

Moscovian (Carboniferous) microfossils (Bryozoa, Conodonta, and Fusulinida) from Novaya Zemlya, Arctic U.S.S.R.

HANS A. NAKREM, INGER NILSSON, and BJØRN T. SIMONSEN



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A considerable amount of geological material collected during a Norwegian expedition, led by Olaf Holtedahl, to Novaya Zemlya in 1921 has been re-examined in light of geological activities in the Barents Shelf area. Parts of the collections were described between 1924 and 1930, but the present work contains the first illustrated descriptions of Carboniferous bryozoans, conodonts and fusulinids from Novaya Zemlya. A total of 15 fusulinid taxa are identified, including the stratigraphically important species *Pseudostaffella gorskyi* (Dutkevich), *P. paracompressa* Safonova, *Neostaffella* cf. *greenlandica* (Ross and Dunbar), *N. sphaeroidea* (Ehrenberg), *Profusulinella prisca* (Deprat) and *P. priscoidea* Rauzer-Chernousova. A few conodonts were extracted and assigned to *Idiognathodus* cf. *delicatus* Gunnell, *Streptognathodus* cf. *parvus* Dunn, and *Declinognathodus* cf. *noduliferus* (Ellison and Graves). Four bryozoan taxa are described, including *Prismopora holtedahli* n.sp., a new species of the order Cystoporata. These faunas are similar to those from the latest Bashkirian and Moscovian of the Russian Platform, Svalbard, the Sverdrup Basin, and North America. The age of the investigated material is early Moscovian (Vereiskian to Kashirskian) according to the standard Russian scheme.

Hans A. Nakrem and Bjørn T. Simonsen*, Paleontological Museum, Sars gate 1, N-0562 Oslo 5, Norway; Inger Nilsson, Continental Shelf and Petroleum Technology Research Institute Ltd. (IKU), N-7034 Trondheim, Norway.

The objectives of the 1921 Norwegian Novaya Zemlya Expedition, led by Professor Olaf Holtedahl, were to explore the geology, as well as the living plant and animal life, of Novaya Zemlya. During the 10 weeks of the expedition, from June to August 1921, Holtedahl and his crew collected a wealth of information which resulted in 40 scientific reports (Holtedahl 1922, 1924, 1930; Fredericks 1927) and numerous shorter papers. Using the vessel "Blaafjeld", the expedition team sailed through the Matochkin Strait as far north as Arkhangel Bay (Fig. 1). Large and varied paleontological collections were made from the Cambrian to Cretaceous strata. The entire collection is housed in the Paleontological Museum in Oslo and has recently been catalogued (Nakrem 1989). Almost 4000 specimens are available for further investigations. Previously described material, including figured fossil types, comprises 290 specimens.

* Present address: Norsk Hydro A/S (Avd. T3-5), P.O. Box 4313, N-5013 Nygårdstangen, Norway.

Investigated material

The carboniferous succession of Novaya Zemlya comprises fossiliferous shales, marls and limestones with rich fauna dominated by brachiopods and corals. During the middle Carboniferous period, the southern seaway to the Tethys faunal province was still open, and light-coloured limestones were formed under tropical conditions (see Heafford (1988) for further palaeogeographic discussion). Three samples have been investigated: two from Cape Productus [Cape Borisoff], 7 km north of Mashigin Fiord, and one from the Eastern Krestovii Island (between Arkhangel Bay and Pankratyeff Peninsula) (see Fig. 1). It has not been possible to obtain a detailed measured section at either of these two localities, but Fig. 2 shows the lithological section at Cape Productus reconstructed after Holtedahl's publications and after discussions with Dr. V. Matweev and Dr. N. N. Sobolev, Leningrad.

All types and illustrated specimens are housed in the collection of the Paleontological Museum,

University of Oslo. Collections are numbered PMO 120.720, 120.721, 120.724, 121.506–121.510 (rock samples); 121.470–121.479 and 121.488–121.504 (thin sections); 121.480–121.487 (acetate peels) and 121.505 (conodont slide).

Conodonts

Two conodont samples were processed using standard conodont techniques: buffered acetic acid digestion and bromoform separation. One sample came from Zone 7 (Fig. 2) at Cape Productus, the other from the fusulinid-rich beds at Eastern Krestovii Island. The latter, a carbonate cemented siltstone (1.7 kilo, of which 1.0 was digested), contained no conodonts, whereas the bioclastic limestone from Zone 7 contained ten conodont elements in a 4.8 kilo sample of which 3.8 kilo was digested.

Three genera and species have been identified from well-preserved platform (Pa) elements: *Idiognathodus* cf. *delicatus* Gunnell, *Streptognathodus* cf. *parvus* Dunn and *Declinognathodus* cf. *noduliferus* (Ellison & Graves). This conodont faunule is of Vereiskian-Kashirskian (earliest Moscovian) age of the Russian scheme; comparable to the Morrowan-Atokan Series of the North American reference section.

Unpublished conodont data exists from Cape Borisoff, close to Cape Productus (N. N. Sobolev, pers. commun. 1990): *Streptognathodus gracilis* Stauffer and Plummer and *S. elongatus* Gunnell have been extracted from limestones correlative to Zone 9 (see Fig. 2); *Streptognathodus oppletus* Ellison from samples correlative to Zone 7; and *Idiognathoides* cf. *sulcata* Higgins and Bouckaert and *Idiognathodus delicatus* Gunnell from limestones correlative to the lowermost part of Zone 5.

The Cape Productus sample contained abundant fusulinids, crinoid stems and brachiopods (*Choristites mosquensis*), as well as a high proportion of indigestible light-coloured grains, probably quartzitic sand.

Fusulinids

Abundant fusulinids were investigated from the Eastern Krestovii Island sample and from the two Cape Productus samples, and fifteen taxa have been identified. A summary of the biostratigraphic implications given by the fusulinid fauna follows.

The lower sample from Cape Productus is of latest earliest Moscovian (Vereiskian) age as based on occurrences of *Pseudostaffella gorskii* Grozdilova and Lebedeva, *P. paracompressa* Safonova and *Profusulinella* cf. *staffellaformis* Kireeva. The upper sample from Cape Productus with *Pseudostaffella* cf. *antiqua* (Dutkevich), *Neostaffella* cf. *greenlandica* (Ross and Dunbar), *N. sphaeroidea* (Ehrenberg) and *Profusulinella prisca* (Deprat) is of late early Moscovian (Kashirskian) age. The fusulinid sample from Eastern Krestovii Island containing *Profusulinella prisca* Rauzer-Chernousova is of a late early Moscovian (Vereiskian-Kashirskian) age.

Similar fusulinid fauna has in part been reported from the Timan-Pechora and Moscow Basins (Rauzer-Chernousova et al. 1951; Grozdilova & Lebedeva 1960), Svalbard (Forbes 1960; Cutbill & Challinor 1965; Nilsson 1988; Simonson, unpubl. data), eastern North Greenland (Ross & Dunbar 1962), and Canada (Ross & Monger 1978).

Bryozoans

After the digestion of the conodont sample from Cape Productus, several bryozoan colonies were extracted from the remaining limestone pieces. Some bryozoans were also prepared from fusulinid samples. Four taxa, including one new species, are described below. Bryozoans are scarce in the investigated samples and are not indicative of a particular age. However, the occurrence of *Tabulipora* cf. *aliutovensis* Shul'ga-Nesterenko in the upper Cape Productus sample suggests an early Moscovian age for this sample. *Prismopora holtedahli* n.sp. co-occurs with *Tabulipora* cf. *aliutovensis* Shul'ga-Nesterenko.

Taxonomic remarks

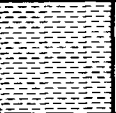


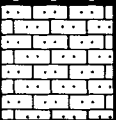



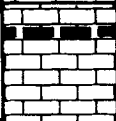
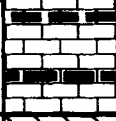


Bryozoans

Order Cystoporata

Fistulipora sp. A.

Fig. 3G–H.

Remarks. – One single zoarium of a species of *Fistulipora* was found. The zoarium is made up of an encrusting sheet with large and widely spaced zooecial apertures. Rounded and slightly oval apertures measure 0.38–0.45 mm in diameter,

Age (this work)	Age (Holtedah, 1924)	Zone (Holtedah (1924)	Lithology	Thickness (Holtedah, 1924)	Fauna (Holtedah, 1924; Sobolev and Matweew, pers. comm. 1990)
		10			
	Late Carboniferous	9		15-20 metres	Bryozoans: <i>Polypora</i> sp. Brachiopods: <i>Linoproductus cora</i> , <i>Spirifer ufensis</i> , <i>S. fritschi</i> <i>Spiriferella saranae</i> , <i>Megousia weyprechtii</i> , <i>Camerophoria sella arctica</i> Conodonts: <i>Streptognathodus gracilis</i> , <i>S. elongatus</i>
		8		?5 metres	Corals
Kashirskian		Moscovian	7		"Few metres"
Vereiskian	Moscovian	6			☆☆
				?Break	
	Late Viséan	5			Conodonts: <i>Idiognathoides</i> cf. <i>sulcata</i> <i>Idiognathodus delicatus</i> Brachiopods: <i>Striatifera striatus</i>
		4			<i>Striatifera striatus</i> <i>Chaetetes radians</i>
		3			<i>Striatifera striatus</i>
		2			?fusulinids, ?ooids
		1		"Some tens metres"	Brachiopods

with 2–4 apertures in 2 mm in all directions. Lunaria are well developed. The zoarium is interwoven with a species of *Tabulipora* (see below), and encrustation is interactive between these two forms. As only one tangential section was made, further observations were not possible. However, the few details observed indicate that this species is most similar to *F. monoseriata* Shul'ga-Nesterenko described from the Russian Platform, in strata of Steshevskian (middle Serpukhovian) age.

Genus *Prismopora* Hall, 1883

Type species *Prismopora triquetra* Hall and Simpson, 1887, from the middle Devonian of the Falls of the Ohio, Jefferson, Indiana, USA.

Generic diagnosis (abridged from Utgaard 1983). – Zoarium trifoliate, irregularly branching. Branches narrow, parallel-sided; faces concave; margins solid, non-celluliferous. Monticules lacking. Autozooezia with peristomes and lunaria; lunaria on proximal side of autozooezia in row in center of branch; rotated to progressively more lateral position in rows of autozooezia toward branch margin. Mesotheca with central layer granular, outer layers granular-prismatic. Autozooezia partially isolated at mesotheca by vesicular tissue; subcircular in cross-section in

exozone. Vesicular tissue forming small, low blisters in endozone and inner exozone; granular-prismatic; stereom in most of exozone, with acanthostyles.

Prismopora holtedahli Nakrem n. sp.

Fig. 3A–F.

Diagnosis. – Trifoliate zoarium with unusually protruding lobes; large and widely separated zooecial apertures as well as large zoarial dimensions.

Description. – Zoarium is trifoliate with lobes diverging at 145°, 130°, and 85° angles. Zoarial lobes are 1.25–1.62 mm thick. One lobe protrudes 7.75 mm from zoarial central axis, the other two lobes are fragmented and their dimensions are not measured. Zooecial apertures are arranged more or less in regular rows. Distance between apertural centers is 0.60–0.90 mm (mean 0.77; STD (Standard deviation) 0.12; CV (Coefficient of variation = STD*100/Mean) 15.18) measured along surface. Same distance measured diagonally: 0.45–0.63 mm (mean 0.52 mm; STD 0.05; CV 8.86). Zooecial apertures are slightly oval with a weakly-developed lunarium and peristome. Apertures measure commonly 0.24 mm × 0.22 mm (STD 0.02 and 0.01; CV 8.17 and 6.07 respectively). There are 2–3.5 apertures along

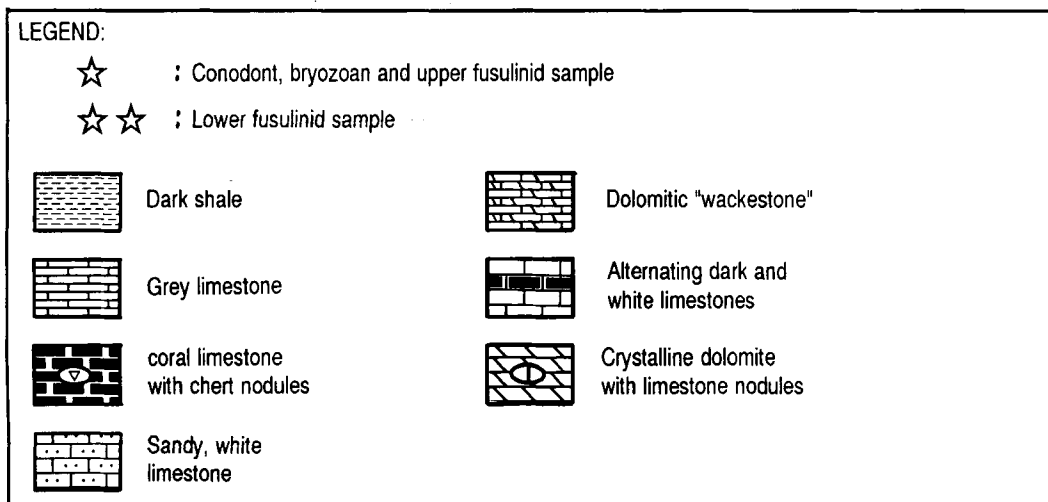
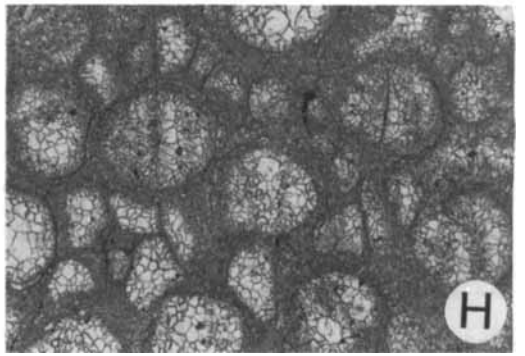
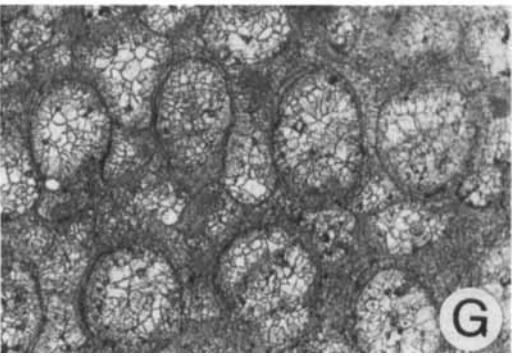
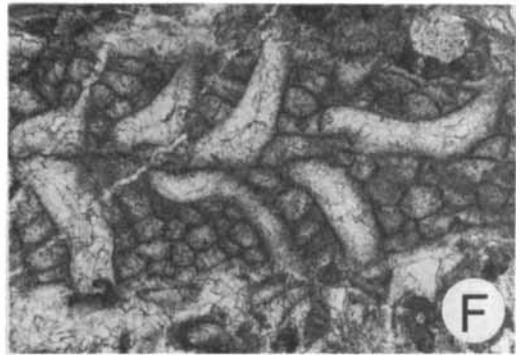
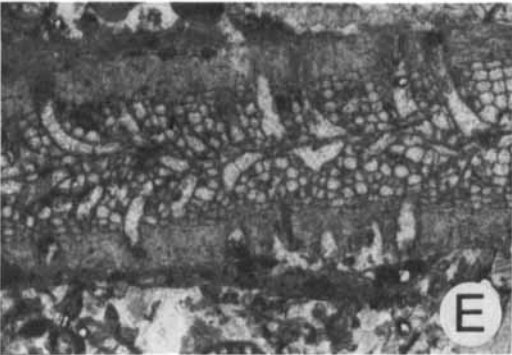
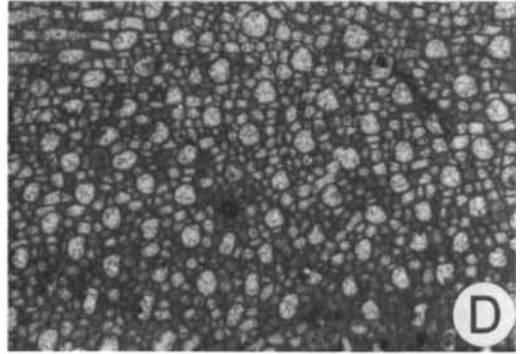
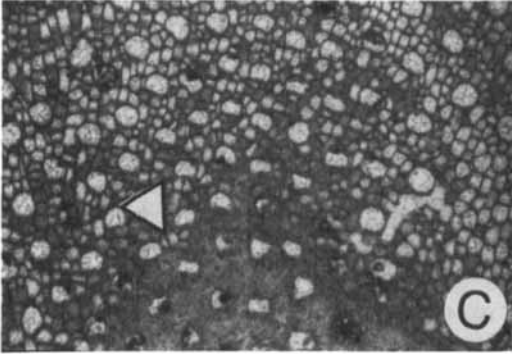
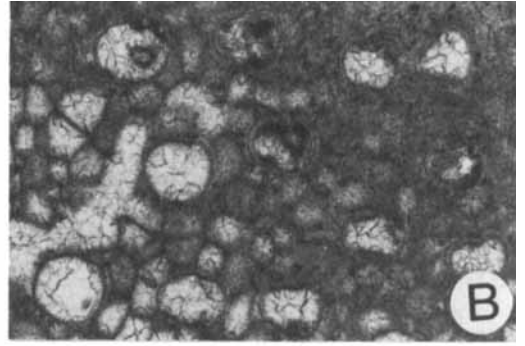


Fig. 2. Simplified lithological section at Cape Productus reconstructed according to information from Holtedahli (1924) and after discussions with Dr. V. Matweev and Dr. N. N. Sobolev (Leningrad). Fossil taxa is in accordance with modern nomenclature, in some cases different from that listed by Holtedahli.



colony per 2 mm (mean 2.5; STD 0.46; CV 18.24) and 3.5–5 diagonally (mean 4; STD 0.44; CV 10.66). Peristome width is 0.012–0.016 mm. Vesicles are developed between autozooeal tubes, and small amounts of stereom is present in exozone. Locally more massive stereom is developed in outermost exozone. Diaphragms are absent from autozooeal tubes.

Remarks. – The quantitative data obtained from the investigated material excludes this species from those previously described. The Australian species of *Prismopora* described by Crockford (1957) display closer spaced zooecial apertures, while *P. triangulata* Kiseleva is distinguished in possessing diaphragms in zooecial tubes. The species described by Hall & Simpson (1887) lack some quantitative data for comparison, but zoarial dimensions seem to be smaller than those measured from the Novaya Zemlya specimens. Species of *Prismopora* are previously only known from the Devonian and Carboniferous of North America, from Lower Permian deposits of Australia and from Upper Permian deposits of the U.S.S.R. (Maritime Territory). Thus this new species described here is the first known representative from outside the Tethys biogeographical province.

Material. – Four specimens embedded in grayish white limestone. Each quantitative character in description is measured on at least 15 points.

Types. – Holotype PMO 121.479 (thin section); paratypes PMO 121.509, 121.510 (rock specimens).

Etymology. – The species is named in honour of Professor Olaf Holtehdahl who collected the investigated material during his Novaya Zemlya expedition in 1921.

Type locality. – Cape Productus, Novaya Zemlya.

Age. – *Choristites mosquensis* brachiopod zone; *Profusulinella prisca* fusulinid zone. Moscovian (Kashirskian) age.

Order Trepostomata

Tabulipora aliutovensis Shul'ga-Nesterenko, 1955 Fig. 4D–H.

cf. 1951 *Tabulipora aliutovensis* Shul'ga-Nesterenko, pp. 88–89, pl. 8, figs. 8–9, pl. 11, fig. 4.

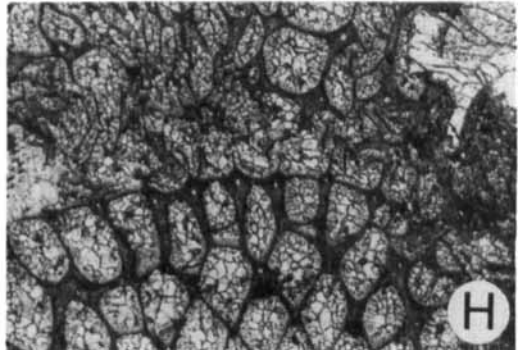
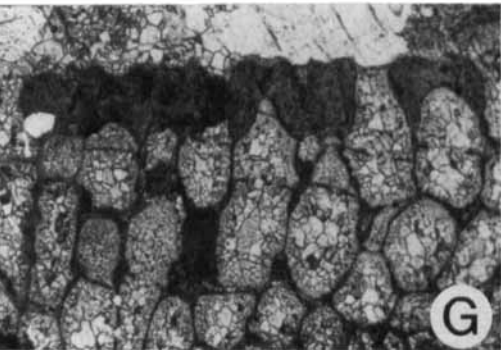
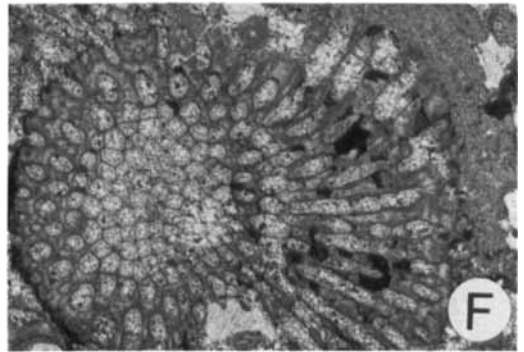
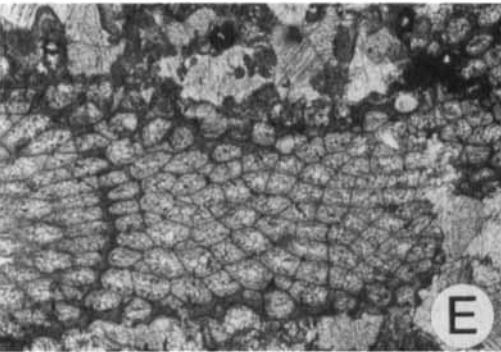
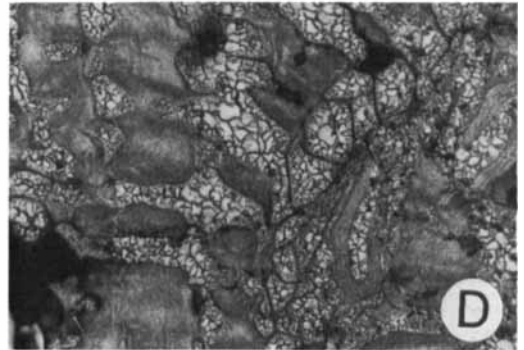
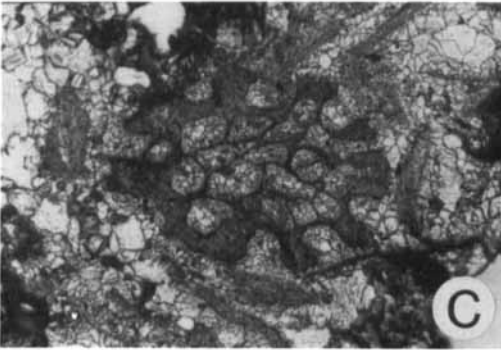
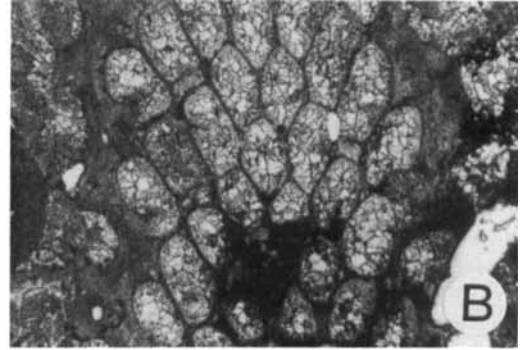
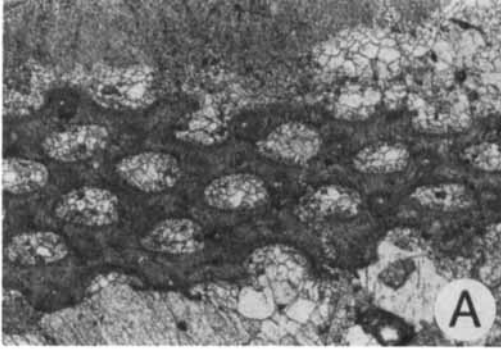
Description. – Three fragmented zoaria showing a ramose branching and encrusting growth were found. Cylindrical branches with diameter of 3.6 mm; exozone 0.32–0.36 mm; self over grown layers 0.40 mm and thicker. Zooecial apertures oval; 0.36 mm long and 0.18 mm wide; 5 apertures per 2 mm in any direction. One hook-like diaphragm present in zooecial tubes in outermost exozone. Acanthostyles developed in autozooeal corners; 0.09–0.11 mm in diameter; 3–4 per autozooeal aperture. Exozonal walls fairly thick (0.15–0.18 mm) where acanthostyles are developed; 0.05–0.07 mm between acanthostyles. Geometry of endozonal zooecial tubes was not observed due to randomly oriented sections.

Remarks. – The investigated zoaria show evidence of hostile environmental conditions or competition with several stages of self over growth, and inter-woven growth together with *Fistulipora* (see above). Brachiopod spines are trapped between stages of growth, and it is believed that this species originally encrusted brachiopod shells, probably in a high-energy environment.

Age. – *Tabulipora aliutovensis* Shul'ga-Nesterenko was originally described from the Russian Platform, from the Vereiskian Horizon (early Moscovian).

Fig. 3. Bryozoans from Cape Productus. All are photographed from petrographic thin sections, except where noted.

- A. *Prismopora holtehdahli* Nakrem n. sp., transverse section showing trifoliate zoarium, 10 ×, PMO 121.479, holotype.
- B. *Prismopora holtehdahli* Nakrem n. sp., tangential section, 10 ×, PMO 121.480.
- C. *Prismopora holtehdahli* Nakrem n. sp., oblique tangential section showing massive stereom in shallowest exozone (arrow), 10 ×, PMO 121.480.
- D. *Prismopora holtehdahli* Nakrem n. sp., deep tangential section, 10 ×, PMO 121.480.
- E. *Prismopora holtehdahli* Nakrem n. sp., transverse section of proximal lobe showing distinctive exozonal stereom, 10 ×, PMO 121.479, holotype.
- F. *Prismopora holtehdahli* Nakrem n. sp., transverse section of distal lobe, 25 ×, PMO 121.481.
- G. *Fistulipora* sp. A., deep tangential section. 25 ×, PMO 121.482, acetate peel.
- H. *Fistulipora* sp. A., shallow tangential section, 25 ×, PMO 121.482, acetate peel.



Order Cryptostomata

Ascopora sp. A.

Fig. 4A–C.

Remarks. – One single zoarium of *Ascopora* was found, and only a few measurements could be made on a shallow to deep tangential section. Diameter of cylindrical zoarium exceeds 1.80 mm; probably 2.00 mm. Oval zoecial apertures are arranged in regular rows; 5.5–6.5 diagonally and 4 along colony surface per 2 mm. Apertures measure 0.25–0.27 mm × 0.14–0.18 mm. One large acanthostyle is present between autozoecial apertures; diameter 0.10–0.11 mm. Smaller acanthostyles (paurostyles) are not observed, possibly due to inadequate preserved specimen, and/or the randomly oriented acetate peel. A single hemiseptum is developed in outer part of zoecial tubes.

Although possessing only one single hemiseptum, as based on the available measured characters, the closest described species is *A. magniseptata* Shul'ga-Nesterenko from the Gzhelian of the Russian Platform.

Conodonts

Idiognathodus cf. *delicatus* Gunnell, 1931

Fig. 5A.

cf. 1931 *Idiognathodus delicatus* Gunnell, p. 250, pl. 29, figs. 23–25.

Remarks. – Two partly broken adult specimens were found. Because the upper surfaces are abraded, diagnostic details are lacking and the species assignation is questioned. For description and synonymy, see Bender (1979).

Age. – *Idiognathodus delicatus* Gunnell has been described from several locations in North America (e.g. Gunnell 1931; Lane et al. 1971; Baese-

mann 1973; Grayson 1984) with a Morrowan-Atokan-Desmoinesian (Pennsylvanian) distribution. This species is also repeatedly reported from the U.S.S.R. with an early Moscovian (Barskov et al. 1982; Goreva 1984) to middle-late Carboniferous (Barskov 1983) range. It also occurs in the Otto Fiord and Nansen Formations (latest Carboniferous age) of the Sverdrup Basin, Arctic Canada (Bender 1979; Beauchamp et al. 1989, fig. 3).

Streptognathodus cf. *parvus* Dunn, 1966

Fig. 5C–D.

cf. 1966 *Streptognathodus parvus* Dunn, p. 1302, pl. 158, figs. 9–10.

Remarks. – Three specimens were extracted. Juvenile specimens of *Idiognathodus* are not easily differentiated from elements of *Streptognathodus*, but the material seems best assigned to *S. cf. parvus* Dunn.

Age. – *Streptognathodus parvus* Dunn was originally described from the Morrowan of Nevada and Oklahoma (Dunn 1966), and is also known from the early Moscovian (Vereiskian and Kashirskian Horizons) of the U.S.S.R. (Barskov et al. 1982; Goreva 1984). An Atokan distribution (Oklahoma) for *Idiognathodus parvus* Gunn is reported by Kent-Grubbs (1984).

Declinognathodus cf. *noduliferus* (Ellison & Graves 1941)

Fig. 5B.

cf. 1941 *Cavusgnathus nodulifera* Ellison and Graves, p. 4, pl. 3, figs. 4, 6.

Remarks. – One specimen with a broken free blade was extracted. The platform itself shows enough taxonomic detail to suggest the present

Fig. 4. Bryozoans from Cape Productus. All are photographed from acetate peels.

A. *Ascopora* sp. A., shallow tangential section, 25 ×, PMO 121.484.

B. *Ascopora* sp. A., deep, oblique tangential section, 25 ×, PMO 121.484.

C. *Ascopora* sp. A., transverse section, 25 ×, PMO 121.485.

D. *Tabulipora* cf. *aliutovensis* Shul'ga-Nesterenko, 1955, transverse exozone with regenerated and encrusting growth, 25 ×, PMO 121.486.

E. *Tabulipora* cf. *aliutovensis* Shul'ga-Nesterenko, 1955, oblique longitudinal section, 10 ×, PMO 121.483.

F. *Tabulipora* cf. *aliutovensis* Shul'ga-Nesterenko, 1955, transverse section with regenerated growth (upper right), 10 ×, PMO 121.486.

G. *Tabulipora* cf. *aliutovensis* Shul'ga-Nesterenko, 1955, longitudinal section, exozone only, 25 ×, PMO 121.487.

H. *Tabulipora* cf. *aliutovensis* Shul'ga-Nesterenko, 1955, terminated growth, 25 ×, PMO 121.483.

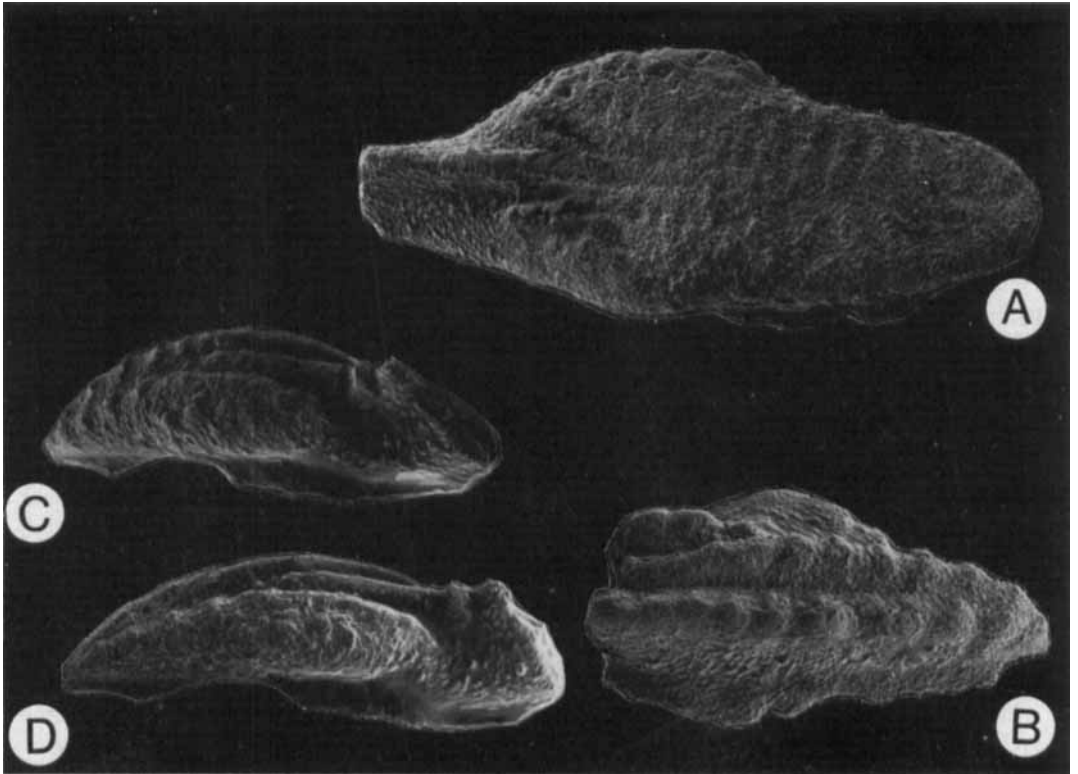


Fig. 5. Conodonts from the Cape Productus section.
 A. *Idiognathodus* cf. *delicatus* Gunnell, 1931. 90 ×. PMO 121.505/2.
 B. *Declinognathodus* cf. *noduliferus* (Ellison & Graves 1941). 60 ×. PMO 121.505/4
 C. *Streptognathodus* cf. *parvus* Dunn, 1966. 60 ×. PMO 121.505/3
 D. *Streptognathodus* cf. *parvus* Dunn, 1966. 60 ×. PMO 121.505/3

assignment. For further description and synonymy, see Grayson (1984).

Age. – *Declinognathodus noduliferus* (Ellison and Graves) has been described from North America from the lower part of the Morrowan Series (Lane 1967; Dunn 1970; Grayson 1984) as well as from Great Britain (Higgins 1985) in strata of middle Namurian age. Occurrences in the U.S.S.R. (Moscow Basin) are reported by Goreva (1984) and Barskov et al. (1982) from the Vereiskian Horizon (early Moscovian). In the Sverdrup Basin this species is index species for the *D. noduliferus* zone with occurrence in the Otto Fiord and Nansen Formations (latest Carboniferous age) (Bender 1979; Beauchamp et al. 1989, fig. 3).

Fusulinids

Note: Synonymy includes only major reassignments. Confusion exists because of deviating taxonomic usage between Soviet and western fusulinid workers.

Pseudoendothyra moelleri (Ozawa 1925)

Fig. 6I.

1925 *Staffella moelleri* Ozawa, pp. 19–20, pl. 2, fig. 9.

1951 *Parastaffella moelleri* (Ozawa); Rauzer-Chernousova in Rauzer-Chernousova et al., p. 151, pl. 12, fig. 19, 20.

1963 *Pseudoendothyra moelleri* (Ozawa); Rozovskaya, p. 30.

Material and occurrence. – One axial and three

slightly tangential sections from the Eastern Krestovii Island sample.

Measurements. – Specimens of 5 volutions reach approximately 1.0 mm in length and 1.1 mm in diameter; form ratio 0.9.

Remarks. – *P. moelleri* (Ozawa) resembles *P. pseudosphaeroidea* (Dutkevich), but the latter has a more spherical outline, specially in the inner whorls.

Age. – Bashkirian to late Moscovian (Myachkovskian) in the Timan-Pechora and Moscow Basins (Rauzer-Chernousova et al. 1951).

Pseudoendothyra timanica (Rauzer-Chernousova) 1951

Fig. 6H.

1951 *Parastaffella timanica* Rauzer-Chernousova in Rauzer-Chernousova et al., pp. 148–149, pl. 12, fig. 12, 13.

1963 *Pseudoendothyra timanica* (Rauzer-Chernousova); Rozovskaya, p. 30.

Material and occurrence. – One slightly tangential and three randomly oriented sections from the Eastern Krestovii Island sample.

Measurements. – Specimen of 4.5 volutions measures approximately 0.7 mm in length and 1.1 mm in diameter; form ratio 0.6.

Remarks. – This species resembles closely to *P. umbonata* (Rauzer-Chernousova) but is less involute than the latter.

Age. – Moscovian in the Timan-Pechora and Moscow Basins (Rauzer-Chernousova et al. 1951).

Pseudoendothyra umbonata (Rauzer-Chernousova) 1951

Fig. 6G.

1951 *Parastaffella umbonata* Rauzer-Chernousova in Rauzer-Chernousova et al., p. 147, pl. 12, fig. 7–9.

1963 *Pseudoendothyra umbonata* (Rauzer-Chernousova); Rozovskaya, p. 31.

Material and occurrence. – Four axial and some slightly tangential sections from the Eastern Krestovii Island sample.

Measurements. – Specimen of 5 volutions measures approximately 0.5 mm in length and 1.3 mm in diameter; form ratio 0.4.

Remarks. – *P. umbonata* (Rauzer-Chernousova) resembles *P. poststruvei* (Rauzer-Chernousova) in the outline of the shell, but has a smaller form ratio.

Age. – Moscovian (Vereiskian to Myachkovskian) on the Russian Platform (Rauzer-Chernousova et al. 1951).

Pseudoendothyra? cf. *mirabilis* (Rauzer-Chernousova) 1951

Fig. 6E–F.

cf. 1951 *Parastaffella?* *mirabilis* Rauzer-Chernousova in Rauzer-Chernousova et al., p. 152, pl. 12, figs. 21, 22.

Material and occurrence. – Two axial and some randomly oriented sections from the Eastern Krestovii Island sample.

Measurements. – Specimen of 4.5 volutions reaches a length of 0.6 mm and a diameter of approximately 0.6 mm; form ratio 1.0.

Remarks. – The present specimens are slightly different from *P?* *mirabilis* (Rauzer-Chernousova) in having a more spherical outline of the test. This species is tentatively assigned to the genus *Pseudoendothyra* due to lack of well-defined wall-structure (?four layers) and the thickness of the wall.

Age. – *Pseudoendothyra?* cf. *mirabilis* (Rauzer-Chernousova) is originally described from the late Moscovian (Myachkovskian) on the Russian Platform. The specimens present in the lower fusulinid sample are associated with *Profusulinella priscoidea* Rauzer-Chernousova which indicates an early Moscovian age.

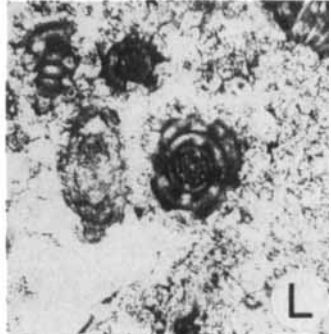
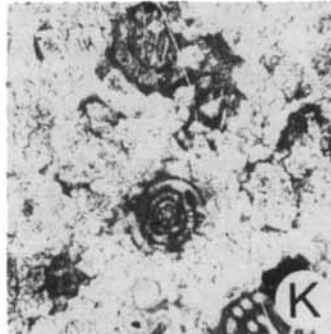
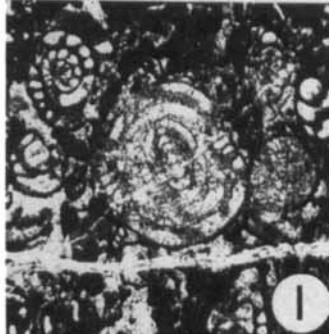
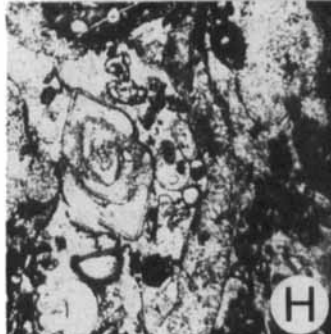
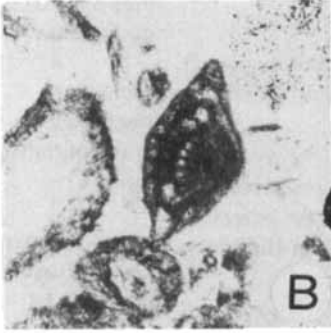
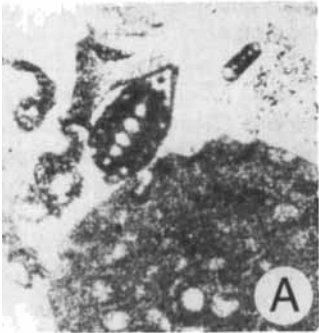
Eostaffella mixta Rauzer-Chernousova, 1951

Fig. 6C–D.

1951 *Eostaffella mixta* Rauzer-Chernousova in Rauzer-Chernousova et al., pp. 50–60, pl. 1, figs. 34, 35.

Material and occurrence. – Two axial sections from the Eastern Krestovii Island sample.

Measurements. – Specimens of 3–4.5 volutions



measure 0.25–0.30 mm in length and 0.50–0.65 mm in diameter; form ratio 0.5.

Age. – Bashkirian to early Moscovian on the Russian Platform (Rauzer-Chernousova et al. 1951.)

Ozawainella sp. A.
Fig. 6A–B.

Material and occurrence. – Randomly oriented sections from the upper fusulinid sample from Cape Productus.

Measurements. – Specimens of more than 3 volutions measure up to 0.3 mm in length and 0.60 mm in diameter; form ratio 0.5.

Age. – *Ozawainella* sp. A is associated with *N. greenlandica* (Ross and Dunbar), *N. sphaeroidea* (Ehrenberg) and *P. prisca* (Deprat) in the investigated sample, and these species indicate an early Moscovian age.

Pseudostaffella cf. *antiqua* (Dutkevich, 1934)
Fig. 6J.
cf. 1934a *Staffella antiqua* Dutkevich, p. 35, text-figs. 4–6.
cf. 1950 *Pseudostaffella antiqua* (Dutkevich); Grozdilova and Lebedeva, pp. 30–31, pl. 3, figs. 8, 9.

Material and occurrence. – One axial section and some randomly oriented sections from the upper fusulinid sample from Cape Productus.

Measurements. – Specimen of 4.5 volutions meas-

ures 0.4 mm in length and 0.5 mm in diameter; form ratio 0.8.

Remarks. – The described species closely resembles *P. antiqua* (Dutkevich), but has broader chomata and a more square outline. *P. cf. antiqua* (Dutkevich) also resembles the morphology of *P. paracompressa* (Safonova), but is slightly smaller and has more loosely coiled early whorls.

Age. – *P. antiqua* (Dutkevich) is a characteristic species in the early Bashkirian but ranges into earliest Moscovian. The associated species, *N. greenlandica* (Ross and Dunbar), *N. sphaeroidea* (Ehrenberg) and *P. prisca* (Deprat), indicate however an early Moscovian age.

Pseudostaffella paracompressa Safonova, 1951.
Figs. 6K–L and 7A.
1951 *Pseudostaffella paracompressa* Safonova in Rauzer-Chernousova et al., p. 100, pl. 5, figs. 12, 13.

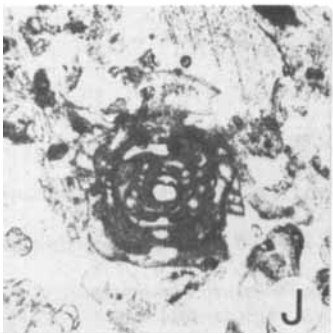
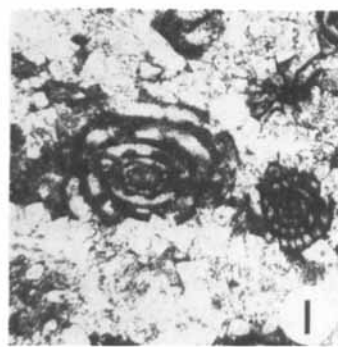
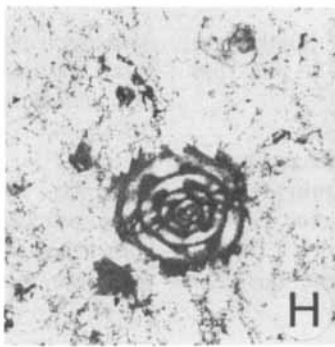
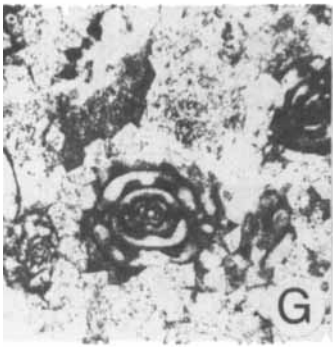
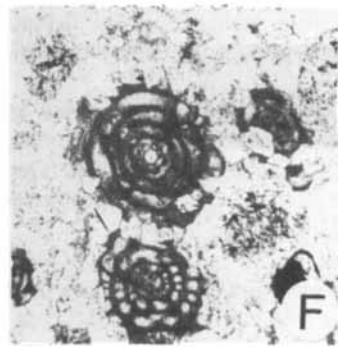
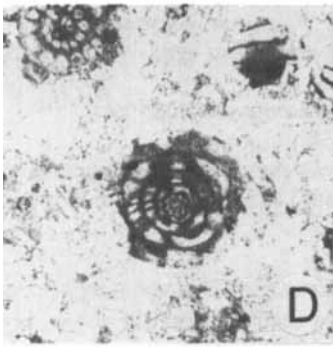
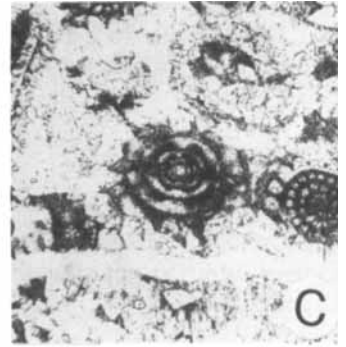
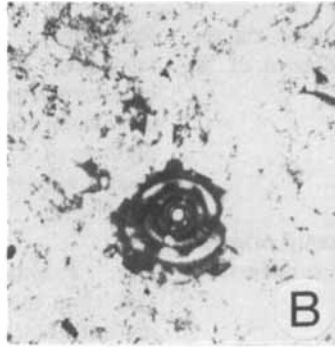
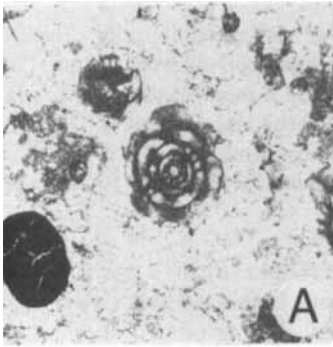
Material and occurrence. – Two axial and many randomly oriented sections from the lower fusulinid sample from Cape Productus.

Measurements. – Specimens of 4 to 5 volutions reach approximately a length of 0.5 to 0.6 mm and a diameter of 0.6 to 0.9 mm; form ratio of 0.7 to 0.8.

Remarks. – This species resembles *Pseudostaffella compressa* (Rauzer-Chernousova) and *P. praegorskyi* Rauzer-Chernousova in size and shape of shell, but the chromata are less massive. The

Fig. 6. Fusulinids.

- A, B. *Ozawainella* sp. A, A: tangential section, 40 ×, PMO 121.473; B: tangential section, 40 ×, PMO 121.472. Upper fusulinid sample from Cape Productus.
C, D. *Eostaffella mixta* Rauzer-Chernousova, 1951, C: axial section, 40 ×, PMO 121.488; D: axial section, 40 ×, PMO 121.491. From the Eastern Krestovii Island.
E, F. *Pseudostaffella?* cf. *mirabilis* (Rauzer-Chernousova), 1951, E: axial section, 20 ×, PMO 121.492; F: axial section, 20 ×, PMO 121.494. From the Eastern Krestovii Island.
G. *Pseudoendothyra umbonata* (Rauzer-Chernousova), 1951, axial section, 20 ×, PMO 121.488. From the Eastern Krestovii Island.
H. *Pseudoendothyra timanica* (Rauzer-Chernousova), 1951, axial section, 20 ×, PMO 121.493/5. From the Eastern Krestovii Island.
I. *Pseudoendothyra moelleri* (Ozawa 1925), axial section, 20 ×, PMO 121.493/4. From the Eastern Krestovii Island.
J. *Pseudostaffella* cf. *antiqua* (Dutkevich 1931), axial section, 20 ×, PMO 121.475/2. Upper fusulinid sample from Cape Productus.
K, L. *Pseudostaffella paracompressa* Safonova, 1951, K: axial section, 20 ×, PMO 121.499/1; L: axial section, 20 ×, PMO 121.502/1. Lower fusulinid sample from Cape Productus.



investigated specimens are badly preserved in outer volutions due to extensive dolomitisation.

Age. – *Pseudostaffella paracompressa* Safonova is a characteristic species in the early Moscovian (Vereiskian) on the Russian Platform (Rauzer-Chernousova et al. 1951) and Canada (Ross & Monger 1978).

Pseudostaffella gorskyi (Dutkevich 1934)

Fig. 7B–F.

1934b *Staffella sphaeroidea* var. *gorskyi* Dutkevich, pp. 119–122, pl. 2, figs. 16, 17.

1950 *Pseudostaffella gorskyi* (Dutkevich) Grozdilova and Lebedeva, pp. 37–38, pl. 4, figs. 5–7.

Material and occurrence. – Two axial and some randomly sections prepared from the lower fusulinid sample from Cape Productus. The specimens are badly preserved in outer volutions due to extensive dolomitisation.

Measurements. – Specimens of 5 whorls measure approximately 0.8 mm to 1.0 mm in length and 0.8 mm to 1.0 mm; form ratio 0.8 to 1.0.

Remarks. – *Pseudostaffella gorskyi* (Dutkevich) is different from *P. praegorskyi* Rauzer-Chernousova and *P. paracompressa* Safonova in having low chomata extending to the lateral shoulders. *P. compressa* Rauzer-Chernousova is similar in shape of shell and chomata, but is smaller. *N. sphaeroidea* (Ehrenberg) and *N. subquadrata* (Grozdilova and Lebedeva) are larger, commonly having much larger proloculus and chomata that extends to the poles. The latter also has a more square outline.

Age. – *Pseudostaffella gorskyi* (Dutkevich) ranges from late Bashkirian to early late Moscovian in the European part of U.S.S.R. (Rauzer-Chernousova et al. 1951; Grozdilova & Lebedeva

1960; Semichatova et al. 1979). On Spitsbergen this species is associated with faunas of late Moscovian age (Nilsson 1988). On Bjørnøya *P. gorskyi* (Dutkevich) is associated with *Profusulinella* and *Pseudostaffella* of ?Bashkirian–early Moscovian age (Simonsen, unpubl. data). In Canada (British Columbia) this species is assigned to a possible Kashkirian age on the basis of size and extent of the chomata (Ross & Monger 1978). The specimens investigated in our work occur together with *P. paracompressa* Safonova which indicates a Vereiskian age.

Neostaffella cf. *greenlandica* (Ross & Dunbar 1962)

Figs. 7J–L.

cf. 1962 *Pseudostaffella greenlandica* Ross & Dunbar, pp. 11–13, pl. 1, figs. 9, 10.

Material and occurrence. – Seven axial and several randomly oriented sections from the upper fusulinid sample from Cape Productus.

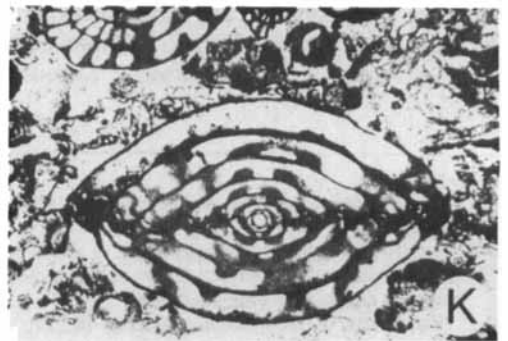
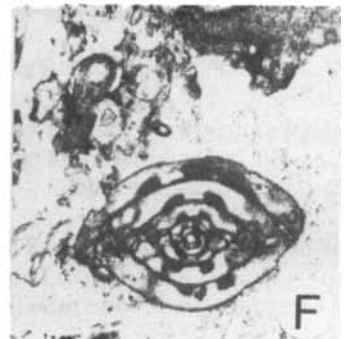
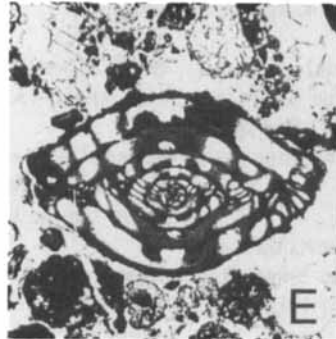
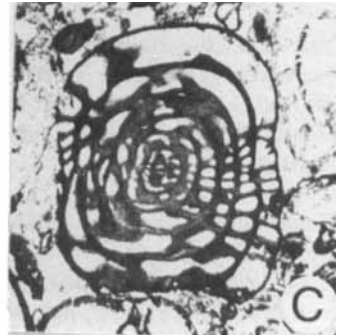
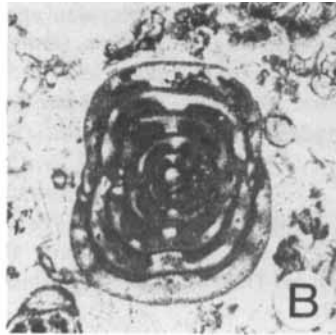
Measurements. – Specimens of 4 to 6 volutions measure 0.9 to 1.3 mm in length and 1.0 to 1.6 mm in diameter; form ratio 0.8 to 1.0.

Remarks. – The investigated specimens agree generally to the type specimens of eastern North Greenland, but have two whorls less. *Neostaffella sphaeroidea cuboides* (Rauzer-Chernousova) is similar in size and number of volutions but has a more rounded outline and more massive chomata extending to the poles. *Neostaffella subquadrata* Grozdilova and Lebedeva is similar in shape of shell and number of whorls but it is different in having less-developed chomata not extending to the poles.

Age. – *Neostaffella greenlandica* (Ross & Dunbar) occurs in late early to early late Moscovian (Kashirskian and Podolskian) on Northeast

Fig. 7. Fusulinids.

- A. *Pseudostaffella paracompressa* Safonova, 1951, axial section, 20 ×, PMO 121.498/1. Lower fusulinid sample from Cape Productus.
 B–F. *Pseudostaffella gorskyi* (Dutkevich 1934), B: axial section, 20 ×, PMO 121.504; C: axial section, 20 ×, PMO 121.499/3; D: axial section, 20 ×, PMO 121.477; E: axial section, 20 ×, PMO 121.470; F: axial section, 20 ×, PMO 121.476. Lower fusulinid sample from Cape Productus.
 G–I. *Profusulinella* cf. *staffellaeformis* Kireeva, 1951, G: axial section, 20 ×, PMO 121.502/2; H: axial section, 20 ×, PMO 121.503; I: axial section, 20 ×, PMO 121.499/2. Lower fusulinid sample from Cape Productus.
 J–L. *Neostaffella greenlandica* (Ross & Dunbar 1962), J: axial section, 20 ×, PMO 121.479/2; K: oblique axial section, 20 ×, PMO 121.477/2; L: axial section, 20 ×, PMO 121.470. Upper fusulinid sample from Cape Productus.



Greenland (Ross & Dunbar 1962), and in the late early Moscovian (Kashirskian) on Spitsbergen (Nilsson 1988). *Neostaffella* sp. A. Fig. 8C.

Neostaffella sphaeroidea (Ehrenberg 1842, sensu Möller 1878)

Fig. 8B.

1842 *Melonia (Borelis) sphaeroidea* Ehrenberg, p. 274.

1878 *Fusulinella sphaeroidea* (Ehrenberg); Möller, pp. 107–111, pl. 5, fig. 4a–e, pl. 15, fig. 1a, b.

1930 *Pseudostaffella sphaeroidea* (Ehrenberg); Lee et al., pp. 114–115, pl. 6, fig. 26.

1959 *Neostaffella sphaeroidea* Ehrenberg; Miklucho-Maklai, pp. 628–630.

Material and occurrence. – One axial and two randomly sections from the upper fusulinid sample from Cape Productus, and one randomly section from the Eastern Krestovii Island sample.

Measurements. – Specimens of 5 to 6 volutions measure approximately 1.2 mm to 1.5 mm in length and 1.6 mm to 1.9 mm in diameter; form ratio 0.8.

Remarks. – The investigated specimens of *Neostaffella sphaeroidea* (Ehrenberg) resembles also *N. umbilicata* (Putrja and Leontovitch), but the latter has smaller test and chomata that thins more rapidly towards the poles.

Age. – *N. sphaeroidea* (Ehrenberg) is common in the late early Moscovian (Kashirskian) to late Moscovian (Podolskian and Myachkovskian) in the U.S.S.R. (e.g. Rauzer-Chernousova et al. 1951; Lebedeva 1966). This species also occurs in strata of late Moscovian age both on Spitsbergen (Nilsson 1988) and on Bjørnøya (Simonsen, unpublished data).

Material and occurrence. – One slightly oblique and tangential section from the Eastern Krestovii Island sample.

Measurements. – The specimen reach a length of approximately 1.4 mm and a diameter of 1.9 mm; form ratio of 0.7.

Remarks. – This species is different from *N. sphaeroidea* (Ehrenberg) in having less lateral developed chomata.

Profusulinella cf. *staffellaeformis* Kireeva, 1951 Fig. 7G–I.

cf. 1951 *Profusulinella staffellaeformis*, Kireeva in Rauzer-Chernousova et al., p. 159, pl. 13, figs. 8, 9.

Material and occurrence. – Two axial and some randomly-oriented sections from the lower fusulinid sample from Cape Productus.

Measurements. – Specimens of 4 to 5 volutions measure 0.9 to 1.3 mm in length and 0.7 to 0.9 mm in diameter; form ratio 1.3 to 1.4.

Remarks. – The investigated specimens of *P.* cf. *staffellaeformis* Kireeva have some morphological similarities to both *P. parva* Lee et al. and *P. bona* Grozdilova and Lebedeva.

Age. – *Profusulinella staffellaeformis* Kireeva ranges from Bashkirian to early Moscovian (Ver-eiskian) in the Urals and the Timan-Pechora Basin (Rauzer-Chernousova et al. 1951).

Fig. 8. Fusulinids.

- A. *Neostaffella greenlandica* (Ross & Dunbar 1962), axial section, 20 ×, PMO 121.479/1. Upper fusulinid sample from Cape Productus.
 B. *Neostaffella sphaeroidea* (Ehrenberg 1842), axial section, 20 ×, PMO 121.471. Upper fusulinid sample from Cape Productus.
 C. *Neostaffella* sp. A., oblique section, 20 ×, PMO 121.478. Upper fusulinid sample from Cape Productus.
 D–J. *Profusulinella prisca* (Deprat 1912), D: axial section, 20 ×, PMO 121.489; E: axial section, 20 ×, PMO 121.491; H: oblique tangential section, 20 ×, PMO 121.494; I: oblique tangential section, 20 ×, PMO 121.492; J: axial section, 20 ×, PMO 121.496. From the Eastern Krestovii Island. F: axial section, 20 ×, PMO 121.472; G: axial section, 20 ×, PMO 121.476. Upper fusulinid sample from Cape Productus.
 K. *Profusulinella priscoidea* Rauzer-Chernousova, 1938, axial section, 20 ×, PMO 121.493/1. From the Eastern Krestovii Island.

Profusulinella prisca (Deprat 1912)

Fig. 8D–J.

1912 *Schwagerina prisca* Deprat, pp. 41–42, pl. 4, figs. 10–14.

1936 *Profusulinella prisca* (Deprat); Rauzer-Chernousova et al., pp. 176–177, pl. 1, fig. 1.

Material and occurrence. – Investigated specimens include three axial sections from the Eastern Krestovii Island sample and three axial sections from the upper fusulinid sample from Cape Productus.

Measurements. – Specimens of 4 to 7 volutions measure 1.2 to 2.0 mm in length and 0.9 to 1.2 mm in diameter; form ratio 1.3 to 1.6.

Remarks. – This species is distinguished from *Profusulinella ovata* Rauzer-Chernousova and *P. priscoidea* Rauzer-Chernousova in being more globose. The latter species also has more massive chomata.

Age. – *Profusulinella prisca* (Deprat) is widely distributed in strata of early Moscovian age in southeastern Asia and eastern Europe (Rauzer-Chernousova et al. 1951; Grozdilova & Lebedeva 1960), Spitsbergen (Nilsson 1988), Bjørnøya (Simonsen, unpubl. data) and western Canada (Ross & Bamber 1978).

Profusulinella priscoidea Rauzer-Chernousova, 1938

Fig. 8K.

1938 *Profusulinella priscoidea* Rauzer-Chernousova, pp. 102–103, pl. 154, figs. 1–3.

Material and occurrence. – One axial section from the Eastern Krestovii Island sample.

Measurements. – Specimen of 6.5 whorls reach 2.5 mm in length and 1.5 mm in diameter; form ratio 1.7.

Age. – *Profusulinella priscoidea* Rauzer-Chernousova ranges through the Lower Moscovian of the U.S.S.R.

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Rossing, IKU, prepared fusulinid and bryozoan thin sections. The Norwegian Research Council for Science and Humanities (NAVF) financed a visit to Leningrad (I. Nilsson and H. A. Nakrem).

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