateral branches (pinnae). There are 10–12 lateral branches per 10 mm along the main stem. The lateral branches are 0.55–0.60 mm wide. Zooecial characters are rather identical in main stem and lateral branches, as there are 10–12 circular apertures (0.10–0.11 mm in diameter) in 5 mm. Distance between apertural centers along branches is 0.40–0.44 mm. Zooecial chambers are oval or elongated rectangular in median tangential section with a distinct superior hemiseptum. Small nodes are present on main branch, being 0.04–0.06 mm in diameter, 0.41–0.46 mm between centers. Nodes on lateral branches are identical in size, but more closely spaced (0.33–0.39 mm between centers).

Remarks. — *Penniretepora* sp. cf. *subtila* in SKA-1–43.5 (PMO A42175) has narrower main stem (0.49 mm wide) and lateral branches (0.37 mm), and is thus more similar to *P. subtila temeraria* (Trizna 1939) from the Artinskian of the Urals (Trizna 1939). Pinnate fragments with two rows of zooecia otherwise too small for detail measurements are assigned to *Penniretepora* sp. with occurrence shown in Fig. 4.

Measurements. — (For abbreviations see pp. 57–58.)

		AVG	STDS	CV	MIN	MAX	n
	LAT10	11.010	0.567	5.15	10.20	12.00	10
Main stem	WB	0.673	0.015	2.27	0.66	0.69	3
	AD	0.102	0.004	4.38	0.10	0.11	5
	AAL	0.418	0.011	2.53	0.40	0.44	12
	A5	11.588	0.295	2.54	11.10	12.00	8
	N1	2.325	0.096	4.12	2.20	2.40	4
	SNB	0.437	0.017	3.90	0.41	0.46	10
	ND	0.049	0.006	13.15	0.04	0.06	8
Lateral branches	WB	0.580	0.026	4.56	0.55	0.60	3
	AD	0.102	0.004	4.38	0.10	0.11	5
	AAL	0.425	0.008	1.97	0.42	0.44	6
	A5	11.700	0.283	2.42	11.50	11.90	2
	N1	3.033	0.058	1.90	3.00	3.10	3
	SNB	0.357	0.031	8.57	0.33	0.39	3
	ND	0.049	0.006	13.15	0.04	0.06	8

Comparison. — Trizna (1939) described three varieties of *P. subtila* (*P. subtila major*, *P. subtila grandicula*, and *P. subtila temeraria*) but at that time *Penniretepora subtila* was a *nomen nudum*. These varieties were basically discriminated in the meshwork composition, distance between and branching angle of lateral branches, apertural dimension and spacing as well as zoarium robustness.

Material. — REF-0–25.0m (PMO A42208, A42309, 138.070), SKA-1–43.5m (PMO A42175).

Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.

Family Acanthocladiidae Zittel 1880

Genus *Acanthocladia* King 1849

Type species: *Keratophytes anceps* Schlotheim 1820, Zechstein of Germany.

Acanthocladia cf. *rhombicellata* Shul'ga-Nesterenko 1955

Figs 18H, 19A–C.

cf. *Acanthocladia rhombicellata* sp. n.; Shul'ga-Nesterenko 1955: p. 133, Pl. 20: 1, 2.

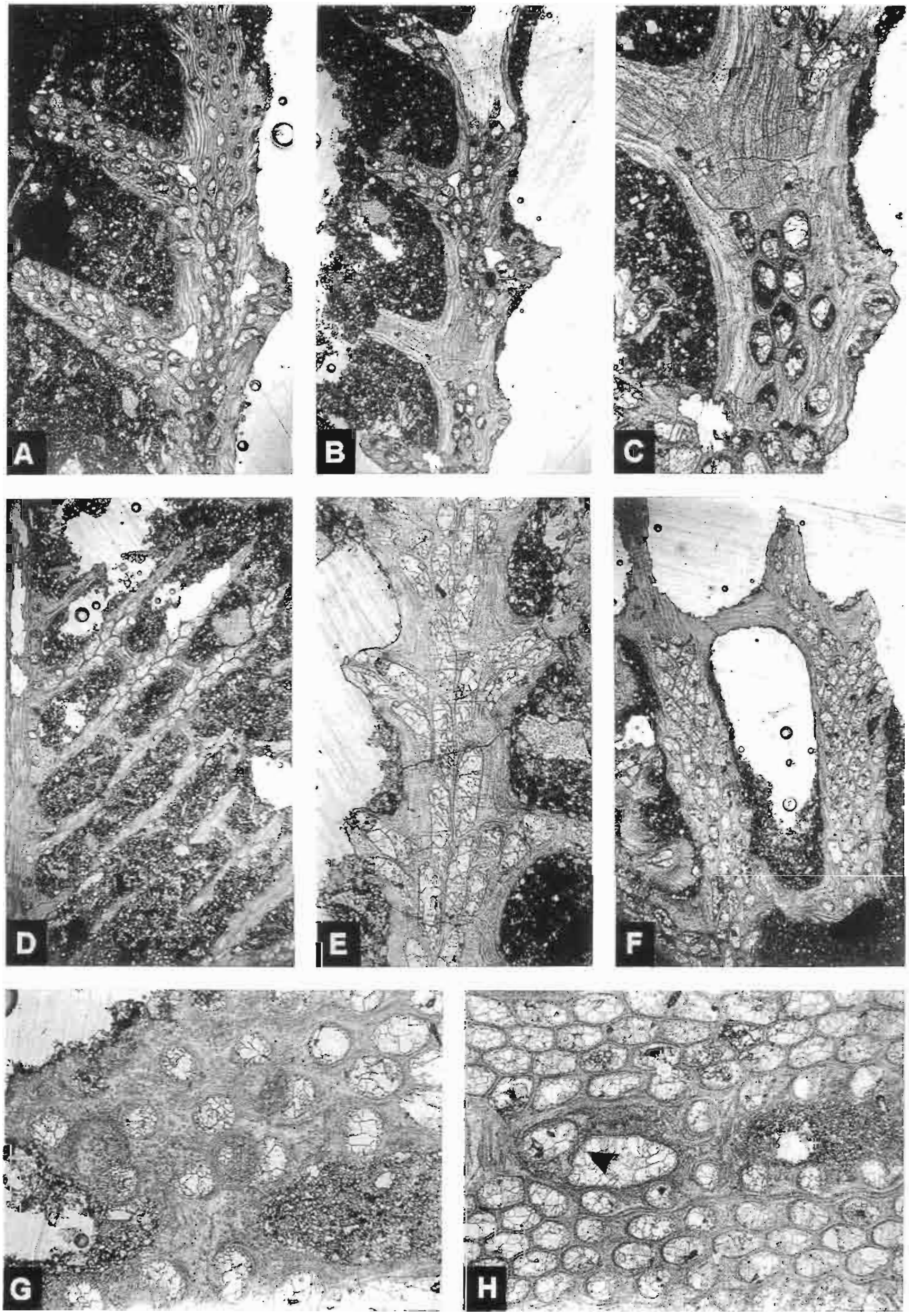
Description. — The zoarium consists of an undulating main stem with alternating offset lateral branches (pinnae). Zoarium surface is striated and densely packed with minute capillaries. Width of main stem is about 0.82 mm; lateral branches are about 0.55 mm wide. There are about 5 lateral branches per 10 mm along main stem. Apertures are slightly ovate in outline, being 0.12–0.12 mm long and 0.10–0.11 mm wide both on the main stem and the lateral branches. There are 12–14 apertures on main stem and 15–16 on lateral branches per 5 mm. The apertures are arranged in 4 rows on the main stem and in 2–3 rows on the lateral branches. Zooecial bases are irregular fabiform in outline in shallow section; rhombic in center rows and more pentagonal in distal rows in median section.

Comparison. — *A.* cf. *rhombicellata* is different from *A. tundrica* Kruchinina 1986 *in* Morozova & Kruchinina (1986), which has wider main stem and lateral branches, as well as more closely spaced apertures. *A. sparsifurcata* Shul'ga-Nesterenko 1941 also has a more robust zoarium, with greater number of apertural rows along main stem and lateral branches as compared with *A.* cf. *rhombicellata*.

Material. — REF-0–25.0m (PMO A42210), REF-1–36.0m (PMO A42114)

Stratigraphic occurrence in Spitsbergen. — Late Gzhelian-early Asselian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lower part of the Tyrrellfjellet Member.

Fig. 19. ❑A–C. *Acanthocladia* cf. *rhombicellata* Shul'ga-Nesterenko 1955; Rejmyrefjellet, Tyrrellfjellet Member. A. Shallow to median deep tangential section, early Asselian, REF-1–36.0m, PMO A42114, × 10. B. Deep tangential section, latest Gzhelian, REF-0–25.0m, PMO A42210, × 10. C. Deep tangential section. Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42210, × 25. ❑D. *Ptylopora* sp. A, tangential section of lateral meshwork and main stem (left). Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42311, × 10. ❑E. *Penniretepora subtila* (Shul'ga-Nesterenko 1941), deep section of main stem. Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO 138.070, × 25. ❑F. *Polypora sulaensis* Nikiforova 1938, median to deep tangential section. Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42120, ×10.



❑G–H. *Polypora martis* Fischer de Waldheim 1837. Gipsvika, Tyrrellfjellet Member, late Asselian, GIP-1–14.0m, PMO A42105. G. Shallow tangential section with large nodes between apertures, × 40. H. Median tangential section with ?ovicell adjacent to fenestrule (arrow), × 25.

Measurements. — (For abbreviations see pp. 57–58.)

		AVG	STDS	CV	MIN	MAX	n
	LAT10	4.450	0.647	14.55	3.70	5.10	6
Main stem	WB	1.052	0.222	21.09	0.81	1.27	5
	AW	0.102	0.008	8.20	0.09	0.11	5
	AL	0.138	0.016	11.91	0.12	0.16	5
	A5	11.463	1.308	11.41	10.00	14.00	8
	AROW	4.000	0.000	0.00	4.00	4.00	4
Lateral branches	WB	0.695	0.162	23.37	0.54	0.90	6
	AW	0.102	0.008	8.20	0.09	0.11	5
	AL	0.138	0.016	11.91	0.12	0.16	5
	A5	13.333	1.949	14.62	11.00	15.80	6
	AROW	2.750	0.500	18.18	2.00	3.00	4

Occurrence outside Spitsbergen. — *Acanthocladia rhombicellata* was originally described from the Gzhelian of the Urals.

Genus *Polypora* M'Coy 1844

Type species: *Polypora dendroides* M'Coy 1844, Viséan of Ireland.

Polypora martis Fischer de Waldheim 1837

Figs 19G–H, 20A–B.

Polypora martis sp. n.; Fischer de Waldheim 1837: p. 1.

Polypora martis Fischer de Waldheim; Trautschold 1876: p. 91, Pl. 11: 2.

Polypora martis Fischer de Waldheim; Stuckenberg 1888: p. 34, Pls 3: 56–58, 4: 30.

Polypora martis Fischer de Waldheim; Stuckenberg 1895: p. 160.

Polypora martis Fischer de Waldheim; Bolkhovitinova 1915: p. 71, Pl. 6: 6.

Polypora martis Fischer de Waldheim; Nikiforova 1938: p. 122 [241], Pls 25: 1–9, 26: 1–7.

Polypora martis Fischer de Waldheim; Shul'ga-Nesterenko 1951: p. 134, Pls 1: 8, 30: 3–4, Text-fig. 53.

Polypora martis Fischer de Waldheim; Morozova 1955: p. 32.

Polypora martis Fischer de Waldheim; Trizna 1961: p. 82–85, Text-figs 31a–b.

Polypora sp. cf. *martis* Fischer de Waldheim; Ross & Ross 1962: p. 51, Pl. 14: 1, 5.

Polypora martis Fischer de Waldheim; Goryunova & Kruchinina 1975: p. 150, Pl. 59: 9.

Description. — Robust meshwork with relatively small fenestrules and moderately narrow branches and dissepiments. There are 8–10 branches across and 8–9 fenestrules along colony per 10 mm. The branches are about 0.80 mm wide carrying 4–5 rows of apertures with a diameter of 0.14–0.15 mm. Up to 6 rows of apertures are developed prior to bifurcation. Distance between apertural centers average 0.29 longitudinally and 0.23 mm diagonally across branch. Tubercles with a stellate outline are randomly distributed on obverse branch surface, about 0.14–0.15 mm or smaller in diameter. Fenestrules average 0.90 mm in length and 0.47 mm in width. The fenestrules are larger in sections taken closer to the reverse side of colony. Also near reverse side, the branches have a striated and spotty pattern.

Comparison. — The current specimen is most similar to *P. martis*, but has generally more closely spaced apertures as compared with previous descriptions (18–19 against 15–17 per 5 mm). The Carboniferous specimens of *P. martis*, described by Shul'ga-Nesterenko (1949, 1951) have a very small apertural diameter (0.07–0.08 mm) as compared with the Permian specimens (0.13–0.15 mm) (e.g. Trizna 1961; Goryunova & Kruchinina 1975). The meshwork formula is otherwise similar to those in many Late Permian species of *Polypora* described by Morozova (1970).

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	8.940	0.481	5.38	8.20	10.00	10
DS10	8.510	0.129	1.51	8.20	8.60	10
A5	18.230	0.323	1.77	17.80	18.90	10
AROW	4.500	0.707	15.71	4.00	5.00	2
WB	0.800	0.058	7.29	0.70	0.87	10
WD	0.313	0.042	13.39	0.25	0.40	10
FL	0.901	0.021	2.30	0.85	0.92	11
FW	0.474	0.034	7.27	0.44	0.55	11
AD	0.145	0.007	4.88	0.14	0.15	2
AAL	0.288	0.011	3.87	0.27	0.31	12
AAC	0.226	0.010	4.41	0.21	0.24	12
NL	–	–	–	–	–	–
NW	–	–	–	–	–	–

Material. — GIP-1–14.0m (PMO A42105).

Stratigraphic occurrence in Spitsbergen. — Late Asselian, below the *Eoparafusulina paralinearis* fusulinid zone (Nilsson & Davydov in press), middle-upper part of the Tyrrellfjellet Member, and late Artinskian-early Kungurian (*Neostreptognathodus pequopensis-Sweetognathus whitei* conodont association, *Horridonia timanica* brachiopod zone), Vøringen Member of the Kapp Starostin Formation (Nakrem in press).

Occurrence outside Spitsbergen. — Early Permian of Timan (Nikiforova 1938), Late Carboniferous of eastern North Greenland (Mallemuk Mountain Group; Ross & Ross 1962), Artinskian and Carboniferous of the Urals (Trizna 1948; Shul'ga-Nesterenko 1951).

Polypora sulaensis Nikiforova 1938

Figs 19F, 20C.

Polypora porosa Eichwald var. *sulaensis* var. n.; Nikiforova 1938: p. 137 [249], Pl. 39: 4–8.

Polypora sulaensis Nikiforova; Morozova & Kruchinina 1986: p. 105, Pl. 38: 1a–c.

Description. — Moderately robust colonies with relatively large fenestrules and wide branches and dissepiments. Five to six branches across and 3–4 fenestrules along colony are present in 10 mm. The branches are straight, average 0.94 mm wide, 1.18 mm wide prior to bifurcation. Striated branch reversal surface with closely packed small capillaries (0.009 mm in diameter) and randomly distributed larger nodes (about 0.06 mm in diameter). There are 10–15 slightly oval apertures (0.13 × 0.18 mm) per 5 mm along branch, with apertural centers 0.40–0.51 mm apart.

Apertural rows number 5–6, with largest number present prior to bifurcation. Between normal autozooecia there are rare 'cyclozooecia', 0.09–0.10 mm in diameter. Dissepiment width shows large inter-zoarial variation (0.30–1.46 mm wide, CV 38.08) whereas intra-zoarial variation is considerably smaller (CV 6.64–6.67). The same great degree of variation is observed in fenestrule dimensions, averaging 1.98 in length and 1.11 in width.

Remarks. — The investigated colonies are generally too deeply polished during thin section preparation and some measurements could not be tabulated.

Comparison. — The recorded meshwork formula (5–6/3–4/10–15/5–6) embrace more than 50 previously described species of *Polypora* (see discussion under *P. voluminosa* below). *P. brevicellata* Baranova 1960b, of Sakmarian-Artinskian age, has a resembling meshwork composition, but differs from *P. sulaensis* in having larger circular apertures (0.15–0.16 mm in diameter) and narrower dissepiments (0.34–0.85 mm).

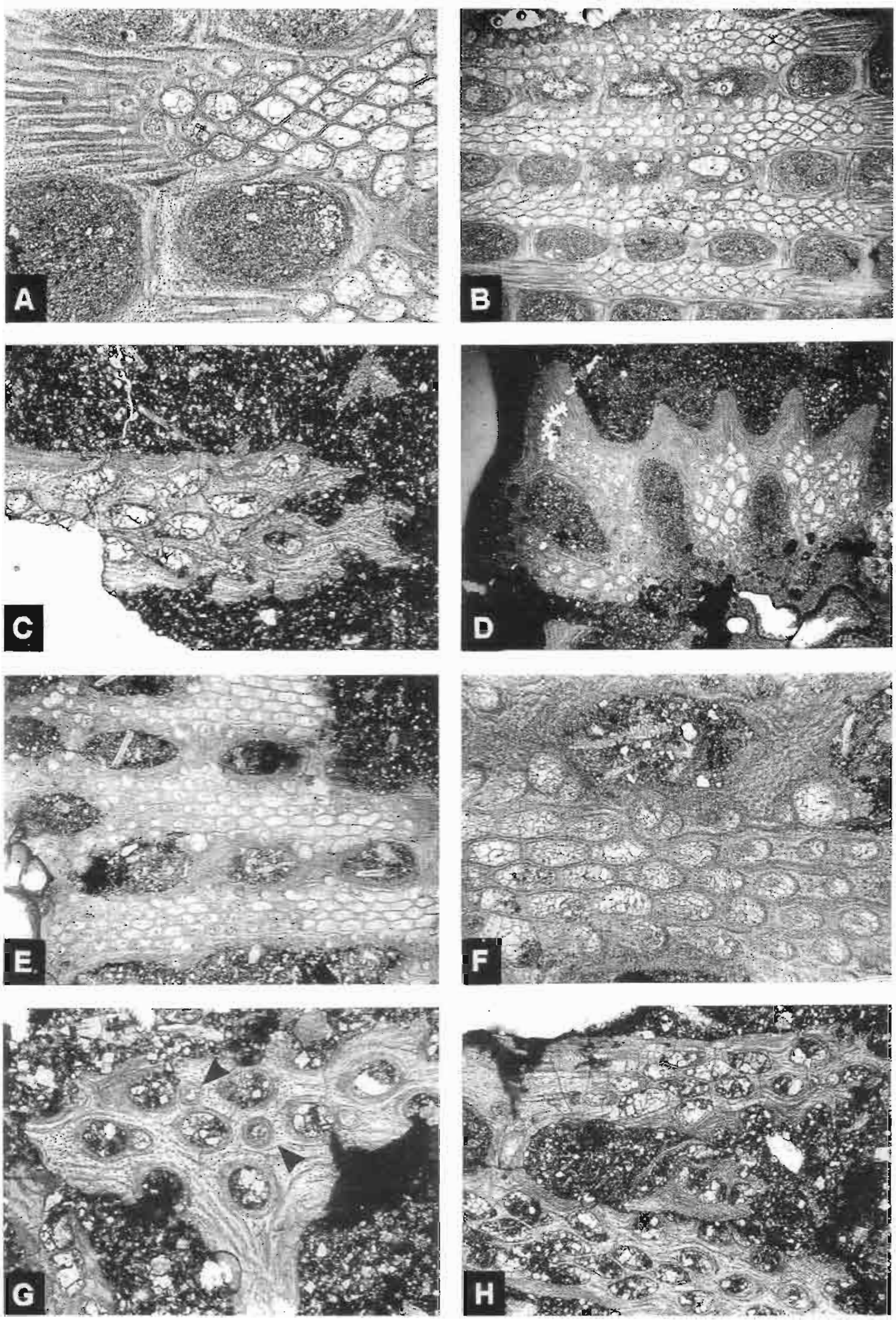
Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	5.393	0.517	9.58	4.90	6.50	14
DS10	3.236	0.518	16.02	2.40	3.90	14
A5	13.136	1.621	12.34	10.00	15.00	22
AROW	5.500	0.577	10.50	5.00	6.00	4
WB	0.941	0.077	8.23	0.82	1.10	14
WD	1.114	0.424	38.08	0.30	1.46	16
FL	1.984	0.969	48.84	1.15	3.64	14
FW	1.031	0.099	9.56	0.86	1.15	14
AD	–	–	–	–	–	–
AAL	0.464	0.034	7.34	0.40	0.51	12
NL	–	–	–	–	–	–
NW	–	–	–	–	–	–

Material. — GIP-1–14.0m (PMO A42106), REF-0–25.0 m (PMO A42120).

Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member, and late Asselian, below the *Eoparafusulina paralinearis* fusulinid zone (Nilsson & Davydov in press), Tyrrellfjellet Member.

Fig. 20. ❑A–B. *Polypora martis* Fischer de Waldheim 1837; Gipsvika, Tyrrellfjellet Member, late Asselian, GIP-1–14.0m, PMO A42105. A. Deep tangential section, × 25. B. Tangential section, × 10. ❑C. *Polypora sulaensis* Nikiforova 1938, shallow tangential section of branch fragment. Rejmyrefjellet, Tyrrellfjellet Member, latest Gzhelian, REF-0–25.0m, PMO A42120, × 25. ❑D–F. *Polypora voluminosa* Trizna & Klautsan 1961; Rejmyrefjellet, Gipshuken Formation, late Artinskian, REF-4–15.0m, PMO A42602. D. Oblique tangential section of diverging branches close to colony origin, × 10. E. Tangential section, × 10. F. Tangential section with ovicells (arrows), × 25. ❑G–H. ?*Shulgapora* sp; Rejmyrefjellet, Tyrrellfjellet Member, latest



Gzhelian, REF-0–25.0m, PMO A42206. G. Shallow tangential section showing cyclozooecial openings (arrows) between autozooecial apertures, × 25. H. Deep tangential section showing presence of dissepiments, × 10.

Occurrence outside Spitsbergen. — Sakmarian-Artinskian of Timan (Morozova & Kruchinina 1986).

Polypora voluminosa Trizna & Klautsan 1961

Fig. 20D–F.

Polypora voluminosa sp. n.; Trizna & Klautsan 1961: p. 433, Pl. 12: 5.

Polypora voluminosa Trizna & Klautsan; Morozova & Kruchinina 1986: p. 106, Pl. 40: 2.

Description. — Robust meshwork with relatively small fenestrules compared to the wide branches. About 7 branches are present across colony, and 6 fenestrules along per 10 mm. The branches average 1.02 mm in width, being up to 1.50 mm wide prior to bifurcation and 0.50 mm immediately after. Dissepiments show less degree of variation being about 0.60 mm wide. The branches carry commonly 5 rows of apertures (6 prior to bifurcation and 3 after). There are about 15 apertures per 5 mm along branches, about 0.34 mm from center to center. Nodes, circular (0.12–0.13 mm in diameter) or elongated (0.12×0.18 mm), are irregularly distributed on branch surface. Zooecial bases are commonly regularly hexagonal to rectangular box-shaped in outline in median tangential section. Ovicells, 0.20–0.25 mm in diameter, are in places present between normal autozooecia. Fenestrules are about 1.20 mm long and 0.58 mm wide.

Comparison. — The variability of the meshwork formula of the current species matches the variability of almost 50 species of *Polypora* recorded from the Late Carboniferous through Permian. This implies that the geometry and robustness of zoarial characters are common for many species (some of which most certainly are synonymous) and probably reflects the ecological fitness of such morphology. Most similar species (and their published meshwork formulas) are *P. culta* Morozova 1981 (6–8/6–7/15/5) from the Ufimian of Kolyma, *P. daurica* Morozova 1970 (6/5/14–15/5–6) from the Late Permian of Primorie, *P. subvoluminosa* Kruchinina 1973 (6–8/5–7/15–16/4–5) from the Sakmarian of Timan and *P. visenda* Trizna 1948 (6–8/4–6/14–16/4–5) from the Artinskian of the Urals.

Measurements. — (For abbreviations see pp. 57–58.)

	AVG	STDS	CV	MIN	MAX	n
BR10	6.840	0.227	3.32	6.60	7.20	10
DS10	5.990	0.543	9.06	5.10	6.60	10
A5	15.050	0.350	2.33	14.50	15.80	12
AROW	4.733	0.961	20.31	3.00	6.00	15
WB	1.019	0.288	28.26	0.49	1.50	12
WD	0.597	0.031	5.12	0.54	0.64	10
FL	1.214	0.119	9.79	1.08	1.40	8
FW	0.579	0.091	15.77	0.43	0.70	8
AD	0.121	0.012	9.61	0.11	0.14	14
AAL	0.344	0.015	4.50	0.32	0.37	15
NL	0.149	0.027	17.99	0.12	0.18	7
NW	0.126	0.010	7.76	0.11	0.14	7

Material. — REF-4–15.0m (PMO A42599, A42602).
Stratigraphic occurrence in Spitsbergen. — Late Artinskian, associated with the conodont species *Neostreptognathodus* cf. *pequopensis*, uppermost part of the Gipshuken Formation.
Occurrence outside Spitsbergen. — Artinskian of the Urals and Timan (Morozova & Kruchinina 1986).

Genus *Shulgapora* Termier & Termier 1971
Type species: *Polypora helenae* Shul'ga-Nesterenko 1951, Moscovian of central Russia.

?*Shulgapora* sp.
Fig. 20G–H.
Remarks. — A small fragment is assigned to ?*Shulgapora* sp. based on presence of reticulate meshwork (unlike *Thamniscus* and *Acanthocladia*) with 3–4 rows of apertures and cyclozooecial apertures between ordinary autozooecial apertures. A single fenestrule could be measured being 0.78 mm long and 0.47 mm wide. Both dissepiments and branches (measured midway) are spaced about 1.0 mm. The branches are about 0.55 mm wide; dissepiments 0.18–0.19 mm wide. Autozooecial apertures slightly oval in outline, about 0.14 × 0.17 mm. Cyclozooecia circular, 0.07–0.08 mm in diameter.
Material. — REF-0–25.0m (PMO A42206–207).
Stratigraphic occurrence in Spitsbergen. — Late Gzhelian, associated with *Schellwienia* aff. *arctica* (Nilsson, personal communication 1993) and *Streptognathodus excelsus* and *S. elongatus*, lowermost part of the Tyrrellfjellet Member.

Acknowledgements

The support from IKU Petroleum Research (Trondheim) 'Arctic Geo-Program' (with funding oil companies A/S Norske Shell, BP Petroleum (Norway) Ltd., Elf Aquitaine Norge A/S, Esso Norge A/S, Fina Exploration Norway A/S, Mobil Exploration Norway Inc., Norsk Agip A/S, Norsk Hydro A/S, Phillips Petroleum Co. Norway, Saga Petroleum A/S, Statoil) and project manager Atle Mørk is gratefully acknowledged. Inger Nilsson (IKU) is thanked for allowance to use her fusulinid datings in my work; together with Roger Konieczny (IKU/Norwegian Institute for Water Research), she is also thanked for help and fruitful discussions during fieldwork in Svalbard. Comments on the manuscript from Patrick N. Wyse Jackson, Trinity College, Dublin, Steven J. Hageman, Appalachian State University, Boone, and Françoise P. Bigey, Paris, are highly appreciated.

References

Alekseeva, I.A., Bogoslovskaya, M.F., Vladimirovich, V.P., Gorskii, V.P., Grozdilova, L.P., Guseva, E.A., Ekhlakov, Yu. A., Zolotova, V.P., Izotova, M.N., Kalmykova, M.A., Kanev, G.P., Kalshnikov, N.V., Kashevarova, N. P., Miklukho-Maklai, K.V., Molostovskaya, I.I., Morozova, I.P., Movshovich, E. V., Polozova, A. N., Simakova, M.A., Ukharskaya, L.B. & Fabeeva, I.Z. (Алексеева, И.А, Богославская, М.Ф., Владимирович, В.П., Горский, В.П., Гроздилова, Л.П., Гусева, Е.А., Еклахов, Ю.А., Золотова, В.Т., Изотова, М.Н., Калмыкова, Н.В., Кашеварова, Н.П., Миклухо-Маклай, К.В., Молостовская, И.И., Морозова, И.П., Мовшович, Е.В., Полозова, А.Н., Симакова, М.А., Ухарская, Л.Б., Фабеева, И.З.) 1986. Мшанки (тип Bryozoa). In: В.Л. Горский, М.А. Калмыкова (eds) Атлас характерных комплексов пермской фауны и флоры Урала и Русской Платформы. *Труды ВНИГРИ* **331**, 28–29.

Astrova, G.G. (Астрова, Г.Г.) 1964. О новом отряде палеозойских мшанок. *Палеонтологический Журнал* **1964**, 2, 22–31.

Astrova, G.G. & Morozova, I.P. (Астрова, Г.Г. и Морозова, И.П.) 1956. К систематике мшанок отряда *Cryptostomata. Доклады Академии Наук СССР* **110**, 661–664.

Bancroft, A.J. 1985. The Carboniferous fenestrate bryozoan *Ptylopora pluma* M'Coy. *Irish Journal of Earth Sciences* **7**, 35–45.

Bancroft, A.J. 1987: Biostratigraphical potential of Carboniferous Bryozoa. *Courier Forschungs-Institut Senckenberg* **98**, 193–197.

Baranova, G.I. (Баранова, Г.И.) 1960a. Некоторые раннепермские мшанки бассейна реки Печоры. *Палеонтологический Журнал* **1960**, 1, 62–72.

Baranova, G.I. (Баранова, Г.И.) 1960b. Новые раннепермские мшанки бассейна реки Печоры. In: *Новые виды древних растений и безпозвоночных СССР* **1**, 263–268.

Bassler, R.S. 1929. The Permian Bryozoa of Timor. *Paläontologie von Timor* **16**, 37–90.

Boardman, R.S., Cheetham, A.H., Blake, D.B., Utgaard, J., Karklins, O.I., Cook, P.L., Sandberg, P.A., Lutaud, G. & Wood, T.S. 1983. *Treatise on Invertebrate Paleontology. Part G. Bryozoa. Revised. Volume 1: Introduction, Order Cystoporata, Order Cryptostomata.* The Geological Society of America and the University of Kansas. 1–625. Boulder, Colorado.

Bolkhovitinova, M.A. (Болховитинова, М.А.) 1915. О каменноугольных кораллах и мшанках Московской губерни. *Записки Геологического Отделения Любителей Естествознания, Антропологии и Этнографии* **3**, 61–81.

Condra, G.E. & Elias, M.K. 1944. Study and revision of *Archimedes* (Hall). *Geological Society of America Special Paper* **53**, 1–243.

Crockford, J. 1947: Bryozoa from the Lower Carboniferous of New South Wales and Queensland. *Proceedings from the Linnéan Society New South Wales* **72**, 1–48.

Cutbill, J.L. & Challinor, A. 1965. Revision of the stratigraphical scheme for the Carboniferous and Permian rocks of Spitsbergen and Bjørnøya. *Geological Magazine* **102**, 418–439.

Czarniecki, S. 1964. Occurrence of genus *Archimedes* (Hall) in Hornsund, Vestspitsbergen. *Studia Geologica Polonica* **11**, 147–153.

Dunaeva, N.N. & Morozova I.P. (Дунаева, Н.Н, Морозова, И.П.) 1967. Особенности развития и систематическое положение некоторых позднепалеозойских трепостомат. *Палеонтологический Журнал* **1967**, 4, 86–94.

Duncan, H. 1969. History of the Redwall Limestone of northern Arizona. Chapter VII. Bryozoans. *Geological Society of America Memoir* **114**, 345–612.

Eichwald, E. 1860. *Lethaea Rossica, ou Paléontologie de la Russie, t. 1, l'ancienne période.* 1–682. E. Schweizerbart, Stuttgart.

Elias, M.K. & Condra, G.E. 1957. *Fenestella* from the Permian of West Texas. *Geological Society of America Memoir* **70**, 1–158.

Etheridge, R. Jr. 1873. Description of *Carinella*, a new genus of Carboniferous Polyzoa. *Geological Magazine* **10**, 433–434.

Etheridge, R. Jr. 1876. Carboniferous and post-Tertiary Polyzoa. *Geological Magazine n.s.* **2**, 522–523.

Fengsheng, Xia 1986. Carboniferous and Early Permian bryozoans from Xainza, northern Xizang. *Bulletin of the Nanjing Institute of Geology and Palaeontology, Academia Sinica* **10**, 201–254 (in Chinese).

Fischer de Waldheim, G. 1837. Oryctographie du Gouvernement de Moscou. 1–189. Moscou.

Fleming, J. 1828. *A History of British Animals.* 1–565. Bell & Bradfute, Edinburgh.

Goryunova, R.V. (Горюнова, Р.В.) 1975. Пермские мшанки Памира. *Труды Палеонтологического Института АН СССР* **148**, 1–125.

Goryunova, R.V. & Kruchinina, O.N. (Горюнова, Р.В., Кручинина, О.Н.) 1975. Bryozoa. In: Палеонтологический атлас каменноугольных отложении Урала. *Труды ВНИГРИ* **383**, 146–153.

Hageman, S.J. 1991. Approaches to systematic and evolutionary studies of perplexing groups: an example using fenestrate Bryozoa. *Journal of Paleontology* **65**, 630–647.

Hall, J. 1857. Observations on the genus *Archimedes*, or *Fenestella*, with descriptions of species. *American Association for the Advancement of Science, Proceedings* **10**, 176–179.

Hall, J. 1885. On the mode of growth and relations of the Fenestellidae. *Report of the State Geologist of New York for the year 1884*, 35–46.

Keilen, H.B. 1992. Lower Permian sedimentary sequences in Central Spitsbergen, Svalbard. In: Nakamura, K. (ed.) *Investigations on the Upper Carboniferous-Upper Permian Succession of West Spitsbergen 1989–1991*, 127–134. Sapporo.

Keyserling, A. 1846. *Wissenschaftliche Beobachtungen auf einer Reise in das Petschora Land*, 151–407. St. Petersburg.

King, W. 1849. On some families and genera of corals. *Annals and Magazine of Natural History, Series 2* **3**, 388–390.

Kruchinina, O.N. (Кручинина, О.Н.) 1973. Тип Bryozoa. In: Новые виды древних растении и беспозвоночных СССР. *Труды ВНИГРИ* **318**, 82–97.

Madsen, L & Håkansson, E. 1989. Upper Palaeozoic bryozoans from the Wandel Sea Basin, North Greenland. *Geological Survey of Greenland Report* **144**, 43–52.

Małecki, J. 1977. Permian bryozoans from Southern Spitsbergen and Bjørnøya. *Studia Geologica Polonica* **51**, 75–87.

Mangerud, G. & Konieczny, R.M. 1993. Palynology of the Permian succession of Spitsbergen, Svalbard. *Polar Research* **12**, 65–93.

M'Coy, F. 1844. *A synopsis of the characters of the Carboniferous Limestone fossils of Ireland*. 1–207. Dublin University Press, Dublin.

McKinney, F.K. & Gault, H.W. 1980. Paleoenvironment of Late Mississippian fenestrate bryozoans, eastern United States. *Lethaia* **13**, 127–146.

Meek, F.B. 1872. *Report on the paleontology of eastern Nebraska*. In: F.V. Hayden (ed.) *Final Report of the United States Geological Survey of Nebraska and Portions of the Adjacent Territories*, 81–239. Washington.

Miller, T.G. 1961. Type specimens of the genus *Fenestella* from the Lower Carboniferous of Great Britain. *Palaeontology* **5**, 540–549.

Morozova, I.P. (Морозова, И.П.) 1955. Каменноугольные мшанки среднего Донбаса. *Труды Палеонтологического Института АН СССР* **58**, 1–88.

Morozova, I.P. (Морозова, И.П.) 1966. Новый подотряд позднепалеозойских мшанок отряда Cryptostomata. *Палеонтологический Журнал* **1966**, 2, 33–41.

Morozova, I.P. (Морозова, И.П.) 1970. Мшанки поздней перми. *Труды Палеонтологического Института АН СССР* **122**, 1–314.

Morozova, I.P. (Морозова, И.П.) 1974. Ревизия рода *Fenestella*. *Палеонтологический Журнал* **1974**, 2, 54–67.

Morozova, I.P. (Морозова, И.П.) 1981. Позднепалеозойские мшанки северо-востока СССР. *Труды Палеонтологического Института АН СССР* **188**, 1–119.

Morozova, I.P. (Морозова, И.П.) 1987. Морфогенез, система и колониальная интеграция мшанок отряда Fenestrida. *Труды Палеонтологического Института АН СССР* **222**, 70–88.

Morozova, I.P. & Kruchinina, O.N. (Морозова, И.П., Кручинина, О.Н.) 1986. *Пермские мшанки Арктики (Западний Сектор)*, 1–144. Наука, Москва.

Nakrem, H.A. 1991a. Distribution of bryozoans in the Permian succession of Svalbard (preliminary data). In: F.P. Bigey (ed.) Bryozoaires actuels et fossiles : Bryozoa living and fossil. *Bulletin de la Société des Sciences Naturelles de l'Ouest de la France, Mémoire HS* **1**, 291–298.

Nakrem, H.A. 1991b. Distribution of conodonts through the Permian succession of Svalbard. *Geonytt* **1**, 38–39.

Nakrem, H.A. 1993. Environmental distribution of bryozoans in the Permian of Spitsbergen. In: P.J. Hayward, J.S. Ryland, & P.D. Taylor (eds) *Biology and Palaeobiology of Bryozoans*. 141–145. Olsen & Olsen, Fredensborg.

Nakrem, H.A. (in press) Bryozoans from the Lower Permian Vøringen Member (Kapp Starostin Formation), Spitsbergen (Svalbard). *Norsk Polarinstitutt Skrifter* **197**.

Nakrem, H.A., Nilsson, I., & Mangerud, G. 1992. Permian biostratigraphy of Svalbard (Arctic Norway) – A review. *International Geology Review* **34**, 933–959.

Nikiforova, A.I. (Никифорова, А.И.)1933. Среднекаменноугольные мшанки Донецкого Бассейна. *Труды ВГРО* **237**, 1–45.

Nikiforova, A.I. (Никифорова, А.И.) 1938. Типы каменноугольных мшанок европейской части СССР. *Палеонтология СССР* **4**, 1–290.

Nikiforova, A.I. (Никифорова, А.И.) 1939. Новые виды верхнепалеозойских мшанок предгорной полосы Башкирии (кроме сем. Fenestellidae и Acanthocladiidae). *Труды НИГРИ* **A115**, 70–101.

Nilsson, I. 1988. *Carboniferous – Permian Fusulinids on the Nordfjorden Block, Spitsbergen (Svalbard).* Unpublished thesis, University of Oslo, 1–143.

Nilsson, I. & Davydov, V.I. (in press) Upper Carboniferous (Kasimovian-Gzhelian) and Lower Permian (Asselian-Sakmarian) fusulinid stratigraphy in central Spitsbergen, Arctic Norway. *Norsk Polarinstitutt Skrifter.*

d'Orbigny, A. 1849. Description de quelques genres nouveaux de Mollusques Bryozoaires. *Revue et Magasin de Zoologie ser. 2,* **1**, 499–504.

Owen, D.D. 1842. Regarding human footprints in solid limestone. *American Journal of Science 1. ser.* **43**, 14–32.

Phillips, J. 1836. *Illustrations of the geology of Yorkshire, or, a description of the strata and the organic remains of the Yorkshire coast, etc. Part II. - The Mountain Limestone district.* 1–253. John Murray, London.

Phillips, J. 1841. *Figures and descriptions of the Palaeozoic fossils of Cornwall, Devon, and West Somerset.* 1–231. Longmans, Brown, Green, & Longmans, London.

Ross, J.R.P. 1981. Biogeography of Permian ectoproct Bryozoa. *Palaeontology* **21**, 341–356.

Ross, J.R.P. & Ross, C.A. 1962. Faunas and correlation of the late Paleozoic rocks of Northeast Greenland. Pt. IV, Bryozoa. *Meddelelser om Grønland* **167**, 1–85.

Ross, J.R.P. & Ross, C.A. 1990. Late Palaeozoic bryozoan biogeography. In: W.S. McKerrow & C.R. Scotese (eds) Palaeozoic Palaeogeography and Biogeography. *Geological Society Memoir* **12**, 353–362.

Sakagami S. & Sugimura, A. 1987. *Hinaclema,* a new Carboniferous bryozoan genus from the Hina Limestone, Southwest Japan. *Proceedings of the Japan Academy* **B63**, 246–249.

Schastlivsteva, N.P. (Щастливцева, Н.П.) 1991. Первая находка в СССР каменноугольного рода *Hinaclema* (мшанки). *Палеонтологический Журнал* **1991**, 1, 118–120.

Schlotheim, E.F. 1820. *Die Petrefaktenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung einer Sammlung versteinerter und fossiler Überreste des Tier- und Pflanzenreichs der Vorwelt erläutert.* 378 pp. Gotha.

Shul'ga-Nesterenko, M.I. (Шульга-Нестеренко, М.И.) 1933. Мшанковая фауна угленосных и подугленосных отложении Печорского края. *Труды ВГРО* **259**, 1–64

Shul'ga-Nesterenko, M.I. (Шульга-Нестеренко, М.И.) 1936. Мшанковая фауна верхнего палеозоя северного Урала. *Fenestella* и *Archimedes* среднепечорского раиона. *Труды Полярной Комисии АН СССР* **28**, 233–288.

Shul'ga-Nesterenko, M.I. (Шульга-Нестеренко, М.И.) 1939. Класс Bryozoa. Мшанки. In: Б. Лихарев (ed.) *Атлас руководящих фаун СССР. том* **6**. *Перм,* 64–76. Ленинград.

Shul'ga-Nesterenko, M.I. (Шульга-Нестеренко, М.И.) 1941. Нижнепермские мшанки Урала. *Палеонтология СССР* **5**, 1–276.

Shul'ga-Nesterenko, M.I. (Шульга-Нестеренко, М.И.) 1949. Функциональное, филогенетическое и стратиграфическое значение микроструктуры скелетных тканей мшанок. *Труды Палеонтологического Института АН СССР* **23**, 1–66.

Shul'ga-Nesterenko, M.I. (Шульга-Нестеренко, М.И.) 1951. Каменноугольные фенестеллиды Русской Платформы. *Труды Палеонтологического Института АН СССР* **32**, 1–157.

Shul'ga-Nesterenko, M.I. 1952. Новые нижнепермские мшанки Приуралья. *Труды Палеонтологического Института АН СССР* **37**, 1–84.

Shul'ga-Nesterenko, M.I. (Шульга-Нестеренко, М.И.) 1955. Каменноугольные мшанки Руской Платформы. *Труды Палеонтологического Института АН СССР* **57**, 1–207.

Simpson, G.B. 1895 (1897). A handbook of the genera of the North American Paleozoic Bryozoa; with an introduction upon the structure of living species. *14th Annual Report from the N.Y. State Geologist*, 403–669.

Skaug, M., Dons, C.E., Lauritzen, Ø., & Worsley, D. 1982. Lower Permian palaeoaplysinid bioherms and associated sediments from central Spitsbergen. *Polar Research* **2**, 57–75.

Snyder, E.M. 1991. Revised taxonomic procedures and paleoecological applications for some North American Mississippian Fenestellidae and Polyporida (Bryozoa). *œontographica Americana* **57**, 1–275.

Stach, L.W. 1936. Correlation of zoarial form with habitat. *Journal of Geology* **44**, 60–65.

Steel, R. & Worsley, D. 1984. Svalbard's post-Caledonian strata – an atlas of sedimentational patterns and palaeogeographic evolution. In: A.M. Spencer *et al.* (eds) *Petroleum Geology of the North European Margin*, 109–135. Graham and Trotman, London, and Norwegian Petroleum Society.

Stuckenberg, A.A. (Штукенберг, А.А.) 1875. Отчет геологического путешествия в Печорский край и Тиманскую тундру. *Материялы для геологии России* **6**, 1–125.

Stuckenberg, A.A. (Штукенберг, А.А.) 1888. Кораллы и мшанки верхнего яруса среднерусского каменноугольного известняка. *Труды Геологического Комитета* **5**, 1–54.

Stuckenberg, A.A. (Штукенберг, А.А.) 1895. Кораллы и мшанки каменноугольных отложении Урала и Тимана. *Труды Геологического Комитета* **10**, 1–244.

Tavener-Smith, R. 1966. The micrometric formula and the classification of fenestrate cryptostomes. *Palaeontology* **9**, 413–425.

Termier, H. & Termier, G. 1971. Bryozoaires du Paléozoique supérieur de l'Afganistan. *Documents des Laboratoires de Géologie, Faculté des Sciences, Lyon* **47**, 1–52.

Toula, F. 1875. Eine Kohlenkalk-fauna von den Barents-Inseln (Nowaja-Semlja N. W.). *Sitzungsberichte der Akademie der Wissenschaften in Wien, Mathematisch-naturwissenschaftliche Klasse, Abt. 1, Biologie, Mineralogie, Erdkunde und verwandte Wissenschaften* **1875**, 527–608.

Trautschold, H.A. 1876–79. Die Kalkbrücke von Mjatschkova. Eine Monographie des oberen Bergkalks. *Nouveaux mémoires de la Société Impériale des naturalistes de Moscou* **13**, 1–367.

Trizna, V.B. (Тризна, В.Б.) 1939. Новые виды мшанок сем. Fenestellidae i Acanthocladiidae предгорной полосы Башкирии. *Труды НИГРИ* **A115**, 102–144.

Trizna, V.B. (Тризна, В.Б.) 1948. Пермские мшанки с р. Сильвы. *Труды ВНИГРИ* **31**, 137–188.

Trizna, V.B. (Тризна, В.Б.) 1961. Мшанки раннего и среднего карбона некоторых раионов западнего склона Урала. *Труды ВНИГРИ* **179**, 27-136.

Trizna, V.B. & Klautsan, R.A. (Тризна, В.Б., Клауцан, Р.А.) 1961. Мшанки артинского яруса уфимского плато и их роль в стратиграфии этого яруса в Приуралье. *Труды ВНИГРИ* **179**, 331–453.

Ulrich, E.O. 1882. American Paleozoic Bryozoa. *Journal of the Cincinnati Society of Natural History* **5**, 121–175.

Ulrich, E.O. 1890. Palaeozoic Bryozoa. *Geological Survey of Illinois* **8**, 285–688.

Ustritskii, V.I. (Устрицкий, В.И.) 1986. О биполярности фаун палеозоя. *Палеонтологический Журнал* **1986**, 2, 33–37.

Vine, R.G. 1884. Fourth report of the committee consisting of Dr. H.C. Sorby and Mr. G.R. Vine, appointed for the purpose of reporting on fossil Bryozoa. *Report of the British Association for the Advancement of Science, 53rd Meeting (Southport, 1883)*, 161–209. London.

Waagen, W.H. & Pichl, J. 1885. Salt Range fossils; *Productus*-limestone fossils. *Palaeontologica Indica*, series 13 **1**, 771–834.

Waagen, W.H. & Wentzel, J. 1886. Salt Range fossils; Productus-limestone fossils. Palaeontologica Indica, series 13 **1**, 835–924.

Winsnes, T.S. 1988. Bedrock map of Svalbard and Jan Mayen. *Norsk Polarinstitutt Temakart nr. 3.*

Worsley, D., Aga, O.J., Dalland, A., Elverhøi, A., & Thon, A. 1986. *The Geological History of Svalbard, Evolution of an Arctic Archipelago.* 1–121. Statoil, Stavanger, Norway.

Young, J. 1883. On Ure's 'Millepore', *Tabulipora (Cellepora) Urii*, Fleming. *Annals and Magazine of Natural History* series 5 **1883**, 154–158.

Young, J. & Young, J. 1874. On a new genus of Carboniferous Polyzoa. *Annals and Magazine of Natural History* series 4 **1874**, 335-339.

Zittel, K.A. 1880. *Handbuch der Paläontologie, Abt. 1. Paläozoologie: Bd. 1.*, 1-765. R. Oldenbourg, München.

Norsk sammendrag

Bryozoer fra Nordenskiöldbreenformasjonen (midtre karbon moskva til tidlig perm sakmar) og Gipshukenformasjonen (sen sakmar – sen artinsk) fra Spitsbergen, Svalbard, er representert med 36 arter (22 slekter). En art er ny: *Hinaclema svalbardensis*, orden Trepostomata. Bryozofaunaen er typisk boreal (nordlig) og ligner på tilsvarende fauna beskrevet fra Timan-Pechoraområdet (vestlige Sibir) og fra Uraldistriktet. Likhetsindekser basert på slektssammensetningen viser at den Boreale faunaen ble stadig mer endemisk mot slutten av tidlig perm, og er markant forskjellig fra Tethysfaunaen i sør. Mange arter har en stratigrafisk utbredelse på Spitsbergen som avviker fra utbredelsen i andre områder.

Streszczenie

Artykuł zawiera taksonomiczną rewizję mszywiołów z formacji Nordenskiöldbreen (środkowy karbon-wczesny perm) i Gipshuken (perm) Spitsbergenu, obejmując również gatunki będące niegdyś przedmiotem publikacji Czarnieckiego (1964) i Małeckiego (1977). W sumie zidentyfikowano 36 gatunków z 22 rodzajów; tylko jeden gatunek nowy. Fauna mszywiołów jest typowo borealna i przypomina fauny obszaru timańsko-peczorskiego i Uralu. Od końca wczesnego permu fauny borealne stały się bardziej endemiczne, wyraźnie odrębne od tetydzkich. Wiele gatunków mszywiołów miało dłuższe zasięgi w permie Spitsbergenu niż gdzie indziej.