A Late Devonian (Frasnian) Microbiota from the Farewell-Lyman Hills Area, West-Central Alaska

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By BERNARD L. MAMET *and* GEORGE PLAFKER

CONTRIBUTIONS TO PALEONTOLOGY

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Microbiota from a limestone sequence near Farewell. Emendation of description of Frondilina *and description of a new species,* Multiseptida farewelli *Mamet*

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A LATE DEVONIAN (FRASNIAN) MICROBIOTA FROM THE FAREWELL-LYMAN HILLS AREA, WEST-CENTRAL ALASKA

By BERNARD L. MAMET[1] and GEORGE PLAFKER

ABSTRACT

A limestone sequence near Farewell in the Alaska Range foothills of west-central Alaska contains a microbiota that includes a large diverse assemblage of foraminifers of Frasnian (early Late Devonian) age not previously reported from Alaska. The fossil assemblages and lithology suggest that the limestone sequence was deposited on a very shallow open marine bank containing patch reefs of corals, stromatoporoids, and algae. The Frasnian limestone appears to overlie pillow basalt and is probably unconformably overlain by Permian limestone and clastic rocks.

The only comparable microfauna reported from the North American Cordillera is from the Southesk Formation in Jasper National Park, Alberta, Canada, which represents a somewhat more restricted facies than the coeval Alaskan carbonates. Frasnian rocks containing complex and diversified microfaunas have been widely reported in the U.S.S.R., but little information is available on their microfacies. The excellent preservation of foraminifers in the Alaskan rocks permits emendation of descriptions originally made by Russian paleontologists for the genera *Frondilina* Bykova 1952 and *Multiseptida* Bykova 1952 and description of a new species of *Multiseptida, M. farewelli* Mamet.

INTRODUCTION

During the course of field investigations of the Farewell segment of the Denali fault system in 1976, George Plafker and Travis Hudson collected a number of limestone samples from north of the fault near Farewell and south of the fault in the Cheeneetnuk River drainage of the Lyman Hills (fig. 1). Petrographic study of these samples by Mamet has revealed a large and diagnostic marine microfauna that includes a diverse assemblage of foraminifers not previously reported in Alaska.

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In this paper, we describe the microbiota in samples collected and discuss some of the biostratigraphic, paleoecologic, and paleogeologic implications of its occurrence.

Discovery of well-preserved foraminifers in the Devonian limestone permits an emendation of descriptions of the genera *Frondilina* 1952 and *Multiseptida* Bykova and description of a new species, *Multiseptida farewelli* Mamet. Plafker is largely responsible for descriptions of the geologic setting and lithologic units; Mamet identified and described the microfossils. J. T. Dutro, Jr., identified the megafossils, and A. K. Armstrong kindly made a preliminary evaluation of the microfossils.

LOCATION OF SAMPLES AND GEOLOGIC SETTING

Samples discussed in this paper were collected along the north flank of the rugged Alaska Range, bordered on the north by the upper Kuskokwim Lowland, less than 500 m above sea level, and hills that rise between 300 and 600 m above the lowland (fig. 1; Fernald, 1960). The area lies within the southeastern part of the McGrath quadrangle. In this area, the rocks crop out only in the hills and mountains because the lowlands are underlain by Quaternary unconsolidated deposits.

Geologic information on the Paleozoic bedrock in the upper Kuskokwim area is sparse, consisting largely of reconnaissance studies by Spurr (1900), Brooks (1911), Cady, Wallace, Hoare, and Webber (1955), and Fernald (1960). Churkin, Reed, Carter, and Winkler (1977) carried out a stratigraphic study of lower Paleozoic rocks in the Alaska Range approximately 35 km southeast of Farewell, and Sainsbury (1965) made

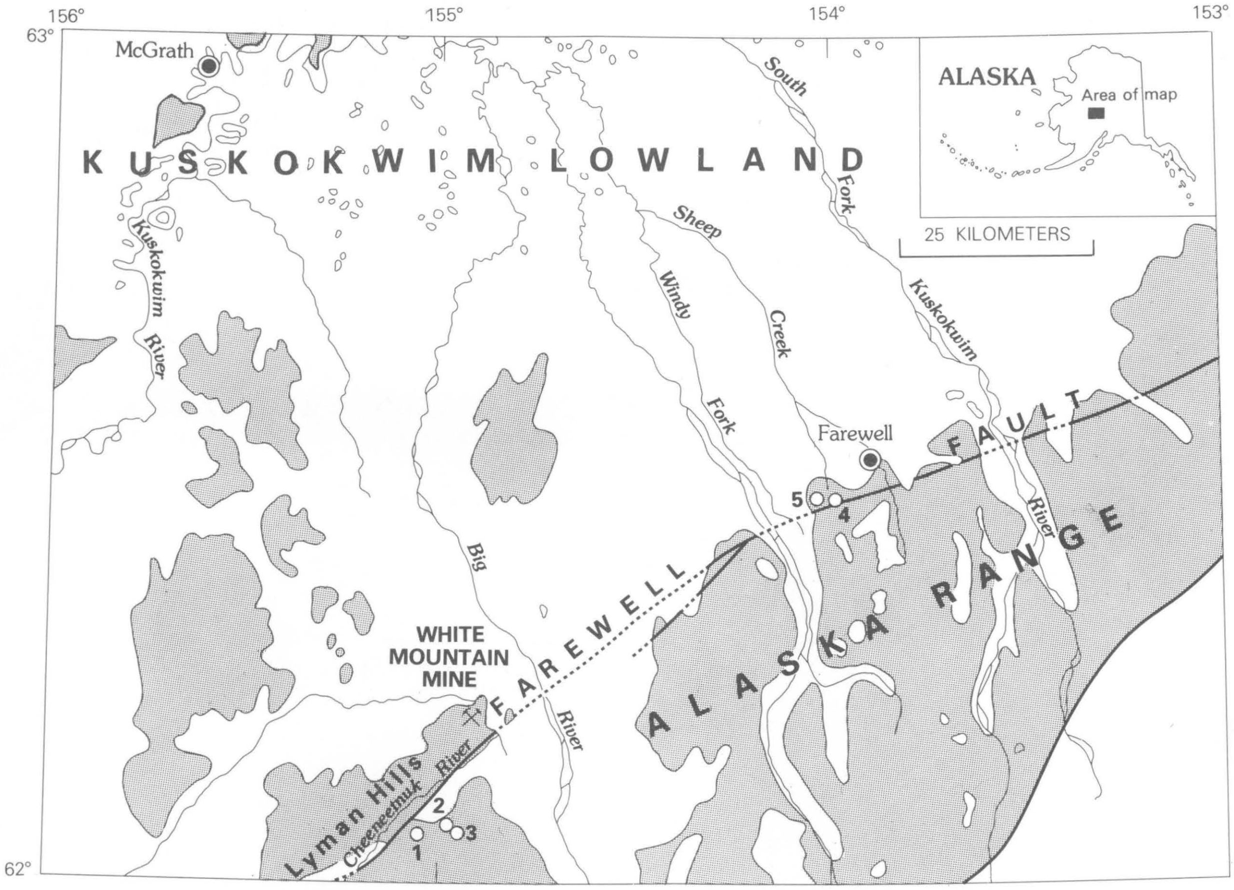

FIGURE 1.—McGrath quadrangle (1:250,000 scale) showing general distribution of bedrock outcrops in the upper Kuskokwim region (stippled) and location of Frasnian limestone samples (numbers). Sample numbers correspond to those in table 1.

a detailed study of the geology in the vicinity of the White Mountain quicksilver mine. Reed and Nelson (1977) completed a 1:250,000-scale geologic mapping project in the Alaska Range (Talkeetna quadrangle), immediately adjacent to the area on the east, that included reconnaissance mapping and sampling in the vicinity of Farewell. Churkin (1973) recently summarized the stratigraphy of the Paleozoic rocks of Alaska and their role in its structural evolution, but that publication includes minimal information on the Farewell-White Mountain area.

The rocks of the area are mostly sedimentary and are assigned to the Holitna (Ordovican?, Silurian, and Devonian), Gemuk (Carboniferous to Cretaceous), and Kuskokwim (Cretaceous) Groups (Cady and others, 1955).

Paleozoic rocks in nearby parts of the Alaska Range form a predominantly clastic sequence about 1,000 m thick of Early Ordovician through Late Silurian age (Churkin and others, 1977). In general, the Paleozoic rocks in the Alaska Range have been highly folded, cut by numerous faults, intruded by dikes and granitic plutons, and locally metamorphosed. In the Lyman Hills area (north of the Farewell fault and west of Big River), the Paleozoic rocks are largely calcareous; on the basis of their megafaunas, they include strata of Middle(?) Ordovician and Devonian(?) age in the vicinity of the White Mountain mine (Sainsbury, 1965). Permian clastic rocks and carbonates occur in the Lyman Hills area in fault contact with, or unconformably overlying, the older Paleozoic units. The Paleozoic rocks in the foothills commonly are moderately to strongly folded and faulted but are much less altered and metamorphosed than coeval rocks of the Alaska Range.

The major fault in the region is the Farewell fault (fig. 1), generally considered to be part of the Denali system that extends in a broad arc for 1,600 km across Alaska from the Canadian border on the east to Bristol Bay on the west. Although displacement on the Denali system east of the Farewell fault has been mainly strike-slip during the Quaternary, Holocene movement on the Farewell segment has been predominantly dip-slip with the south side relatively upthrown (Plafker

TABLE 1.—*Localities, microfacies, and megafauna of microfossil samples of Frasnian age in the Farewell-Lyman Hills area*

[U.S.G.S. quadrangle map scale 1:63,360]

Sample localities (fig. 1)	Field Nos.	U.S.G.S. quadrangle	Township, range, section	Microfacies	Megafauna
			Lyman Hills area		
1	76APr239	McGrath A-5	T. 23 N., R. 32 W., sec. 34	Fossiliferous packstone.	Bivalves, corals, algae.
2	76APr235	do	T. 23 N., R. 31 W., sec. 30	Algal-coral boundstones and packstones. Algal-stromatoporoid boundstones and grainstones. Pelletoidal grainstones. Extensive recrystalliztion.	Algal-corals, bivalves, stromatoporoids.
3	76APr260	do	do	Recrystallized algal wackestones. Recrystallized fossiliferous packstones to wackestones.	*Indospirifer*? sp., *Gypidula* sp., *Thamnopora*, algae.
			Farewell area		
4	76APr243	McGrath B-4	T. 27 N., R. 25 W., sec. 8	Algal wackestones. Some *Issinella* bafflestones. Algal boundstones.	Bivalves, corals, algae.
5	76AH156	McGrath B-2	do	Algal fossil wackestones and packstones.	Algae, few corals and stromatoporoids.

and others, 1977). Dextral separation may have occurred during the earlier history of the fault, although published estimates suggest that the offset is less than 100 km (Churkin and others, 1977; Grantz, 1966) and new unpublished data (George Plafker and Travis Hudson, 1976) indicate that it could be as little as 10 km.

Five sample localities, shown on figure 1 and table 1, yield diagnostic Devonian microfaunas. Localities 1-3 are from a thick moderately folded sequence of carbonates that is in contact toward the southeast with interbedded fine-grained clastic rocks and carbonates that include beds of probable Permian age. The limestone is thin to thick bedded, gray-weathering, black, and locally fetid. It contains megafossils in varying abundance; these include bivalves, corals, and algae. One thin sandy bed within the limestone contained an abundant fauna of brachiopods in growth position. Immediately southwest of sample locality 1 along the Cheeneetnuk River, dark-colored altered and sheared pillow basalt crops out over a small area. Although the contact between the limestone and basalt is not exposed, it appears that the basalt lies structurally below the limestone.

Sample localities 4 and 5 are immediately north of the Farewell fault approximately 6.4 km south-southwest of Farewell. Locality 4 is an isolated ridge, several meters high and a few tens of meters long, of slabby to massive-bedded, gray-weathering black calcite-veined limestone containing a moderately abundant and well-preserved fauna. It is separated by a small valley in the headwaters of Sheep Creek from locality 5, an elongate ridge 200 m high along the north side of the Farewell fault. The north end of this ridge is underlain by tightly folded fossiliferous limestone of the kind at locality 4. A covered interval separates the limestone from a greenish-black pillow basalt that underlies part of the ridge to the southwest.

MICROFACIES. MICROBIOTA, AND AGE

Of the five samples that contained diagnostic fossils, three (samples 76APr235, 76APr239, 76APr260) are from the Lyman Hills area and two (samples 76APr243 and 76AH156) from near Farewell (table 1). The distribution of foraminifers in the samples is given in table 2 and the microfacies, microbiota, and age of these samples are summarized below.

Sample: 76AH156

Algal fossil wackestones and packstones. Few corals and stromatoporoids.

Auroria sp.
Bisphaera sp.
Calcisphaera sp.
Earlandia sp.
Eonodosaria sp.
Evlania sp.
cf. *Eogeinitzina* sp.
Girvanella sp.
Frondilina sororis Bykova
Issinella sp. (extremely abundant; many intertwined with *Kamaena*

Kamaena sp.
Multiseptida corallina Bykova
M. farewelli n. sp.
Paratikhinella sp.
Tikhinella sp.
"*Uslonia*" sp.
Age: Frasnian.

Sample: 76APr235
Algal-coral boundstone and packstone. Algal-stromatoporoid boundstones and grainstones. Pelletoidal grainstone. Recrystallized algal wackestones. Extensive recrystallization.
Bisphaera sp.
Calcisphaera sp.
Eogeinitzina sp.
Eonodosaria sp.
Frondilina sororis Bykova
Girvanella sp.
"*Irregularina*" sp.
Issinella sp. (extremely abundant; forms boundstone and bafflestone patches)
Kamaena sp.
Multiseptida sp.
Multiseptida corallina Bykova
Multiseptida farewelli n. sp.
Parathurammina sp.
Pseudoglomospira sp.
Semitextularia sp.
Tikhinella sp.
Uslonia sp.
Age: Frasnian.

Sample: 76APr239
Fossiliferous packstones.
Eonodosaria sp.
Frondilina sororis Bykova
Paratikhinella sp.
Tikhinella sp.
Age: Frasnian.

Sample: 76APr243
Algal wackestones. Some *Issinella* bafflestones. Algal boundstones.
Bisphaera sp.
Eonodosaria evlanensis (Lipina).
Eogeinitzina sp.
Evlania sp.
Frondilina sororis Bykova
Girvanella sp.
Issinella sp.
Kamaena sp.
Multiseptida corallina Bykova
M. farewelli n. sp.

TABLE 2.—*Distribution of microfossils in the Farewell-Lyman Hills area*

Species	Farewell area		Lyman Hills area		
	McGrath B-2	McGrath B-4	McGrath A-5		
	76AH156	76APr243	76APr239	76APr235	76APr260
Auroria sp	×				
Bisphaera sp	×	×		×	
Calcisphaera sp	×			×	
Earlandia sp	×				
Earlandia? sp				×	×
Eogeinitzina sp		×		×	
cf. *Eogeinitzina* sp	×				
Eonodosaria evlanensis		×			
Eonodosaria sp	×		×	×	×
Evlania sp	×	×			
Frondilina sororis	×	×	×	×	
Girvanella staminea					×
Girvanella sp	×	×		×	
"*Irregularina*" sp			×		
Issinella sp	×	×		×	
Kamaena sp	×	×		×	×
Multiseptida corallina	×	×		×	
Multiseptida farewelli	×	×		×	×
Multiseptida sp				×	
Nanicella sp					×
Palaeoberesellea e					×
Parathurammina sp				×	
Paratikhinella sp	×	×	×		×
Pseudoglomospira sp		×		×	
Pseudosolenopora sp		×			
Semitextularia sp				×	
Tikhinella sp	×	×	×	×	×
Umbellina sp		×			
Uslonia sp				×	
"*Uslonia*" sp	×				

Paratikhinella sp.
Pseudoglomospira sp.
Pseudosolenopora sp.
Tikhinella sp.
Umbellina sp.
Age: Frasnian.

Sample: 76APr260
Recrystallized fossiliferous packstones to wackestones.
Earlandia? sp.
Girvanella staminea Garwood
Eonodosaria sp.
Kamaena sp.
Multiseptida farewelli n. sp.
Nanicella sp.
Palaeoberesellea e
Paratikhinella sp.
Tikhinella sp.
Age: Frasnian.

The carbonate microfacies suggests a very shallow open-marine bank with abundant corals, stromatoporoids, and algae. Algal microflora is mostly represented by abundant tubular *Issinella* and a few *Kamaena*, many of the two genera intertwined to form bafflestones. Red algae (*Pseudosolenopora*) are scarce. *Girvanella* and Calcisphaeridae are present but uncommon. Usually this kind of assemblage contains *Sphaerocodium*, but none was found here.

This environment, within the photic zone, is favorable to the foraminifers, which are abundant but undiversified; *Multiseptida*, *Frondilina*, and *Eogeinitzina* are the most widespread genera.

Umbellinids, of probable charophyte affinities, are represented only by occasional floated, mud-filled specimens of *Umbellina*.

MEGAFAUNA

Fossil bivalves, corals, and algae were observed in the limestone at localities 76APr235, 239, 243, and 260, but preservation is rarely good enough for identifications to be made at the species level. Brachiopods from locality 76APr260 include large *Indospirifer*? sp., large *Gypidula* sp., and poorly preserved tabulate corals (*Thamnopora*) that range in age from early Middle Devonian to early Late Devonian (J. T. Dutro, Jr., written commun., 1978). A diverse assemblage of Middle(?) Devonian corals was collected earlier from the Lyman Hills area immediately north of the Cheeneetnuk River. According to Oliver, Merriam, and Churkin (1975, table 14), the corals identified include *Alveolites* sp., *Cladopora* sp., *Favosites* sp., *Heliolites* sp., *Pachyfavosites* sp., *Syringopora* sp., *Thamnopora* sp., *Grypophyllum* sp., cf. *Neostringophyllum* sp., cf. *Siphonophrenitis* sp., and *Sociophyllum* sp., cf. *S. glomerulatum* (Crickmay). The megafossils suggest deposition on a shallow open marine bank with patch reefs.

Environmental interpretations and ages based on megafossils are consistent with the conclusions arrived at in this paper from microscopic studies of limestone samples from these same localities.

CORRELATIONS, FRASNIAN MICROBIOTA

NORTH AMERICA

The only closely comparable Frasnian microbiota reported from the American Cordillera is that of the Southesk Formation, Ancient Wall carbonate complex, Jasper National Park, Alberta (Toomey and others, 1970), Canada. In this carbonate complex, which represents a restricted and lagoonal environment, calcispheres and parathuramminids dominate; tikhinellids and multiseptidids are scarcer than in the Farewell-Lyman Hills area. Dasycladacean algae, like *Vermiporella*, are associated with blue-green "chain algae" such as *Sphaerocodium*.

In our samples, parathuramminids and calcisphaerids are scarce, birdseyes are not observed, and plurilocular foraminifers are dominant. Of the microflora, the only abundant specimens are *Issinella*. These differences with the Southesk Formation indicate more open marine conditions and greater water agitation for the Alaskan localities. Although there are differences in relative abundances between the Canadian and Alaskan material, the elements of the foraminiferal assemblage is similar, as both include *Eogeinitzina*, *Eonodosaria*, *Multiseptida*, *Nanicella*, *Paratikhinella*, and *Tikhinella*.

Other described North American microbiotas show less similarity to the Alaskan microbiota, even though they have some fossil elements in common. Examples are biotas from: (1) the Leduc Formation of central Alberta (Toomey, 1965), where abundant parathuramminids are mixed with tikhinellids, paratikhinellids, and nanicellids; (2) the Lime Creek Shale (Upper Devonian) of Iowa, which contains an *Eonodosaria/Evlania* assemblage (Toomey, 1972) including some *Semitextularia* (Miller and Carmer, 1933); (3) the Mount Hawk Limestone of British Columbia, which displays a *Girvanella/Eonodosaria/Nanicella* assemblage (Toomey, 1972); and (4) the Cedar Valley Limestone (Middle Devonian) of Iowa, which contains mostly *Bisphaera/Semitextularia*/Parathuramminidae, mixed with *Girvanella*, *Sphaeroporella*, ?*Vermiporella*, kamaeniids, and red algae (Kettenbrink and Toomey, 1975). All these microbiota characteristically have very low diversity at both the generic and specific levels.

EURASIA

Frasnian foraminiferal assemblages in the U.S.S.R. are reported on and described in Lipina (1950), Bykova (1952), Reitlinger (1954), Bykova *in* Bykova and Polenova (1955), Chuvashov (1963, 1965), and Manukalova-Grebeniuk (1974). Although little analysis of the faunal and floral distributions in relation to the carbonate microfacies has been made by Russian paleontologists, the Russian microbiotas are clearly more diversified than their American counterparts.

Toomey (1972, p. 628) coined the term *Tikhinella/Eonodosaria/Multiseptida* microfauna and described it as "the most complex assemblage in terms of biotic abundance." This description is certainly valid in the American Cordillera but not in Eurasia, where far more complex and diversified faunal assemblages have been described from the Russian Platform and from the Urals (see Toomey and Mamet, 1979).

SYSTEMATIC PALEONTOLOGY

Phylum PROTOZOA

Order FORAMINIFERIDA Eichwald, 1830

Family undetermined

Genus FRONDILINA Bykova, 1952, emend. herein

1952. *Frondilina* Bykova, VINIGRI Trudy 60, Mikrofauna SSSR, Sbornik 5, p. 24-27.
1954. *Frondilina* Reitlinger. VNIGRI, Paleont. Sbornik, no. 1, p. 75.
1955. *Frondilina* Bykova. Bykova and Polenova, VNIGRI Trudy 87, Mikrofauna SSSR, Sbornik 6, p. 10.
1964. *Frondilina* Loeblich and Tappan. Protista, pt. C, *in* Moore, R. C., ed., Treatise Invert. Paleontology, p. C324.
1959. *Frondilina* Bykova, Dain, and Fursenko. Rauzer-Chernoussova and Fursenko, Protozoa, pt. 1, *in* Orlov, Yu., ed., Principles of Paleontology, Akad. Nauk SSSR, p. 251.
1965. *Frondilina* Chuvashov. Akad. Nauk SSSR Ural. Fil., Inst. Geol. Trudy 74, p. 67-68.

Discussion.—In the original diagnosis of *Frondilina*, Bykova (1952, p. 24) states that the foraminifers consist of a series of uniserial overlapping chambers. The type of the genus, *Frondilina devexis*, was drawn (Bykova, 1952, pl. 5, fig. 4b) flattened and laterally compressed with a rectilinear pseudobiserial arrangement. The other representative of the genus, *Frondilina sororis* (Bykova, 1952, pl. 5, fig. 5b) also was reported to be uniserial with bilateral symmetry. This diagnosis was accepted by Bykova, Dain, and Fursenko (in Rauzer-Chernoussova and Fursenko, 1959) and by Loeblich and Tappan (1964). However, Loeblich and Tappan (1964) stated that the chamber arrangement is similar to that of *Lunucammina*, a uniserial nodosinellid with a longitudinal depression giving a pseudobiserial appearance.

The uniserial character described in Bykova's original diagnosis, however, does not fit the rest of the description. Bykova noted that "the chambers are not always located on one plane. Part of them are sometimes deflected around the longitudinal axis on the body" (translated). For example, her drawing of the holotype (Bykova, 1952, pl. 5, fig. 4a) shows that the third and the fourth chambers are not in the same plane as the first and second chambers. A thin section of the paratype (pl. 6, fig. 7) shows an "erratic" deviation of the chambers. Bykova (1952) described this deviation "towards the end quite often a deflection of the chambers around the longitudinal axis is noted and the plane of the chambers becomes almost perpendicular to the planes of the others. The result of this is sections in which part of the chambers are in transverse and part in a longitudinal direction" (translated). If this description is correct, a simple uniserial bilateral disposition of the chambers is unlikely.

The second special feature attributed to the genus as represented by *Frondilina sororis* is equally puzzling. In the diagnosis uniserially arranged chambers are "sometimes deflected to one side or another along the longitudinal axis" (translated). For the type (Bykova, 1952, pl. 5, figs. 5b and 5c), a simple straight-forward uniserial arrangement is drawn. But in one of the paratypes (pl. 6, fig. 9), the highly irregular disposition is described as "sections in which six chambers are cut laterally and two longitudinally, due to the deflection of the chambers along the longitudinal axis" (translated).

Many longitudinal, axial, and oblique sections of *Frondilina* from Alaska allow a somewhat different reconstruction (fig. 2). In axial section, the chambers do not have bilateral symmetry as reported by Bykova (1952, see her idealized drawings pl. 5, figs. 4b and

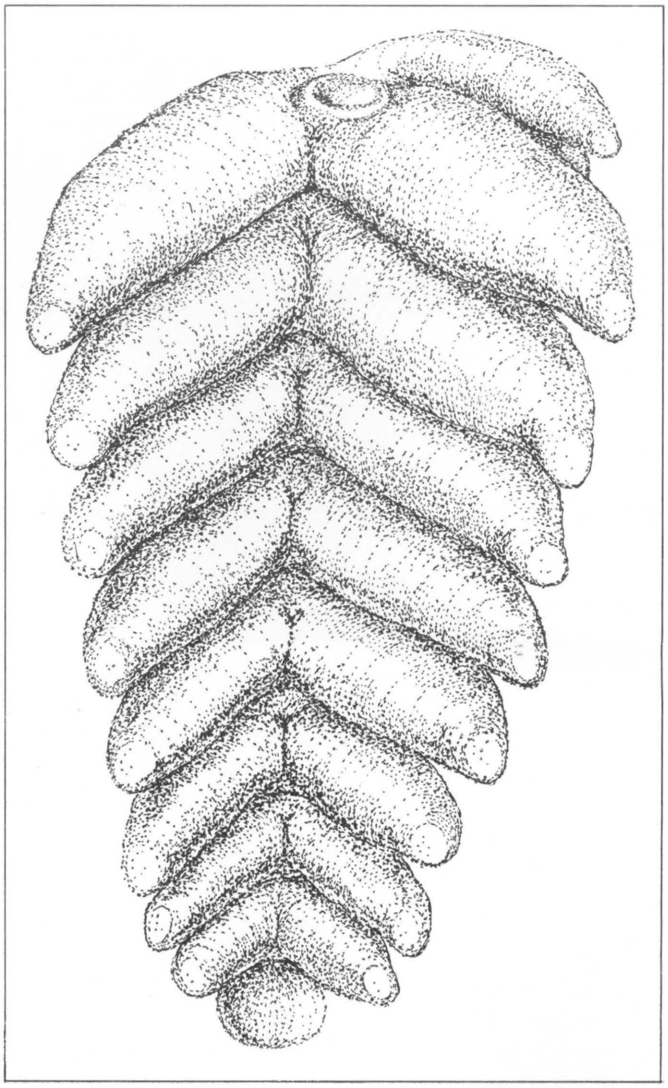

FIGURE 2.—Reconstruction of *Frondilina*. The elongate test consists of uniserial series of triradiate chambers with deep sutures. The chambers are curved, roundly tapered toward the end, and overlap one another.

5b) but are triradiate with deep sutures. In addition, the chambers are strongly arcuate and overlap each other. An axial cut, therefore, shows the three round tips of the overlying chamber (see pl. 2, figs. 12-17).

A deceptive illusion that the chambers are situated in the same plane is produced by a longitudinal section along the sutures (see, for instance, pl. 1, fig. 4); but the 120° symmetry of the triradiate chambers is demonstrated in plate 1, figures 11-14.

With respect to the nature of the wall structure, Bykova (1952) mentioned an outer micritic layer and an inner radial layer, the sutures being "three-layered." "Three layered" sutures are well displayed in our material, as exemplified along the septa of the specimen figured in plate 1, figure 9. This structure, however, is produced by penecontemporaneous cementation and is not an original microstructure. Most of our material shows partial dissolution of the wall and development of early cement. We suggest that the same process diagenetically altered Bykova's material.

We therefore propose the following emendation of *Frondilina.*

Emended diagnosis.—Test elongate, free, tapering, consisting of a uniserial series of triradiate chambers. In axial section, chambers have a ternary symmetry. Chambers are curved, roundly tapered toward the end, and overlap one another. In thin section, this arrangement gives the illusion of uniserial-biserial and triserial series, depending on the orientation of the cut. Sutures deep. Aperture is a round opening in the depressed apertural face. Wall double-layered, consisting of a dark micritic layer and a thin, commonly dissolved, yellowish pseudofibrous layer.

Type of genus.—1952. *Frondilina devexis* Bykova. VNIGRI Trudy 60, Mikrofauna SSSR, Sbornik 5, p. 25, pl. 5, Figs. 4a, b, c, pl. 6, Figs. 4-7.

Taxa included in the genus *Frondilina*:

1952 *devexis* Bykova
1952 *sororis* Bykova

Remarks.—Figure 4b of the type is idealized and contradicts figures 4a and 4c, which are more nearly correct.

Though originally assigned to the Lagenidae by Bykova (1952), transferred to the Nodosinellidae/Nodosinellinae by Loeblich and Tappan (1964), and considered a Lagenidae/Lageninae by Chuvashov (1965), the genus does not belong to either family. The same holds true for the Frasnian *Eogeinitzina*, *Eonodosaria*, which belong to an as yet undescribed family.

Frondilina sororis Bykova, 1952, emend. herein

Plate 1, figures 1-18; plate 2, figures 1-21

1952. *Frondilina sororis* Bykova, VNIGRI Trudy 60, Mikrofauna SSSR, Sbornik 5, p. 26-27, pl. 5, fig. 5, pl. 6, figs. 8-10.

1954. *Frondilina sororis* Reitlinger. VNIGRI, Paleont. Sbornik, no. 1, p. 7, pl. 22, fig. 8.

1965. *Frondilina sorosis* [*sic*] Chuvashov. Akad. Nauk SSSR, Ural. Fil., Inst. Geol. Trudy 74, p. 67-68, pl. 15, figs. 10-11.

Diagnosis.—Test elongate, tapering, consisting of 9 to 11, exceptionally 12, uniserial triradiate chambers. Chambers have a ternary symmetry in axial section. Sutures deep. In longitudinal section, chambers are arcuate, and overlap one another. Chambers increase uniformly in width; their height increases less sharply.

Total length for 6 chambers (range): 480-610 μ
7 chambers (range): 500-640 μ
8 chambers (range): 660-800 μ
9 chambers (range): 750-930 μ
10 chambers (range): 810-970 μ
11 chambers (range): 850-980 μ
12 chambers (range): 850-1,040 μ
Diameter of the sixth chamber (range): 210-340 μ
seventh chamber (range): 240-360 μ
eighth chamber (range): 260-370 μ

Chambers taper toward the peripheral end, where they become rounded. Peripheral border of the test roundly lobate. Wall double-layered, thin, about 10-15 μ. Thickness difficult to estimate owing to extensive diagenetic alteration and subsequent early cementation. Proloculum, oval to round, extremely variable, commonly crushed or deformed, varying from 70-160 μ in diameter.

Remarks.—By its general morphology, our material is very similar to that of the original description of Bykova (1952). Bykova's types and paratypes, however, are immature forms. She drew tests consisting of four to seven chambers, but in her description, cites "nine or more chambers." Our material shows that the adults have indeed 9 to 11 chambers, 12 being exceptional. The only noticeable difference between the American and Russian material is the shape and size of the proloculum. Bykova reports an oval form, whereas our material shows all types of deformation owing to the large size of the first chamber. This characteristic should not be used as a valid argument for the erection of a new taxon.

Stratigraphic range and distribution.—Frasnian. Eurasia and Alaska.

Figured specimens.—USNM 305135, USNM 305173.

Genus MULTISEPTIDA Bykova, 1952

1952. *Multiseptida* Bykova, VNIGRI Trudy 60, Mikrofauna SSSR, Sbornik 5, p. 27.

1954. *Multiseptida* Reitlinger. VNIGRI, Paleont. Sbornik, no. 1, p. 73-74.

1955. *Multiseptida* Bykova. Bykova and Polenova. VNIGRI Trudy 87, Microfauna SSSR, Sbornik 6, p. 10.

1959. *Multiseptida* Bykova, Dain, and Fursenko, Rauzer-Chernoussova and Fursenko, Protozoa, pt. 1, *in* Orlov, Yu., ed., Principles of Paleontology, Akad. Nauk SSSR, p. 251, figs. 394-395.
1962. [Not] *Multiseptida* Bogush and Yuferev. Akad. Nauk SSSR Sibirsk Otdeleniye, Inst. Geologii Geofiziki Trudy, p. 200.
1963. *Multiseptida* Pokorny. Principles of Zoological Micropalaeontology, v. 1, p. 299, fig. 260.
1964. *Multiseptida* Loeblich and Tappan. Protista, pt. C, *in* Moore, R. C., ed., Treatise Invert. Paleontology, p. C328.
1965. *Multiseptida* Chuvashov. Akad. Nauk SSSR, Ural. Filial, Inst. Geol. Trudy 74, p. 68.
1970. *Multiseptida* Toomey, Mountjoy, and MacKenzie. Canadian Jour. Earth Sciences, v. 7, no. 3, p. 978.
1972. *Multiseptida* Toomey. International Geol. Congress, 24th, sec. 7, Paleontology, p. 626.
1975. *Multiseptida* Neumann, Pozaryska and Vachard. Revue Micropaléontologie, v. 18, no. 1, p. 50.

Diagnosis.—Test free, elongate, cylindrical, slowly tapering, rectilinear, uniserial. Proloculum spherical to oval followed by low discoidal overlapping chambers. Chambers subcylindrical. Septa have secondary thickenings at the tip. Secondary partitions, more or less complete, are perpendicular to the primary septa near the aperture, then slanted, oblique toward the periphery. Wall secreted, calcareous, two-layered. Inside wall micritic, dark, with a thin outer yellowish pseudofibrous layer.

Type of genus.—*Multiseptida corallina* Bykova, 1952. VNIGRI Trudy 60, Mikrofauna SSSR, Sbornik 5, p. 27, pl. 7, figs. 1-4, pl. 8, figs. 1-5.

Taxa included in the genus *Multiseptida*:

1952 *corallina* Bykova
1982 *farewelli* new species

Multiseptida akkusica Bogush and Yuferev 1962, which is not a foraminifer, should be transferred to the botanical realm. It is probably related to the Palaeoberesselleae.

Remarks.—Diagrammatic reconstructions of the genus by Bykova (1952), later reproduced by Bykova and others (1959), Pokorny (1963), and Loeblich and Tappan (1964) are correct. *Multiseptida* was originally assigned to the Lagenidae by Bykova (1952), considered as a Nodosariidae by Pokorny (1963), transferred to the Collaniellidae by Loeblich and Tappan (1964) and to the Lagenidae/Collaniellinae by Chuvashov (1965) and by Toomey, Mountjoy, and MacKenzie (1970).

Colaniella is exclusively Upper Permian, and *Multiseptida*, Upper Devonian. Because there is no link between the two genera, they should not be included in the same family.

The occurrence of secondary partitions is of little value for the erection of a new family or subfamily. Secondary partitions have appeared at least three times among Devonian, Carboniferous, and Permian foraminifers. For instance, in the Viséan, *Valvulinella* (see pl. 4, fig. 20 and compare with *Multiseptida*) is derived from *Pseudotaxis* by progressive development of secondary walls. Both *Valvulinella* and *Pseudotaxis* have always been placed in the same family.

Stratigraphic range and distribution.—Frasnian. Eurasia, Alaska, Alberta.

Multiseptida corallina Bykova, 1952

Plate 2, figures 22-23; plate 3, figures 5-6

1952. *Multiseptida corallina* Bykova, VNIGRI Trudy 60, Mikrofauna SSSR, Sbornik 5, p. 27, pl. 7, figs. 1-4, pl. 8, figs. 1-5.
1954. *Multiseptida corallina* Reitlinger. VNIGRI, Paleont. Sbornik, no. 1, p. 73-74, pl. 20, figs. 1-6.
1963. *Multiseptida corallina* Pokorny. Principles of Zoological Micropalaeontology, v. 1, p. 299, fig. 260.
1964. *Multiseptida corallina* Loeblich and Tappan. Protista, pt. C, *in* Moore, R. C., ed., Treatise Invert. Paleontology, p. C328, fig. 244, 1-3.
1965. *Multiseptida corallina* Chuvashov. Akad. Nauk SSSR, Ural. Filial, Inst. Geol. Trudy 74, p. 68, pl. 15, figs. 12-14.
1970. *Multiseptida* sp. cf. *M. corallina* Toomey, Mountjoy, and MacKenzie. Canadian Jour. Earth Sciences, v. 7, no. 3, p. 978, pl. 7, figs. 64-69.
1970. *Multiseptida* sp. Toomey, Mountjoy, and MacKenzie. Canadian Jour. Earth Sciences, v. 7, no. 3, p. 978, pl. 7, figs. 70-77.
1972. *Multiseptida* sp. cf. *M. corallina* Toomey. International Geol. Congress, 24th, sec. 7, Paleontology, p. 626, pl. 2, figs. 1-3.
1975. *Multiseptida corallina* Neumann, Pozaryska and Vachard. Revue Micropaléontologie, v. 18, no. 1, p. 50, pl. 3, figs. 5-8.

Diagnosis.—Test free, elongate, cylindrical, tapering, rectilinear, uniserial. Proloculum spherical, about 20-40 μ in diameter, followed by low discoidal overlapping chambers. Number of chambers 6-10, the most common count being 8 or 9.

Septa long with terminal thickenings. Total length for adult specimens varies from 300-520 μ. For individuals of seven chambers, length varies between 370 and 430 μ, for individuals of nine chambers, length varies between 450 and 510 μ. Diameter of the seventh chamber varies between 160 and 230 μ, diameter of the ninth chamber varies between 180 and 250 μ.

Wall double layered with an inner dark microcrystalline layer and an outer hyaline layer. Wall commonly dissolved and replaced by early penecontemporaneous cement. Owing to recrystallization, leaching, and early cementation, original thickness of the wall is difficult to assess. Bykova (1952) reports 13-18 μ, Toomey (1970) somewhat more. Our specimens are closer to Bykova's estimate. Early cementation in our material produces a "three-layered wall" (see pl. 3, fig. 6). Diameter of the aperture 30-50 μ. Number of secondary septa in our material 8-12; Bykova reports 8-11; Toomey, 8-12.

Stratigraphic range and distribution.—Frasnian. Eurasia, Alaska, Alberta, British Columbia.

Figured specimens.—USNM 305174, 305175 (part), 305187, and 305188.

Multiseptida farewelli Mamet, new species

Plate 2, figure 23; plate 3, figures 1-4, 7-11; plate 4, figures 1-19

Diagnosis.—Test free, elongate, cylindrical, tapering. Nine to 11 cylindrical chambers. Exceptionally large specimens have 12 chambers. Proloculum oval to round, fragile, usually crushed, around 100-140 μ in diameter. Chambers low, discoidal, strongly overlapping, with deep suture. Diameter of chambers increase progressively:

Chamber	*Range* (μ)	*Average* (μ)	*Height progression* (μ)
1	160-240	200	25-51
2	180-270	235	32-58
3	195-300	255	41-66
4	230-340	280	42-68
5	255-380	320	48-72
6	300-410	375	58-88
7	320-480	400	60-91
8	390-520	430	68-103
9	425-530	450	90-105
10	460-550	500	95-120
11	550-560	560	102-123
12	570-600	575	102-130

Range of total length for adult specimens: 9 chambers, 560-720 μ; 10 chambers, 580-810 μ; 11 chambers, 680-830 μ.

Wall double layered with inner dark microcrystalline layer and an outer yellowish layer, typically dissolved. Penecontemporaneous cement and recrystallization obscure the original ultrastructure making the actual wall thickness difficult to assess. Micritic layer about 15 μ thick, commonly reduced to 10 μ or less by leaching. Septa have septal thickenings.

The number of secondary partitions increases with the number of chambers as follows:

Chamber	*Average number of partitions*
3	23
4	24
5	25
6	29
7	30
8	35
9	36
10	38
11	40

The apertural size increases progressively and is proportional to its diameter.

Comparison.—Specimens of *Multiseptida farewelli* are readily distinguishable from those of *M. corallina* by having larger tests with more chambers and by having more secondary partitions in its chambers than those of *corallina*. The secondary partitions of *farewelli* appear to be remarkably similar to those of Pseudotaxidae from the Viséan. For comparison, the secondary chamberlets of *Valvulinella youngi*, a Viséan Pseudotaxidae, are shown on plate 4, figure 20.

Stratigraphic range and distribution.—Frasnian. Apparently endemic to Alaska.

Figured specimens.—USNM 305176-USNM 305186; 305189-305207; and 305175 (part).

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PLATES 1-4

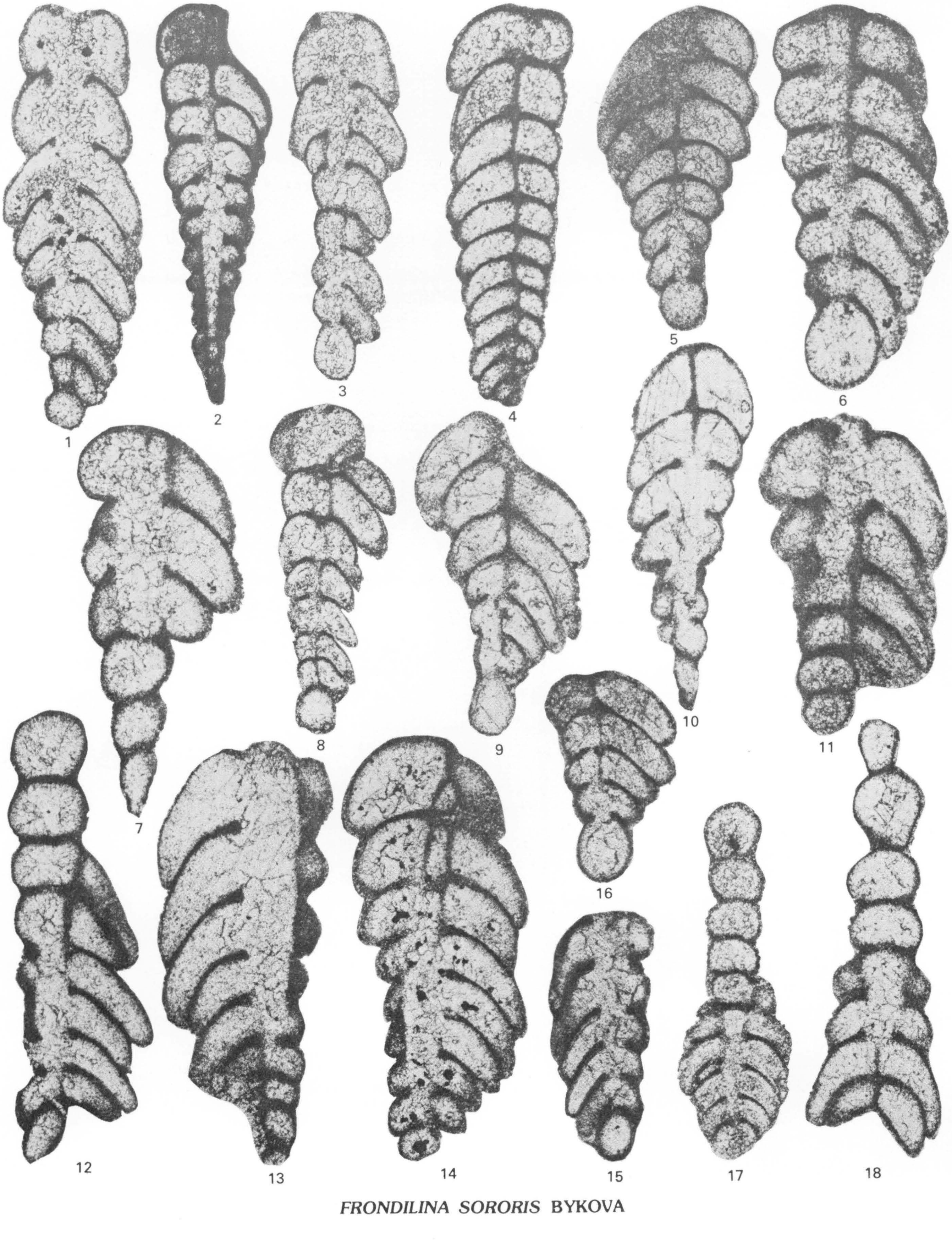
[Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey Photographic Library, Federal Center, Denver, Colorado 80225]

PLATE 1

FIGURES 1-18. *Frondilina sororis* Bykova 1952, (p. 7).

All samples from Frasnian, Farewell-Lyman Hills area. See table 1 for locations. Thin sections from a given sample are designated by a letter following sample number.

1. Central longitudinal section through aperture (× 90). USNM 305135, 76APr156A (10), Univ. Montreal 458/29.
2. Longitudinal section, slightly off-centered, showing sutures of triradiate chambers (× 58). USNM 305136, 76APr156A (10), Univ. Montreal 402/1.
3. Centered longitudinal section showing proloculum (× 90). USNM 305137, 76APr156A (8), Univ. Montreal 458/22.
4. Longitudinal section along suture of series of triradiate chambers, giving illusion that they are coplanar (× 73). USNM 305138, 76APr156A (10), Univ. Montreal 458/32.
5. Section as in figure 2 (× 90). USNM 305139, 76APr156A (3), Univ. Montreal 457/23.
6. Section as in figure 5 (× 90). USNM 305140, 76APr156A (8), Univ. Montreal 458/23.
7. Oblique section along tip of front row of chamber, then through aperture (× 90). USNM 305141, 76APr156A (11), Univ. Montreal 458/16.
8. Section similar to figure 3, showing arcuate, overlapping chambers (× 90). USNM 305142, 76APr156A (10), Univ. Montreal 458/26.
9. Section as in figure 5 (× 90). USNM 305143, 76APr243D (1), Univ. Montreal 456/14.
10. Section similar to figure 7 (× 90). USNM 305144, 76APr243D, Univ. Montreal 456/15.
11. Section similar to figure 7 (× 90). USNM 305145, 76APr156D (2), Univ. Montreal 459/18.
12. Longitudinal oblique section passing along axis of one "row" of chambers and through tip of underlying "row" (× 90). USNM 305146, 76APr156A (3), Univ. Montreal 457/26.
13. Longitudinal section passing through axis of one "row" of chambers and showing other "row" at 120° (× 90). USNM 305147, 76APr156D (2), Univ. Montreal 459/17.
14. Section similar to figures 6 and 13 (× 90). USNM 305148, 76APr156A (4), Univ. Montreal 457/30.
15. Section similar to figure 13 (× 90). USNM 305149, 76APr243D (13), Univ. Montreal 457/13.
16. Section similar to figure 13 (× 90). USNM 305150, 76APr243D (11), Univ. Montreal 457/8.
17. Oblique longitudinal section, centered along apertures between two series of front "rows," and through tips of underlying "row" of chambers (× 90). USNM 305151, 76APr156A, Univ. Montreal 401/36.
18. Section similar to figure 17 (× 90). USNM 305152, 76APr156A (10), Univ. Montreal 458/27.



FRONDILINA SORORIS BYKOVA

PLATE 2

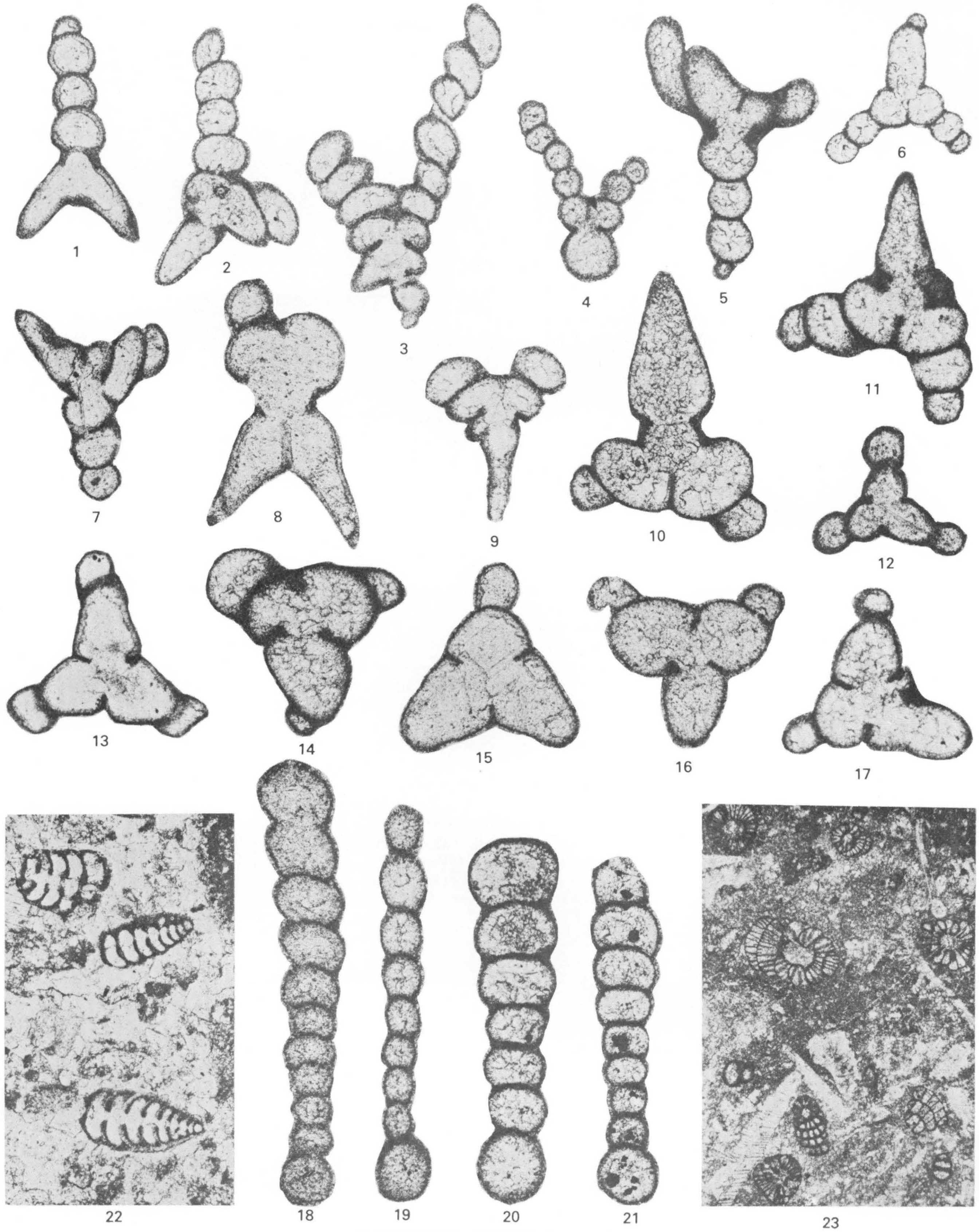
FIGURES 1-21. *Frondilina sororis* Bykova 1952, (p. 7).

All samples from Frasnian, Farewell-Lyman Hills area. See table 1 for locations. Thin sections from a given sample are designated by a letter following sample number.

1. Highly oblique, nearly axial section, through two rows at 120°, and along top of chambers of third "row" (× 90). USNM 305153, 76APr243D (1), Univ. Montreal 456/11.
2. "Random" oblique section (× 90). USNM 305154, 76APr243D (2), Univ. Montreal 456/16.
3. Oblique high section along tips of two divergent "rows" (× 90). USNM 305155, 76APr243D (2), Univ. Montreal 456/17.
4. Section as in figure 3 (× 90). USNM 305156, 76APr243D (2), Univ. Montreal 456/18.
5. "Random" oblique section (× 90). USNM 305157, 76APr243D (3), Univ. Montreal 456/20.
6. Nearly perfect axial section, with ends of overlying chambers (× 73). USNM 305158, 76APr243D, Univ. Montreal 402/19.
7. "Random" axial oblique section (× 90). USNM 305159, 76APr243D (7), Univ. Montreal 456/36.
8. Section as in figure 7 (× 90). USNM 305160, 76APr243D (7), Univ. Montreal 456/34.
9. Section as in figure 7 (× 90). USNM 305161, 76APr243D, Univ. Montreal 402/22.
10. Slightly oblique axial section (× 90). USNM 305162, 76APr156A (6), Univ. Montreal 458/6.
11. Section similar to figure 10 (× 90). USNM 305163, 76APr156A (11), Univ. Montreal 459/7.
12. Perfect axial section showing chamber divisions at 120°, wide aperture, and circular shape of tip of overlying chambers (× 90). USNM 305164, 76APr243D (5), Univ. Montreal 456/28.
13. Section similar to figure 12 (× 90). USNM 305165, 76APr156A (4), Univ. Montreal 457/34.
14. Section similar to figure 12 (× 90). USNM 305166, 76APr243D (5), Univ. Montreal 456/39.
15. Section similar to figure 12 (× 90). USNM 305167, 76APr156D (4), Univ. Montreal 459/22.
16. Section similar to figure 12 (× 90). USNM 305168, 76APr243D (13), Univ. Montreal 457/10.
17. Section similar to figure 12 (× 90). USNM 305169, 76APr243D (5), Univ. Montreal 456/32.
18. Longitudinal very high section along end of one "row" of chambers (× 90). USNM 305170, 76APr156D (2), Univ. Montreal 459/20
19. Section similar to figure 18 (× 90). USNM 305171, 76APr156D (5), Univ. Montreal 459/25.
20. Section similar to figure 18 (× 90). USNM 305172, 76APr156A (10), Univ. Montreal 458/31.
21. Section similar to figure 18 (× 73). USNM 305173, 76APr156A (10), Univ. Montreal 458/34.

22-23. *Multiseptida corallina* Bykova 1952 and *Multiseptida farewelli* n. sp. (p. 8,9)

22. Pelletoidal grainstone containing three *Multiseptida corallina* Bykova, 1952 (× 58). USNM 305174, 76APr235 (2), Univ. Montreal 402/11.
23. Fossiliferous wackestone containing echinoderm debris, *Multiseptida corallina* Bykova, 1952, and *Multiseptida farewelli* n. sp. (× 23). Locality as in figure 1. USNM 305175, 76APr156A (3), Univ. Montreal 457/27.



FRONDILINA SORORIS BYKOVA

PLATE 3

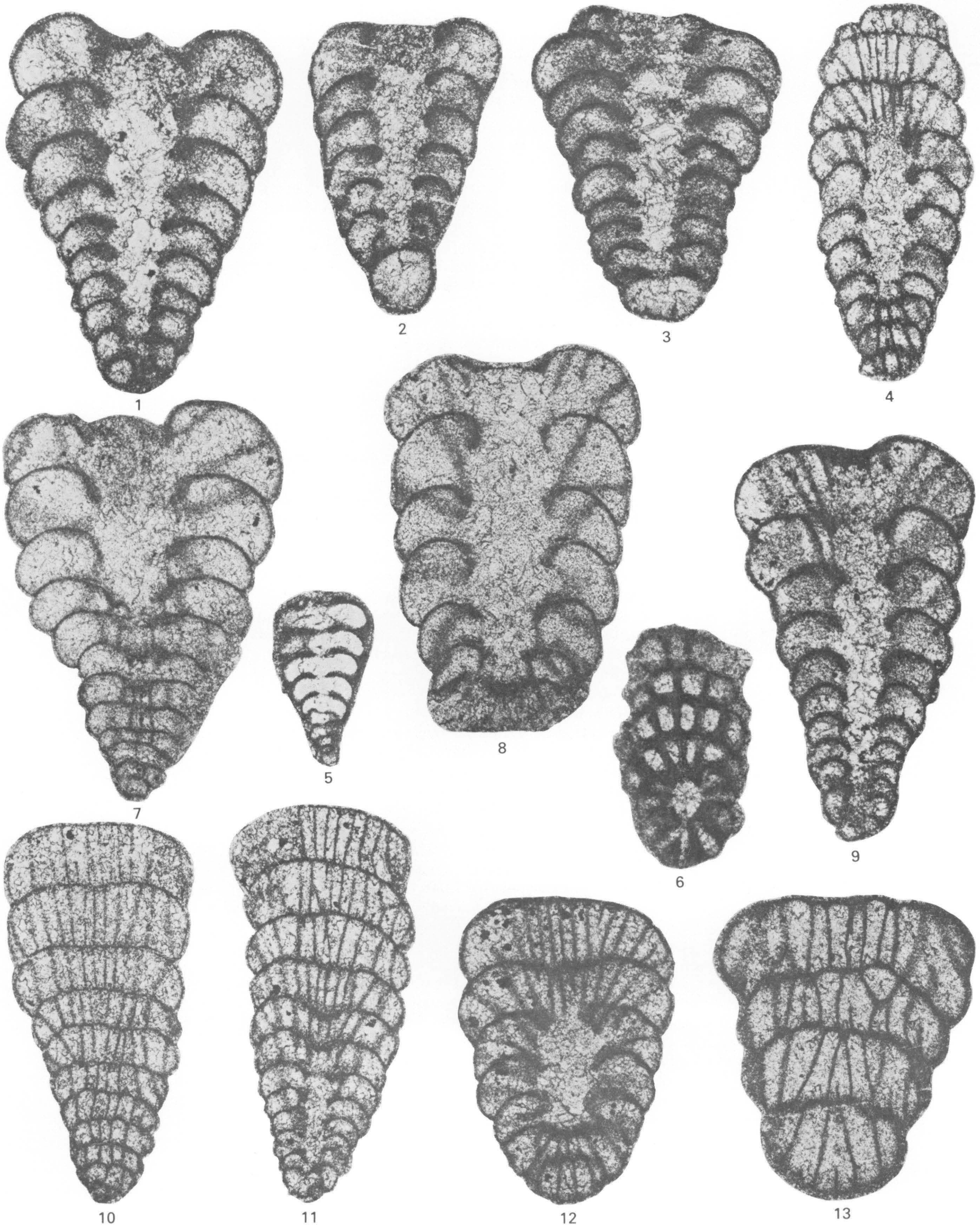
FIGURES 1-4, 7-13. *Multiseptida farewelli* Mamet, n. sp., (p. 9).

All samples from Frasnian, Farewell-Lyman Hills area. See table 1 for locations.

1. Centered longitudinal section along apertures; first chambers crushed (× 90). USNM 305176, 76APr156A (10), Univ. Montreal 458/35.
2. Longitudinal section, passing through proloculum. Type of new species (× 90). USNM 305177, 76APr156D (8), Univ. Montreal 457/29.
3. Section comparable to figure 2 (× 90). USNM 305178, 76APr156D (7), Univ. Montreal 459/28.
4. Slightly off-centered, longitudinal section showing secondary partitions (× 90). USNM 305179, 76APr156A (10), Univ. Montreal 458/35.
7. Slightly oblique longitudinal section, off-centered at proloculum and within apertures at last chambers (× 90). USNM 305180, 76APr156A (3), Univ. Montreal 457/24.
8. Oblique section showing strong lateral slant of secondary partitions (× 90). USNM 305181, 76APr156A (7), Univ. Montreal 458/15.
9. Slightly oblique longitudinal section (× 90). USNM 305182, 76APr156A (10), Univ. Montreal 459/16.
10. High, off-centered, longitudinal section (× 73). USNM 305183, 76APr156A (7), Univ. Montreal 458/16.
11. High, off-centered, slightly oblique longitudinal section (× 90). USNM 305184, 76APr156A (8), Univ. Montreal 458/21.
12. Oblique section (× 90). USNM 305185, 76APr156A (2), Univ. Montreal 459/26.
13. High, epidermic section, showing irregular secondary partitions (× 90). USNM 305186, 76APr156 (6), Univ. Montreal 459/26.

5-6. *Multiseptida corallina* Bykova, 1952, (p. 8).

5. Centered longitudinal section along apertures (× 90). USNM 305187, 76APr235 (2), Univ. Montreal 402/12.
6. Oblique high section showing heavy secondary partitions (× 90). USNM 305188, 76APr156A (3), Univ. Montreal 457/25.



MULTISEPTIDA FAREWELLI MAMET, N. SP. AND *MULTISEPTIDA CORALLINA* BYKOVA

PLATE 4

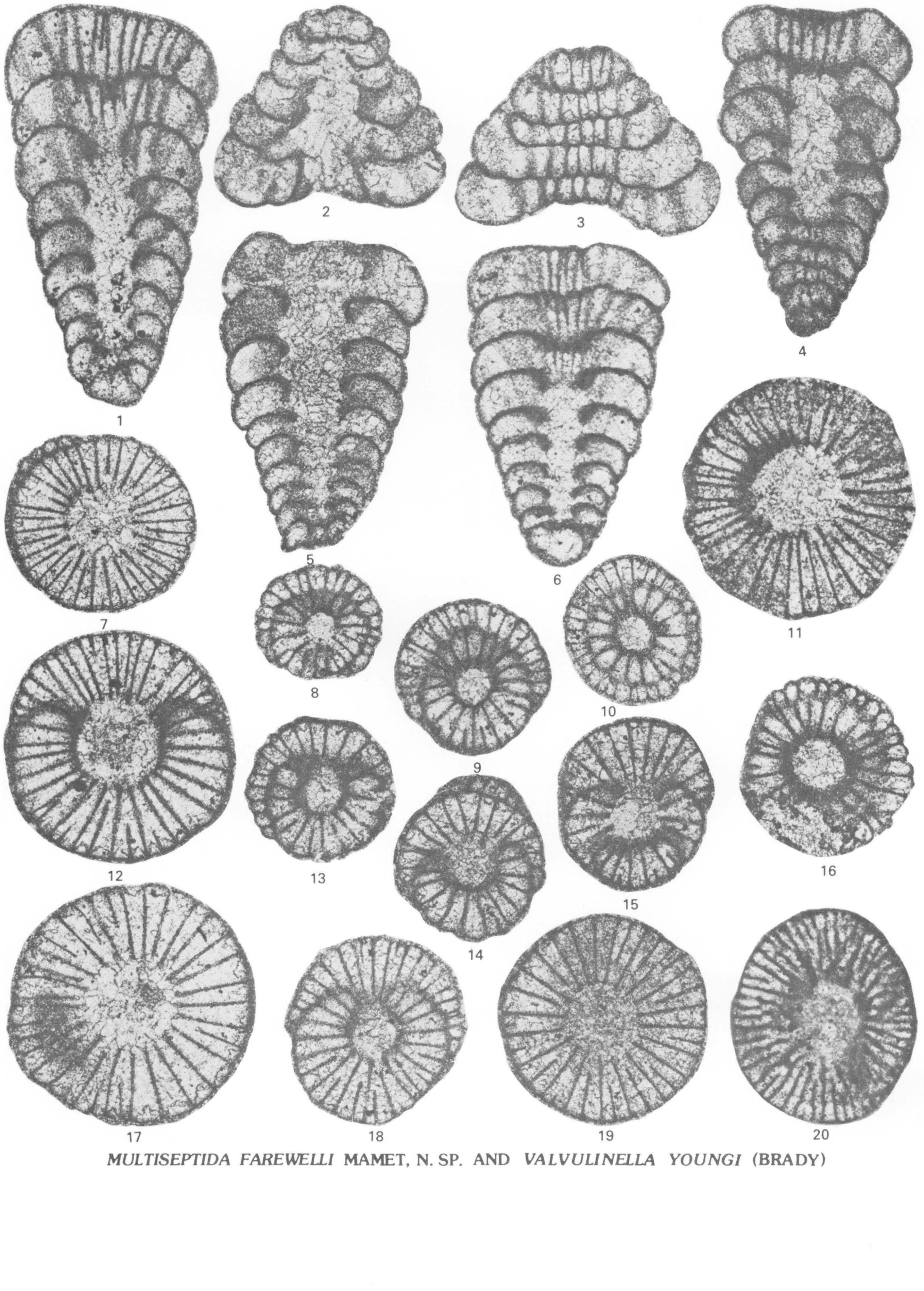
FIGURES 1-19. *Multiseptida farewelli* Mamet, n. sp., (p. 9).

All samples from Frasnian, Farewell-Lyman Hills area. See table 1 for locations.

1. Slightly oblique longitudinal section, passing through proloculum, apertures, and chamberlets (× 90). USNM 305189, 76APr156A (6), Univ. Montreal 458/7.
2. Oblique section through apertures and chamberlets but missing proloculum. Picture inverted to simulate *Valvulinella* (× 90). USNM 305190, 76APr243D (3), Univ. Montreal 456/2.
3. Highly oblique off-centered section showing primary and secondary incomplete partitions. Picture inverted to simulate *Valvulinella* (× 90). USNM 305191, 76APr243 (6), Univ. Montreal 456/33.
4. Section similar to that in figure 1, but slightly off-center (× 90). USNM 305192, 76APr156A (3), Univ. Montreal 457/21.
5. Perfectly centered longitudinal section showing septal thickenings and crushed, collapsed proloculum (× 90). USNM 305193, 76APr156A (4), Univ. Montreal 457/1.
6. Section similar to that in figure 1 (× 90). USNM 305194, 76APr156A, Univ. Montreal 401/38.
7. Centered axial section of eighth chamber, showing ribbing of overlying ninth chamber (× 90). USNM 305195, 76APr156A (7), Univ. Montreal 458/14.
8. Slightly oblique axial section of third and overlying fourth chamber. Note slight ribbing produced by secondary partitions (× 90). USNM 305196, 76APr156A, Univ. Montreal 458/12.
9. Slightly oblique axial section of fifth and overlying sixth chamber (× 90). USNM 305197, 76APr156A (1), Univ. Montreal 457/17.
10. Perfectly centered axial section of fourth and overlying fifth chamber (× 90). USNM 305198, 76APr156A (11), Univ. Montreal 459/6.
11. Centered axial section of tenth chamber (× 90). USNM 305199, 76APr156A, Univ. Montreal 401/37.
12. Slightly oblique axial section of tenth and eleventh chamber (× 90). USNM 305200, 76APr156A (11), Univ. Montreal 459/3.
13. Slightly oblique axial section of fifth and sixth chamber (× 90). USNM 305201, 76APr156A (7), Univ. Montreal 458/13.
14. Oblique axial section of fifth, sixth, and seventh chambers (× 90). USNM 305202, 76APr156A (3), Univ. Montreal 457/19.
15. Slightly oblique axial section of fifth and sixth chamber (× 90). USNM 305203, 76APr156A (3), Univ. Montreal 457/20.
16. Slightly oblique axial section of sixth and seventh chamber. Note external ribs (× 90). USNM 305204, 76APr156D (2), Univ. Montreal 459/19.
17. Centered axial section of eleventh chamber (× 90). USNM 305205, 76APr156A (8), Univ. Montreal 458/24.
18. Slightly oblique axial section of seventh and eighth chamber (× 90). USNM 305206, 76APr156A (5), Univ. Montreal 457/36.
19. Centered axial section of ninth chamber (× 90). USNM 305207, 76APr156A (5), Univ. Montreal 457/37.

20. *Valvulinella youngi* (Brady), 1876, (p. 9).

Dagirsacik Plateau near Ankara, Turkey. Late Middle to Early Late Viséan. Sample of Professor S. Erk. Axial section showing secondary chamberlets. (× 58). Compare with figures 8, 11, and 17. Univ. Montreal 454/1.



MULTISEPTIDA FAREWELLI MAMET, N. SP. AND *VALVULINELLA YOUNGI* (BRADY)

GPO 587-041/36

Mamet and Plafker—A LATE DEVONIAN (FRASNIAN) MICROBIOTA FROM THE FAREWELL-LYMAN HILLS AREA WEST-CENTRAL ALASKA—Geological Survey Professional Paper 1216-A