

Some middle Permian bryozoans from Svalbard, Arctic Norway

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ABSTRACT: The middle to upper Permian (Ufimian-Kazanian) succession of Svalbard comprises the upper part of the Kapp Starostin Formation (above the Vøringen Member) in western and central Spitsbergen, and the Miseryfjellet Formation of Bjørnøya both units within the Tempelfjorden Group. The Ufimian-Kazanian part of the Kapp Starostin Formation consists of silicified spiculitic shales ('cherts'), partly silicified limestones and locally developed glauconitic sandstones in the uppermost part. The Miseryfjellet Formation is made up of partly silicified sandy limestones and more sandy units. The fossils in the investigated sections are typical middle to late Permian cold water forms – sponges, brachiopods, echinoderms and bryozoans. Corals and trilobites are rare, ammonoids are extremely rare and other temperate to warm-water forms, such as fusulinid foraminiferans are absent. The shaley parts of the Kapp Starostin Formation are dominated by abundant delicate trepostomids, rhabdomesids, cryptostomids and fenestellids. The partly silicified limestone units are dominated by more robust trepostomids, and robust species of *Polypora*, *Acanthocladia* and *Reteporidra*. This division may reflect the recurrent changing depositional environments (quiet/rough waters), sea level changes or a selection through transport. The identified faunas resemble Ufimian-Kazanian faunas described from adjacent Boreal (Arctic) regions, and are significantly different from Tethys (equatorial) faunas.

1 INTRODUCTION – GEOLOGICAL SETTING

The Svalbard Archipelago comprises all islands in the area 74° to 81°N and 10° to 35°E, situated at the

northwestern part of the Barents Shelf (Fig. 1). The middle to upper Permian succession here comprises the Tempelfjorden Group totalling some 380 m thickness in the area covered by the present study.

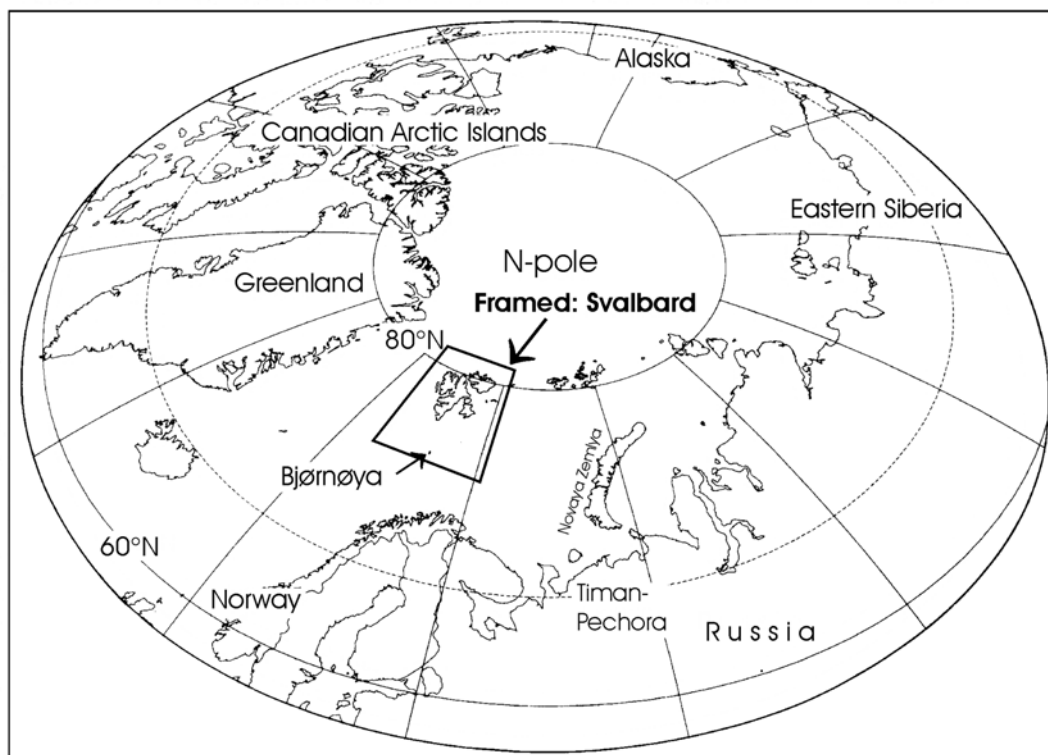


Figure 1. Map of the Arctic with localities mentioned in the text.

Bjørnøya	Southern Spitsbergen	Central-Western Spitsbergen	Nordauslandet	Age	
				Tatarian	LATE
				Kazanian	MIDDLE PERMIAN
		Revtanna / Hovtinden / Stensiöfjellet Mbr.	Selanderneset Mbr.		
		Kapp Starostin Fm.		Ufimian	
Miseryfjellet Formation	Tokrossøya Formation	Svenskeggja Mbr.	Palanderbukta Mbr.	Kungurian	EARLY PERMIAN (part)
		Vøringen Mbr.		Artinskian	
Hambergfjellet Formation, Bjarmeland Group					
		Gipshuken Fm. (Gipsdalen Grp.)			

Figure 2. Stratigraphic division of the middle Permian units of Svalbard.

Spitsbergen is the largest island, and Bjørnøya lies on a southerly continuation of the Sørkapp-Hornsund High on the western margins of the Svalbard platform. Thicker and more continuous Permian sequences occur in a series of basins lying between the Svalbard platform and northern Norway. The lithological descriptions and interpretations below are in part based on Worsley et al. (1986), Stemmerik (1997), Dallmann (1999) and Worsley et al. (2002).

Thickness and facies patterns of Permian sequences on Svalbard are related to a series of NNW-SSE trending lineaments which were active as a result of tensional stress in the Carboniferous. A relatively stable platform developed throughout Svalbard during the Permian, while intracratonic rift systems developed to the west forming the Zechstein seaway. A marked change in both litho- and biofacies types occurs at the base of the Tempelfjorden Group. The fossils in the investigated sections are typical middle to late Permian cold water forms – sponges, brachiopods, echinoderms and bryozoans. Corals and trilobites are rare, ammonoids are extremely rare and other temperate to warm-water forms, such as fusulinid foraminiferans are absent. Carbonates throughout the underlying Gipsdalen Group contain biotic associations with chlorozoan or warm water affinities, including fusulinids and abundant algae (Stemmerik 1997). All observations suggest a climatic shift around the boundary between the Gipsdalen and Tempelfjorden groups (Fig. 2) – this reflects both northwards plate movement and changing palaeogeographic regimes and change in oceanic current systems related to rifting and development of the Zechstein seaway.

1.1 Stratigraphy

The Tempelfjorden Group contains shales, siltstones and cherts, silicious sandstones and limestones, as

well as sandy bioclastic limestones. Throughout Svalbard the Tempelfjorden Group is laterally divided into several formations (see Fig. 2) – bryozoans in the current study have been collected from the Kapp Starostin Formation of Spitsbergen and adjacent smaller islands (mainly Akseløya), and the Miseryfjellet Formation of Bjørnøya, see Figure 1.

The Kapp Starostin Formation is 380 m thick in its type section in the Festningen profile of outer Isfjorden (Fig. 3). The formation is here dominated by spiculitic shales, cherts and siltstones, with minor siliceous sandstones and sandy limestone intervals, and is in the sampled localities divided into three members. The basal Vøringen Member (up to 20 m thick) is a sandy bioclastic limestone with a rich brachiopod and bryozoan fauna (Nakrem 1995). The middle unit, the Svenskeggja Member is composed of alternating shales, siltstones and cherts and siliceous limestones. Rich bryozoan faunas occur in the siliceous limestones whereas mainly delicate forms, especially rhabdomesids and fenestellids are locally abundant in the shales (Nakrem 1994a). The uppermost unit, the Hovtinden Member is shale and siltstone dominated and contains few fossils. It is approximately 50 m thick in the Festningen area. The age of the Vøringen Member is late Artinskian to early Kungurian based on conodonts (Szaniawski & Malkowski 1979), non-fusulinid foraminiferans in the underlying units (Sosipatrova 1972) and bryozoans (Nakrem 1995). Correlation of the upper part of the formation is problematic, but Nakrem et al. (1992) conclude with a Kazanian age for this part (see also Fig. 2).

The Miseryfjellet Formation consists of 115 m partially silicified biosparites directly overlying Devonian, Carboniferous and lower Permian units on Bjørnøya (Fig. 2). Basal sandstones and conglomerates also

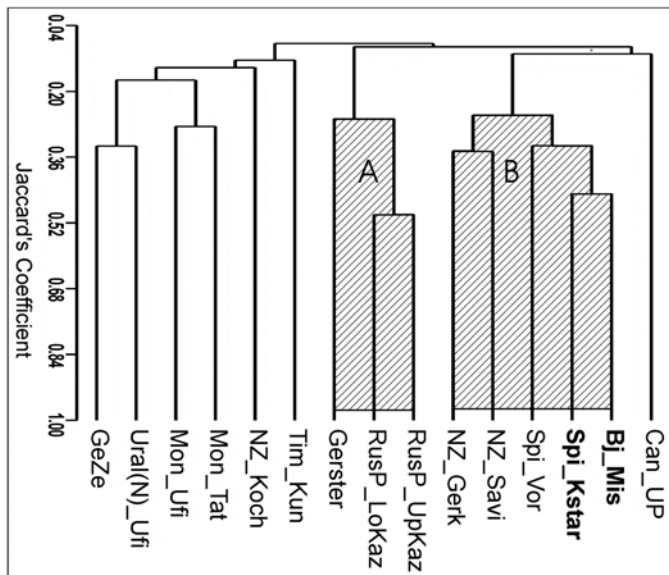


Figure 3. Cluster diagram (UPGMA, Unweighted Pair Group Method with Arithmetic Mean, MVSP, Kovach 2002) showing similarities between middle Permian bryozoan faunas in different Boreal units. A: Cluster showing great similarity between Gerster Formation and Kazanian (Russian Platform) faunas. B: Svalbard and Novaya Zemlya cluster. GeZe = German Zechstein (Morozova 1970, Ernst 2001), Ural(N)_Ufi = Northern Urals [Ufimian] (Lisitsyn & Morozova 1998), Mon_Ufi = Mongolia [Ufimian] Mon_Tat = Mongolia [Tatarian] (Goryunova & Morozova 1979, Jarinpil, 1998), Gerster = Nevada [Gerster Formation] (Gilmour & Morozova 1999), RusP_LoKaz = Russian Platform [Lower Kazanian] (Morozova 1970), RusP_UpKaz = Russian Platform [Upper Kazanian] (Morozova 1970), Tim_Kun = Timan [Kungurian] (Morozova & Kruchinina 1986), NZ_Koch = Novaya Zemlya [Kocherga Group, Lower Ufimian] (Morozova & Kruchinina 1986), NZ_Gerk = Novaya Zemlya [Gerka Group, Upper Ufimian] (Morozova & Kruchinina 1986), NZ_Savi = Novaya Zemlya [Savina Group, Kazanian] (Morozova & Kruchinina 1986), Can_UP = Canadian Arctic [Upper Permian] (Morozova & Kruchinina 1986), Spi_Vor = Spitsbergen, Svalbard [Vøringen Member, latest Artinskian-early Kungurian] (Nakrem 1995), Spi_Kstar = Spitsbergen, Svalbard [Upper Kapp Starostin Formation, Ufimian-Kazanian] this study, Bj_Mis = Bjørnøya, Svalbard [Miseryfjellet Formation, Kungurian-Kazanian], this study.

infill up to 8–10 m deep karstic features in underlying units. The basal part of the Miseryfjellet Formation is a result of the latest Early Permian transgression. These basal beds pass up into partially silicified fossiliferous sandy limestones with a rich fauna of brachiopods and bryozoans. The age of the Miseryfjellet Formation is Kungurian-Ufimian (Nakrem et al. 1992).

The name 'Starostinskaya Svita' is used in many Russian publications, for example Morozova & Kruchinina (1986), and in Ross (1995), and is equal to the Tempelfjorden Group (Dallmann 1999).

2 BRYOZOAN FAUNA

2.1 Kapp Starostin Formation, above the Vøringen Member

Spiculitic shales and cherts form the single most abundant lithofacies of the Kapp Starostin Formation at Festningen (Hellem 1981) and Akseløya (Fredriksen 1988, Henriksen 1988) where most bryozoans discussed in the present study derive from. Abundant trace fossils, such as *Zoophycos* and *Chondrites*, clearly indicate low energy, but oxygenated bottom environments well below normal wave base. Bryozoans and other fossils, especially brachiopods are occasionally present as coquina lags within this facies type, and they may represent periodic storm reworking. Sponges, usually of the genus *Haplition*, are abundant in these beds, some sponges are encrusted by trepostomid bryozoans like *Neoeridotrypella* preserved in life position, and are thus believed to be fossilized *in situ*. In some cases colonial sponges form moundlike buildups with encrusting bryozoans.

Typical bryozoans in the spiculitic shales and cherts comprise delicate colonies of *Ramipora hochstetteri* Toul, 1875; *Permoheloclema merum* Ozhgibesov, 1983; *Primorella polita* Romanchuk & Kiseleva, 1968; *Clausotrypa spinosa* Fritz, 1932; delicate fenestellids (*Rectifenestella pseudoretiformis* (Morozova, 1970); *R. compacta* Morozova, 1986; *Fabifenestella completa* Morozova, 1986; *Alternifenestella greenharboureensis* (Nikiforova, 1936); *A. spitzbergenensis* (Nikiforova, 1936); *Lyrocladia vera* Morozova, 1986); and finely branched trepostomids like *Dyscritella spinigera* (Bassler, 1929).

Laterally persistent beds of silicious limestones occur repeatedly throughout the Kapp Starostin Formation. These beds predominantly consist of interbedded packstones and shales, and their boundaries are gradual from spiculitic cherts. These limestone beds were formed on an open marine platform situated below normal wave base, as is indicated by the presence of lime mud and interbedded shales. Grain supported textures in some units may be due to reworking by currents or waves. More massive coquinas dominated by transported bryozoans and less abundant brachiopod shells are believed to have been formed as platform edge bars above normal wave base, perhaps during periods of lower sea level.

Typical bryozoans in the silicious bioclastic limestones include robust trepostomids like multilamellar *Neoeridotrypella* sp., *Anisotrypella* sp., *Tabulipora aberrans* Morozova, 1986; *Tabulipora arcticensis* Ross & Ross, 1962; *Rhombotrypella insolita* Morozova, 1986; *Rhombotrypella alfredensis* Morozova, 1986; *Stenopora timanensis* Morozova, 1970; *Dyscritella parallela* Morozova, 1970; *Dyscritella savinaensis* Morozova, 1986 and *Dyscritella arctica* Morozova,

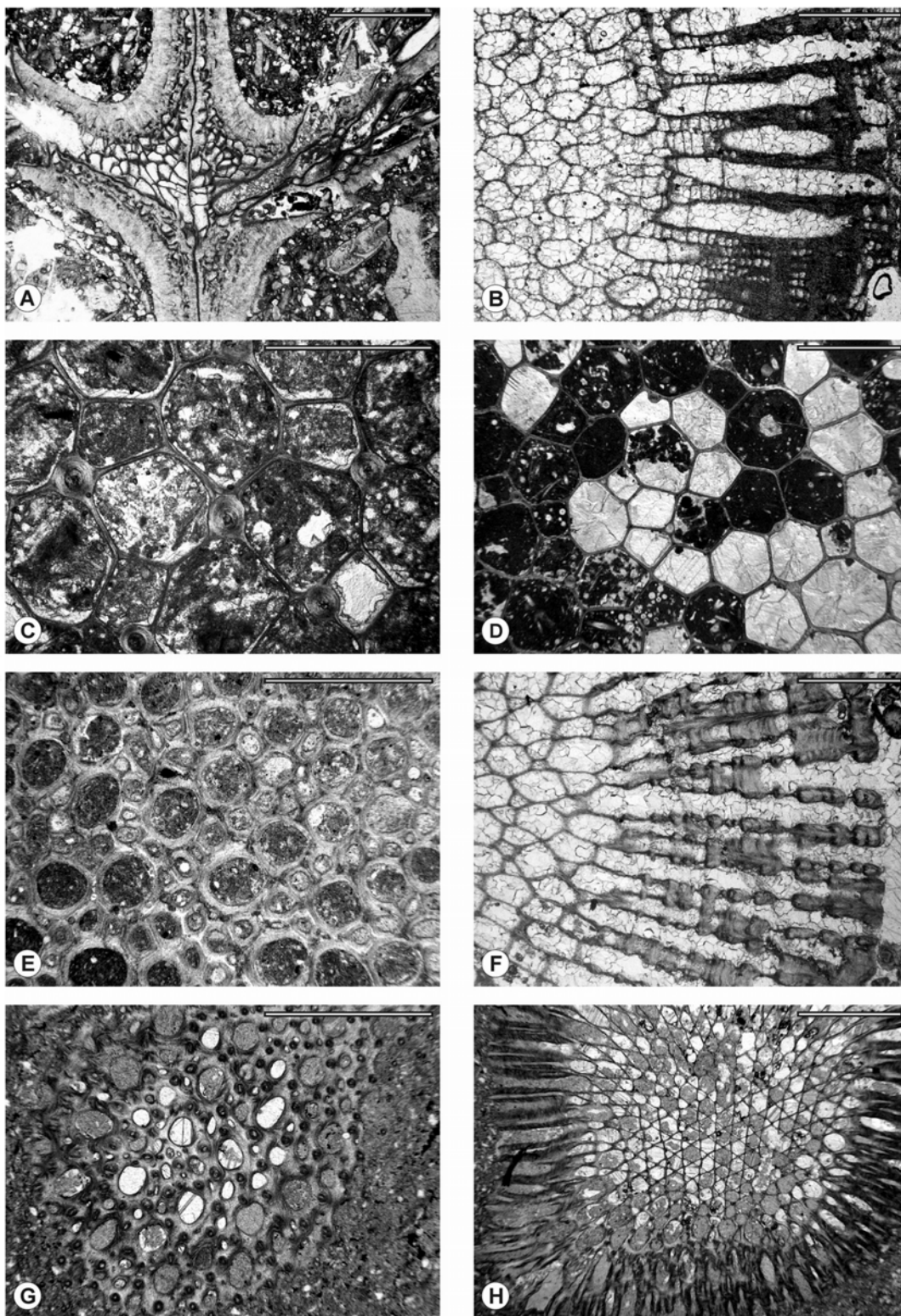


Figure 4. Scale bar = 1 mm. A – *Ramipora hochstetteri* Toulou, 1875. Longitudinal thin section, PMO A42290. Brettingsdalen, Bjørnøya, 52.0 mab MF Fm. B – *Fistulipora jakovlevi* Nikiforova, 1933. Transverse thin section, PMO A42064. Skrekkujuvet, Bjørnøya, 112.4 mab MF Fm. C, D – *Neoeridotrypella* sp. C: Shallow tangential thin section, PMO A42598. Festningen, Spitsbergen, 185.0 mab KS Fm. D: Deep tangential thin section, PMO A42596. Mariaholmen, 111.7 mab KS Fm. E – *Anisotrypella* sp. Shallow tangential thin section, PMO 132.069. Akseløya, 244.0 mab KS Fm. F – *Stenopora grandis* Morozova, 1970. Transverse thin section, PMO A42024. Skrekkujuvet, Bjørnøya, 85.0 mab MF Fm. G, H – *Stellahexaformis* sp. G: Tangential thin section, PMO 118.213, H: Transverse thin section, PMO 118.213. Mariaholmen, 172.0 mab KS Fm. mab KS Fm. = metres above base of Kapp Starostin Formation; mab MF Fm. = metres above base of Miseryfjellet Formation.

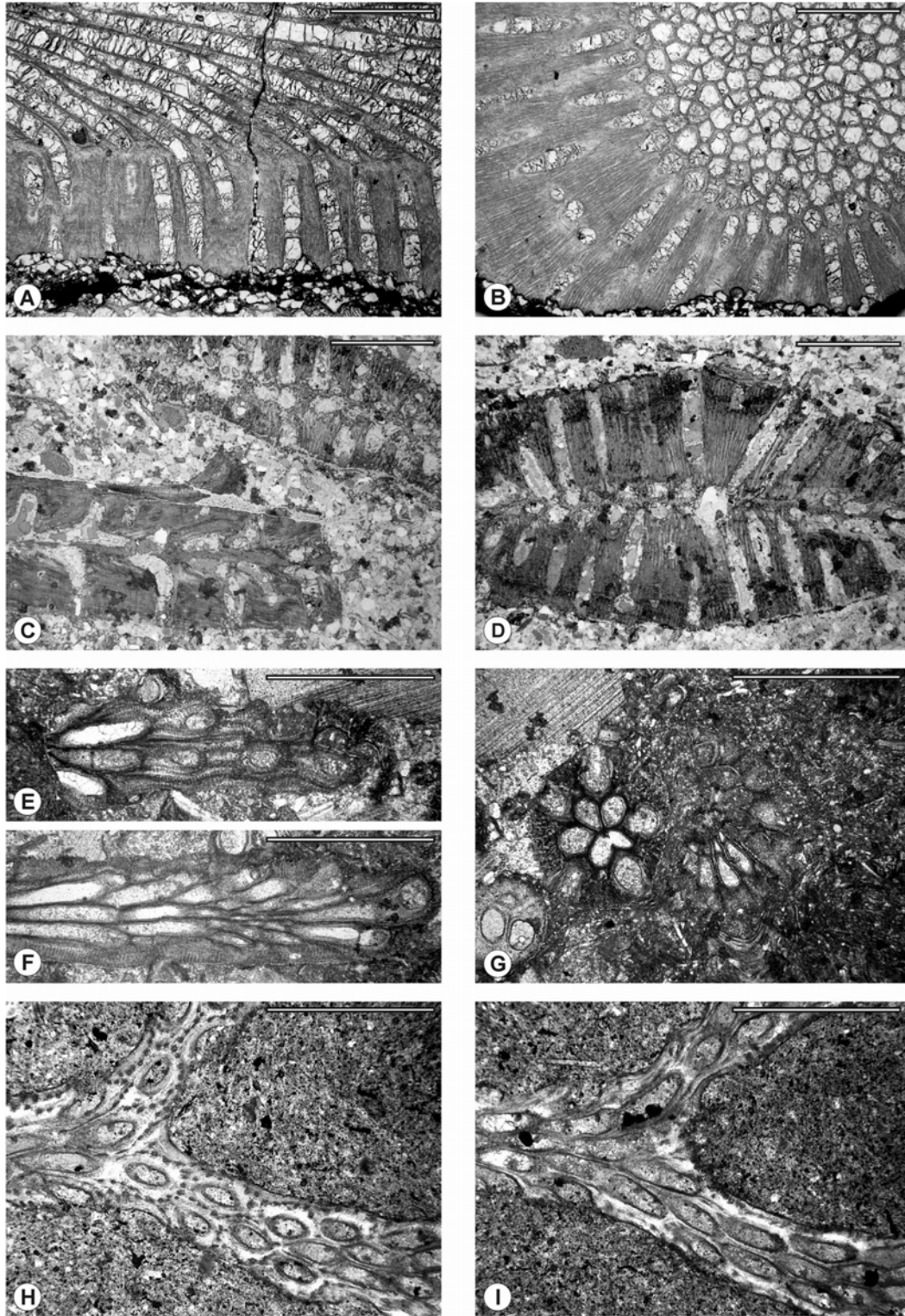


Figure 5. Scale bar = 1 mm. A, B – *Gilmoropora heintzi* (Malecki, 1977). A: Longitudinal thin section, PMO A32111/T, B: Transverse thin section, PMO A32111/V. Kapp Olsen, Bjørnøya, basal Miseryfjellet Formation. C, D – *Timanodictya niki-forovae* Morozova, 1966. C: Longitudinal thin section (lower left) and transverse thin section (upper right), PMO A41852, D: Transverse thin section, PMO A41851. Hambergfjellet, Bjørnøya, basal Miseryfjellet Formation. E, F – *Permoheloclema merum* Ozhgibesov, 1983. E: Deep (left) to shallow (right) tangential thin section, PMO A41804, F: Longitudinal thin section, PMO PMO A41804. Festningen, Spitsbergen, 180.0 mab KS Fm. G – *Clausotrypa monticola* (Eichwald, 1860) (left) and *Permoheloclema merum* Ozhgibesov, 1983 (right). Transverse thin sections, PMO A41804. Festningen, Spitsbergen, 180.0 mab KS Fm. H, I – *Primorella polita* Romantchuk & Kiseleva, 1968. H: Tangential thin section, PMO, I: Longitudinal thin section, PMO A42652. Akseløya, 76.8 mab KS Fm. mab KS Fm. = metres above base of Kapp Starostin Formation; mab MF Fm. = metres above base of Miseryfjellet Formation.

1986. Fenestellids in these lithologies are also rather robust, for example firm species of *Polypora* and *Acanthocladia* as well as *Reteporidra tuncheimensis* Morozova, 1986 and *Reteporidra grandis* Morozova, 1970. Associated taxa include *Fistulipora* sp., *Cyclotrypa* sp., *Timanodictya nikiforovae* Morozova, 1966 and *Gilmoropora heintzi* (Malecki, 1977). This division may reflect the recurrent changing depositional environments (quiet/rough waters), repeated sea level changes, or a selection through transport.

2.2 Miseryfjellet Formation

The Miseryfjellet Formation of Bjørnøya shows an atypical development of sandy limestones, silicious limestones and well-sorted sandstones. Both fauna and sedimentary structures suggest shallow, well-agitated depositional environments, probably above normal wave base.

The basal sandstones and conglomerates are usually 1 to 3 m thick, and few thick trepostomids (*Tabulipora*) have been found in this unit. Faunal elements, including bryozoans are short-distance transported as they show little wear in otherwise rough depositional conditions. Apart from a middle sandstone unit, the remaining part of the formation is dominated by sandy limestones with a prolific brachiopod and bryozoan fauna. Typical bryozoans in the sandy limestones comprise *Rhombotrypella alfredensis* Morozova, 1986; *Tabulipora greenlandensis* Ross & Ross, 1962; *Tabulipora aberrans* Morozova, 1986; *Dyscritella bogatensis* Morozova, 1970; *D. insolita* Morozova, 1986; *D. lucida* Morozova, 1986; *D. arctica* Morozova, 1986; *D. savinaensis* Morozova, 1986; *Dyscritellina fuglensis* Morozova, 1986; *Rectifenestella retiformis* (Schlotheim, 1816); *Septopora synocladiaformis* Nikiforova, 1936; *Polyporella optima* Morozova, 1986; *Kingopora micropora* (Stuckenberg, 1895); *Timanodictya nikiforovae* Morozova, 1966 and *Gilmoropora heintzi* (Malecki, 1977).

Other species are introduced in the upper part, among them *Ramipora hochstetteri* Toulou, 1875; *Stenopora grandis* Morozova, 1970; *Permoheloclema merum* Ozhigibesov, 1983; *Rectifenestella* cf. *gijigensis* (Nekhoroshev, 1959); *Lyrocladia* cf. *vera* Morozova, 1986; *Polypora kossjensis* Ravikovich, 1948; *Anisotrypella certa* Morozova, 1986; *Wjatella assueta* Morozova, 1986 and *Reteporidra tuncheimensis* Morozova, 1986.

It should be noted that *Hinganella* is so far not recorded from the middle Permian of Svalbard, because '*Hinganella heintzi*' Malecki, 1977 was reassigned to *Gilmoropora heintzi* (Malecki, 1977) in Nakrem (1988). Reference to Malecki's work (1977) is made both in Morozova & Kruchinina (1986) and in Ross (1995), but *Hinganella* still remains unknown from Svalbard.

3 BRYOZOAN BIOSTRATIGRAPHY AND PALAEOBIOGEOGRAPHY

The completion of Pangaea during the late Permian saw the formation of several sedimentary provinces and regions. The most conspicuous differences in faunal composition can be seen when comparing northern Boreal faunas with equatorial Tethys faunas. The seaway between these regions was closed off in Ufimian-Kazanian times, and endemic taxa evolved. Svalbard, together with the Canadian Arctic Islands (Sverdrup Basin), North Greenland (Wandel Sea Basin) and Novaya Zemlya (Russia) is part of the Franklinian province, and the faunas are compared with those published from the Cordilleran province (western North America), the Kazanian province (Russia), Timan-Pechora (Russia) and East-Siberian arctic provinces (Mongolia, Russia) (Morozova & Kruchinina 1986, Gilmour & Morozova 1999 and references therein).

Middle to late Permian bryozoans are reported from North Greenland, Wandel Sea Basin in several papers, for example Madsen & Håkansson (1989) and Madsen (1994). Bryozoans in the Station Nord and Ingeborg Formations are only identified to genus level, and the fauna contains *Ramipora*, *Tabulipora*, *Dyscritella*, *Fenestella*, *Penniretepora*, *Polypora*, *Ascopora* and *Clausotrypa*. These faunas, except for *Ascopora*, are very similar to those from the middle Permian of Svalbard.

Novaya Zemlya marks the continuation of the Urals, and the Permian lithologies resemble closely those found in Svalbard. The bryozoan faunas are quite similar on a generic level, but many species from Novaya Zemlya are not reported from Svalbard. The youngest Permian deposits (and faunas) of Novaya Zemlya may be younger than those found in Svalbard.

Late Palaeozoic bryozoans from the Canadian Arctic Islands – the Sverdrup Basin, are described in Morozova & Kruchinina (1986), but faunas identified in that work were taken from samples collected for other purposes, and bryozoans were not collected systematically through the units. Bryozoans are common in most of the Permian formations of the Sverdrup Basin, but these require systematic treatment and description. The collections of middle to upper Permian bryozoans published by Morozova & Kruchinina (1986) are, however, clearly similar to the middle Permian faunas from Svalbard.

Middle Permian bryozoans from the Cordilleran province of Nevada, Idaho and Washington (western North America) (Gilmour & Snyder 1986, Gilmour & Walker 1986, Gilmour & Morozova 1999 and references therein) have many taxa in common with the Kazanian province, as well as Svalbard. *Stellahexaformis* (Gilmour & Snyder, 1986) has been considered as endemic for the Cordilleran province,

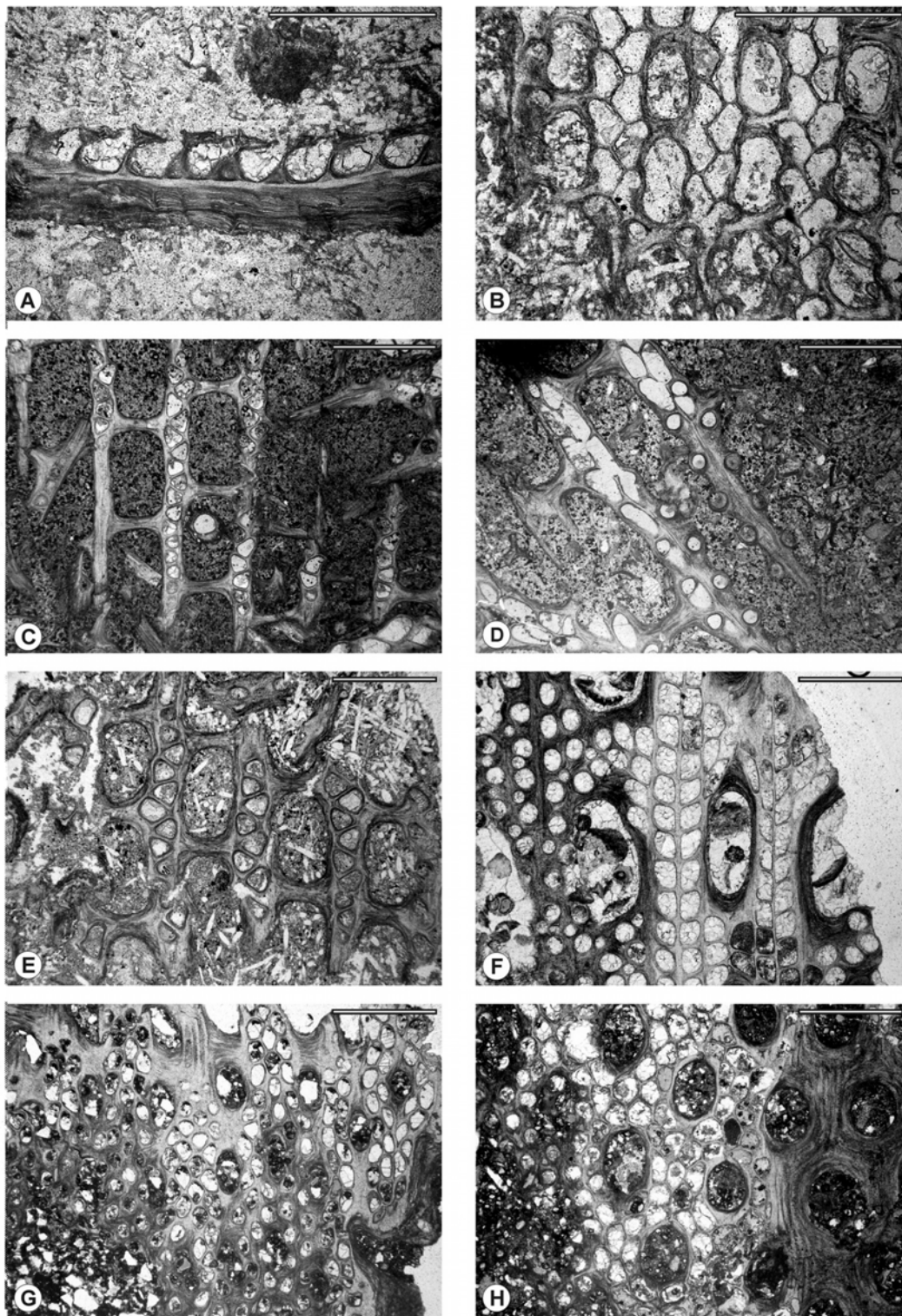


Figure 6. Scale bar = 1 mm. A, B – *Rectifenestella pseudoretiformis* (Morozova, 1970). A: Longitudinal thin section, PMO A41827, B: Tangential thin section, PMO A41826. Festningen, Spitsbergen, 280.0 mab KS Fm. C, E – *Alternifenestella greenharboureensis* (Nikiforova, 1936). Tangential thin sections. C: PMO A41947, Kapp Wijk, Spitsbergen, 72.0 mab KS Fm. E: PMO A41835, Kapp Wijk, Spitsbergen, 65.0 mab KS Fm. D – *Fabifenestella* sp. Tangential thin section, PMO A41943. Kapp Wijk, Spitsbergen, 72.0 mab KS Fm. F – *Septopora* sp. Tangential thin section, PMO A41998. Hambergfjellet, Bjørnøya, basal Miseryfjellet Formation. G – *Polyporella perfecta* Kruchinina, 1986. Tangential thin section, PMO A42299. Skrekkujuvet, Bjørnøya, 0.5 mab MF Fm. H – *Kingopora micropora* (Stuckenberg, 1895). Tangential thin section, PMO A42254. Skrekkujuvet, Bjørnøya, 2.0 mab MF Fm. mab KS Fm. = metres above base of Kapp Starostin Formation; mab MF Fm. = metres above base of Miseryfjellet Formation.

but is also found in the middle Permian of Svalbard in the current study.

The Russian Platform and northern Urals (the Kazanian province) (Morozova 1970, Lisitsyn & Morozova 1998) have many genera in common with the Boreal regions. Many taxa first believed to be endemic of this region have later proved to have a distribution through the rest of the Boreal seas and also westwards to the Cordilleran province. The Boreal sea thus was no barrier for fauna migration in middle to late Permian times.

Zechstein deposits with bryozoans are known from Great Britain, Germany and Poland (data compiled in Morozova (1970) with additions in Ernst (2001)). According to palaeogeographic reconstructions the Zechstein seaway provided a connection to the Boreal seas, but the Svalbard faunas are rather different from the more temperate Zechstein faunas.

A database containing 253 taxa, mainly species, extracted from references mentioned above has been used in a simple multivariate statistical analysis of 15 middle to upper Permian stratigraphic units of present day Northern to Arctic areas. Only 67 taxa are present in more than one unit, – this indicates the strong endemism on species level. A cluster analysis using MVSP (Kovach 2002) based on these 67 taxa reveals two distinct clusters (Fig. 3), – one consisting of middle to upper Permian units from Svalbard and Novaya Zemlya and one consisting of Cordilleran and Kazanian units. These two clusters, which also have the richest faunas, also form a cluster separating them from the other units. East Arctic units (Mongolia) with very high degree of endemism are clearly different from these, as is the Zechstein fauna and the Ufimian of Northern Urals.

4 CONCLUSIONS

The distribution of bryozoans in the middle Permian Templefjorden Group of Svalbard may be utilized as biostratigraphical and biogeographical tools. A total of 31 taxa are identified in the Kapp Starostin Formation (Spitsbergen) and 20 in the Miseryfjellet Formation (Bjørnøya). Some genera and species of *Anisotrypella*, *Neoridotrypella*, *Kingopora* and *Ramipora* have distinct stratigraphic and geographic distribution, whereas many others have a more global distribution.

Some genera common in the Lower Permian Gipsdalen Formation of Svalbard (Nakrem 1994b) are absent in the middle Permian units, among them *Ascopora* and *Rhabdomeson*. These genera are otherwise well known from middle Permian units elsewhere, especially in the Tethys realm (Ross 1978, Ross & Ross 1990, Gilmour & Morozova 1999). It may be deduced from this that the mentioned genera did not adapt to the shift towards cooler depositional

settings in the Boreal sea that Svalbard was part of during middle Permian time.

On a generic level the middle Permian bryozoan fauna of the Tethys Realm was distinctly different from the Boreal faunas, and many Tethyan genera, for example *Epiactinotrypa*, *Ruzhencevia*, *Tavayzopora*, *Dybowskiella*, *Hayasakapora*, and *Araxopora* have still not been found in the middle Permian Boreal deposits (see also Gilmour & Morozova 1999). More studies need to be done to reveal bryozoan distributions in rather large areas, for example the Canadian Arctic, where bryozoans still are only known from scattered collections.

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