

## Middle Devonian parathuramminid and earlandiid foraminifers from shallow marine carbonates of the Carnic Alps (Austria)

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**Abstract.**—The Devonian of the Carnic Alps (Austria) is developed in different facies. The shallow marine facies is up to 1200 m thick. The Feldkogel Limestone of the Polinik Formation, >330 m thick, was dated as Eifelian–Late Devonian. The Feldkogel Limestone at Mount Polinik is developed in a peritidal facies composed of subtidal, intertidal, and supratidal deposits. Subtidal sediments are represented by dark gray *Amphipora* limestone and intertidal deposits by laminated and partly bioturbated grainstone and packstone, ostracode wackestone to packstone, and locally intercalated intraclast breccias documenting tidal channel fills. Laminated microbial mats (stromatolites) formed in a supratidal depositional environment. Grainstone and packstone contain abundant unilocular parathuramminid foraminifers. This latter group encompasses a diversified assemblage of ivanovellids, parathuramminids, uralinellids, and irregularinoids; some earlandiids are also present. They are dated herein as late Eifelian–early Givetian. These foraminifers provide a more precise systematics of these taxa, which often have not been studied for more than half a century. The taxonomic problems of their assignment to foraminifers, pseudo-foraminifers, calcitarcha, thauatoporellaceans, volvocaleans, or other algae are also discussed. Several taxa are emended: Parathuramminida, Parathuramminoidea, Irregularinoidea, Eovolutinidae, Ivanovellidae, Parathuramminidae, Uralinellidae, *Ivanovella*, *Elenella*, *Neoarchaesphaera*, *Parathuramina*, *Bykovaella*, *Uralinella*, and *Paracaligella*. The new taxa are: *Ivanovella reitlingeræ* n. sp., *Elenella polinikensis* n. sp., *Uralinella sabirovi* n. sp., and *Radiosphaerella poyarkovi* n. sp.

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### Introduction

Many monothalamous Devonian and pre-Devonian foraminifers, which are more or less spherical and have a single, terminal, rounded aperture, are considered as members of the foraminiferal class Astrorhizata; or even as members of the class Textulariata, which more traditionally includes plurilocular agglutinated foraminifers. This similarity has even been taken to its logical extreme: the assignment of Paleozoic taxa to extant genera of Astrorhizata/Textulariata (e.g., *Saccamina*, *Psammosphaera*, *Lagenamina*, *Thuramina*, *Hyperamina* and *Sorosphaera*) (Loeblich and Tappan, 1964, 1987; Poyarkov, 1969, 1977, 1979; Ross and Ross, 1991; Vdovenko et al., 1993).

The parathuramminids are considered as foraminifers principally because the fossil genus *Parathuramina* is homeomorphous of the extant genus *Thuramina* (Vachard, 2016a). However, there are several arguments against this assignment, and other putative phyla have been proposed, to which parathuramminids may be assigned: (1) Kaźmierczak (1975, 1976) considered this group to be related with calcisphaeraceans and radiosphaeraceans, and might be interpreted as volvocale algae; (2) Vachard (1994) designated these forms as pseudoforaminifers; (3) Pr at et al. (2007) included in the calcispheres the genera *Calcisphaera*, *Parathuramina*, and *Vicinesphaera*; (4) Versteegh et al. (2009) assigned the calcisphaeraceans to the Calcitarcha,

which probably, like the acritarchs, constitute a heterogeneous group that includes dinoflagellates, chlorophytes, haptophytes, foraminifers, and radiolarians; (5) Vachard and Cl ement (1994) indicated possible morphological and paleobiological similarities between some irregularinids or usloniids with thauatoporellacean incertae sedis algae; Schlagintweit et al. (2013) even synonymized both groups; (6) Vishnevskaya and Sedaeva (2002a, b), Afanasieva and Amon (2011), and Nestell et al. (2011) considered that these forms are radiolarians, the tests of which were calcified after diagenesis, returning to outdated assumptions about the calcispheres (Williamson, 1880; Pia, 1937); (7) E. Armynot du Ch atelet (personal communication, 2016) advocates a relationship with thecamoebian protozoans; this assignment has also been proposed for upper Proterozoic agglutinated, monothalamous tests of Namibia and Mongolia (Bosak et al., 2011, 2012); and (8) the tintinnids, which are other agglutinating protists (Tappan and Loeblich, 1968; Henjes and Assmy, 2008), also display sizes and shapes corresponding to some parathuramminids.

Rich assemblages of parathuramminoids and irregularinoids discovered in our material provide: (1) a more precise systematics of these taxa, which have not been investigated for more than half a century; (2) more extensive illustrations of these poorly known taxa; (3) additional paleoecological data; and (4) an opportunity to discuss the taxonomical problems of these foraminifers, pseudoforaminifers, or algae.

## Geologic setting

The Carnic Alps, which are part of the Southern Alps and form an east-west-trending mountain range along the border between southern Austria and Italy, are well known for its almost continuous and well-preserved sedimentary succession ranging in age from the Late Ordovician to the Late Permian (e.g., Schönlaub, 1979, 1980, 1985a, b; Schönlaub and Heinisch, 1993; Schönlaub and Histon, 2000). The Devonian of the Carnic Alps, which is best exposed in the Plöckenpass-Wolayersee area, is developed in different facies ranging from shallow marine environments (including carbonate buildups formed by stromatoporoids and tabulate corals and lagoonal sediments) to reef slope deposits, condensed pelagic cephalopod limestones, and deep marine offshore shales and siliceous sediments (bedded chert). The shallow marine facies is up to 1200 m thick, whereas the condensed pelagic limestone facies measures ~100 m (Schönlaub, 1979, 1985a, 1985b; Schönlaub and Heinisch, 1993; Schönlaub and Histon, 2000).

The Feldkogel Limestone is part of the Devonian shallow marine facies of the Feldkogel Nappe (“northern shallow-water facies”) and is described as algal laminite with dolomite layers (Schönlaub, 1985a, 1985b; Kreutzer, 1992b). The Feldkogel Limestone is more than 330 m thick and dated as Eifelian–Late Devonian (Kreutzer, 1990).

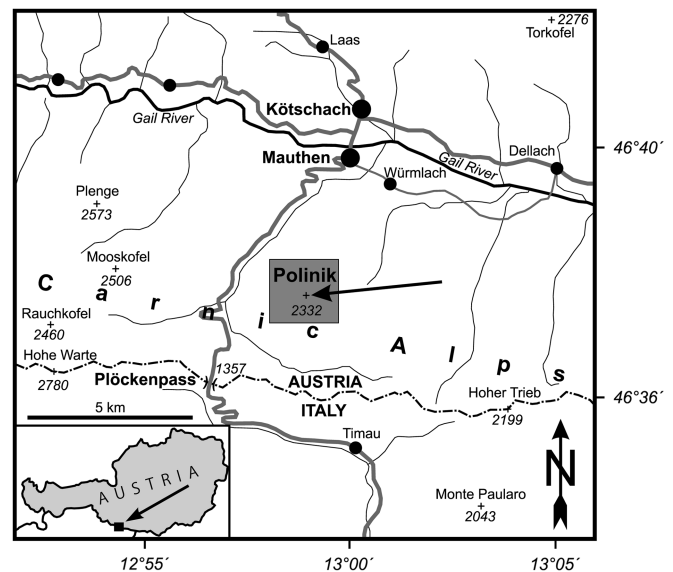
The Gamskofel Limestone is developed in a similar facies (800 m thick bedded succession of algal laminites with intercalated *Amphipora* limestone beds), but is older (Pragian–Givetian?) and belongs to the “southern shallow-water facies” of the Kellerwand Nappe according to Kreutzer (1992a).

From the Feldkogel Limestone at Mount Polinik, Kreutzer (1992a) described the following microfacies types: (1) MF-Type 5c—bindstone (stromatolite with rare ostracodes and parathuramminids), (2) MF-Type 12—quartz-rich dolosparite and stromatolites, and (3) MF-Type 13—ostracode and *Parathurammina*-packstone (peloid-pack-/grainstone with parathuramminids of Kreutzer, 1992b). Kreutzer (1992a) assigned the monolocular foraminifers to *Parathurammina dagmarae* Suleimanov and cf. *Cribrosphaeroides* sp.

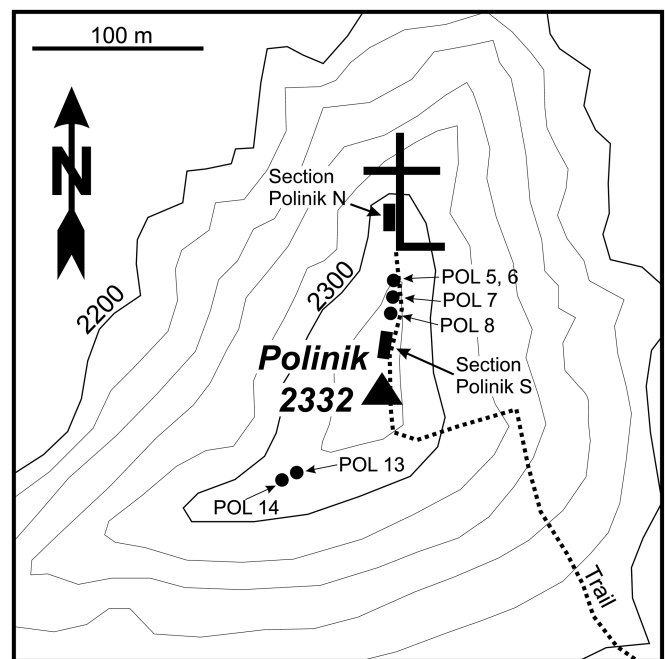
Recently, Pohler et al. (2015) introduced the term Polinik Formation, in which they included the Gamskofel Limestone and Feldkogel Limestone. These authors described the Polinik Formation as a bedded, cyclic, shallow marine succession of dominantly algal laminites and *Amphipora* limestone. The type locality is at Mount Polinik. The Polinik Formation is of Pragian to Frasnian, probably of younger, age; its estimated thickness is 700–800 m.

## Materials and methods

The studied samples are derived from bedded limestones of the Devonian “Feldkogel-Kalk” (Feldkogel Limestone) of the Polinik Formation exposed at the summit of Mount Polinik (2332 m) in the Carnic Alps (Figs. 1, 2), ~5 km SSW of Kötschach in the Gail Valley (Carinthia, southern Austria) (see geologic map of Schönlaub, 1985a). At the summit of Mount Polinik, we measured two short sections that characterize the facies of the Feldkogel Limestone (Figs. 2, 3). Section A is



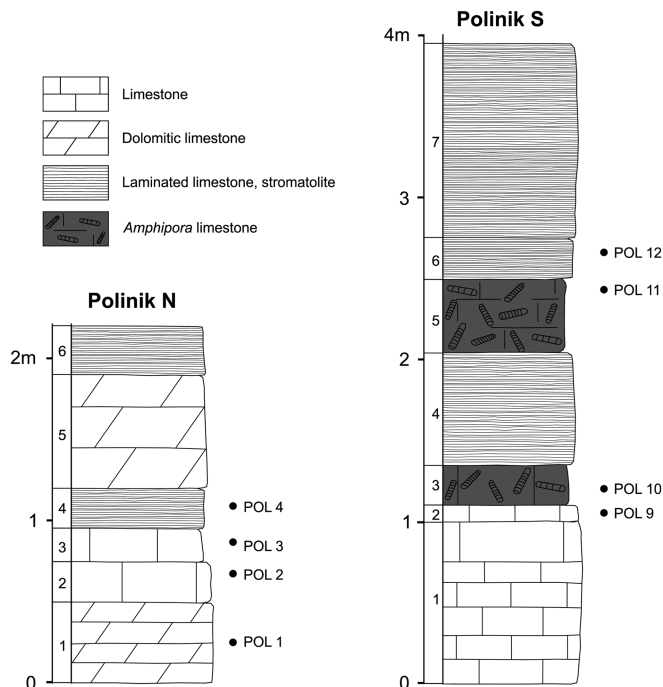
**Figure 1.** Geographical map of the studied area with location of Mount Polinik.



**Figure 2.** Top of Mount Polinik with locations of the two sections (Fig. 3) and the fossiliferous samples. Contour lines (2200, 2300) in meters.

located ~10 m north of the summit cross of Mount Polinik and is 2 m thick. Section B was measured ~50 m south of the summit cross and measures ~4 m. Four samples were collected from section A and four samples from section B. Additionally, samples were collected from bedded limestones of the summit area of Mount Polinik (Fig. 2). From all samples, 16 thin sections were prepared, which were studied under the microscope in terms of microfacies and paleontology.

*Repositories and institutional abbreviations.*—All thin sections used in this study are stored in the collection of the Institute of Geology (POL 1–POL 15), University of Innsbruck, Austria.



**Figure 3.** Stratigraphical columns of the studied sections with location of samples (for geographical maps, see Figures 1, 2).

Other repositories and abbreviations include: Geological Museum of Novosibirsk (IGiG SO AN SSSR); UTGU, Ural Geological Museum; VNIGRI, Leningrad/Sankt Petersburg.

### Lithofacies

At Mount Polinik, the Feldkogel Limestone is composed of medium- to thick-bedded limestone and dolomitic limestone/dolomite. Bed thickness ranges from 20 cm to 120 cm. We observed the following lithofacies (Fig. 2): (1) dark gray massive *Amphipora* limestone, 20–50 cm thick; (2) well-laminated dark gray limestone that weathers light gray, with individual beds up to 120 cm thick; (3) massive to indistinctly laminated limestone and dolomite beds, 20–70 cm thick; (4) stromatolite beds, 20–50 cm thick; and (5) intraclast breccia composed of reworked, poorly sorted, angular intraclasts up to 30 cm in diameter. The intraclast breccia is rare, up to 50 cm thick, displays a channel-form geometry, and thins laterally. The base is erosive.

### Microfacies

Limestones of the Feldkogel Limestone at the summit of Mount Polinik are composed of four microfacies types (Mörtl, 2014; Figs. 4, 5).

(1) *Amphipora* floatstone to rudstone (Fig. 4.2, 4.3). Skeletons of *Amphipora* are embedded in a matrix of grainstone composed of abundant peloids and foraminifers. Rare skeletons of brachiopods occur. *Amphipora* skeletons are up to several cm in size, mostly complete, rarely fragmented. The following species are present (J. Hladil, written communication, 2014): *Amphipora* cf. *A. angusta* Lecompte, 1952; *A.* cf. *A. rudis* Lecompte, 1952; *A.* cf. *A. laxeperforata* Lecompte, 1952; and *A.* cf. *A. perversiculata* Lecompte, 1952 (Mörtl, 2014, text-fig. 31).

(2) Grainstone to packstone containing abundant peloids and foraminifers (Figs. 4.1, 4.2, 4.5, 4.6, 5.1–5.6). This microfacies is partly laminated, locally bioturbated. Locally, small amounts of micritic matrix are present. Subordinately, fragments of brachiopods, *Amphipora*, and ostracodes are observed (Mörtl, 2014, text-fig. 32).

(3) Ostracode wackestone to packstone. This microfacies is composed of alternating densely and less densely packed ostracode layers. Ostracode shells are oriented parallel to bedding and are embedded in peloidal micrite. Many ostracodes are preserved with both valves, and the interior is filled with calcite cement (Mörtl, 2014, text-fig. 29).

(4) Bindstone, composed of laminated cyanobacteria mats (microbial mats, stromatolites), alternating with thin layers containing abundant peloids and aggregate grains, rare micritic intraclasts and some fossils, such as ostracodes and foraminifers. LF-fabrics are common (Mörtl, 2014, text-fig. 30).

### Systematic paleontology

Subkingdom Rhizaria Cavalier-Smith, 2002

Phylum Foraminifera d'Orbigny 1826 emend.

Cavalier-Smith, 2003

Class Fusulinata Gaillot and Vachard, 2007 emend.

Vachard, 2016a

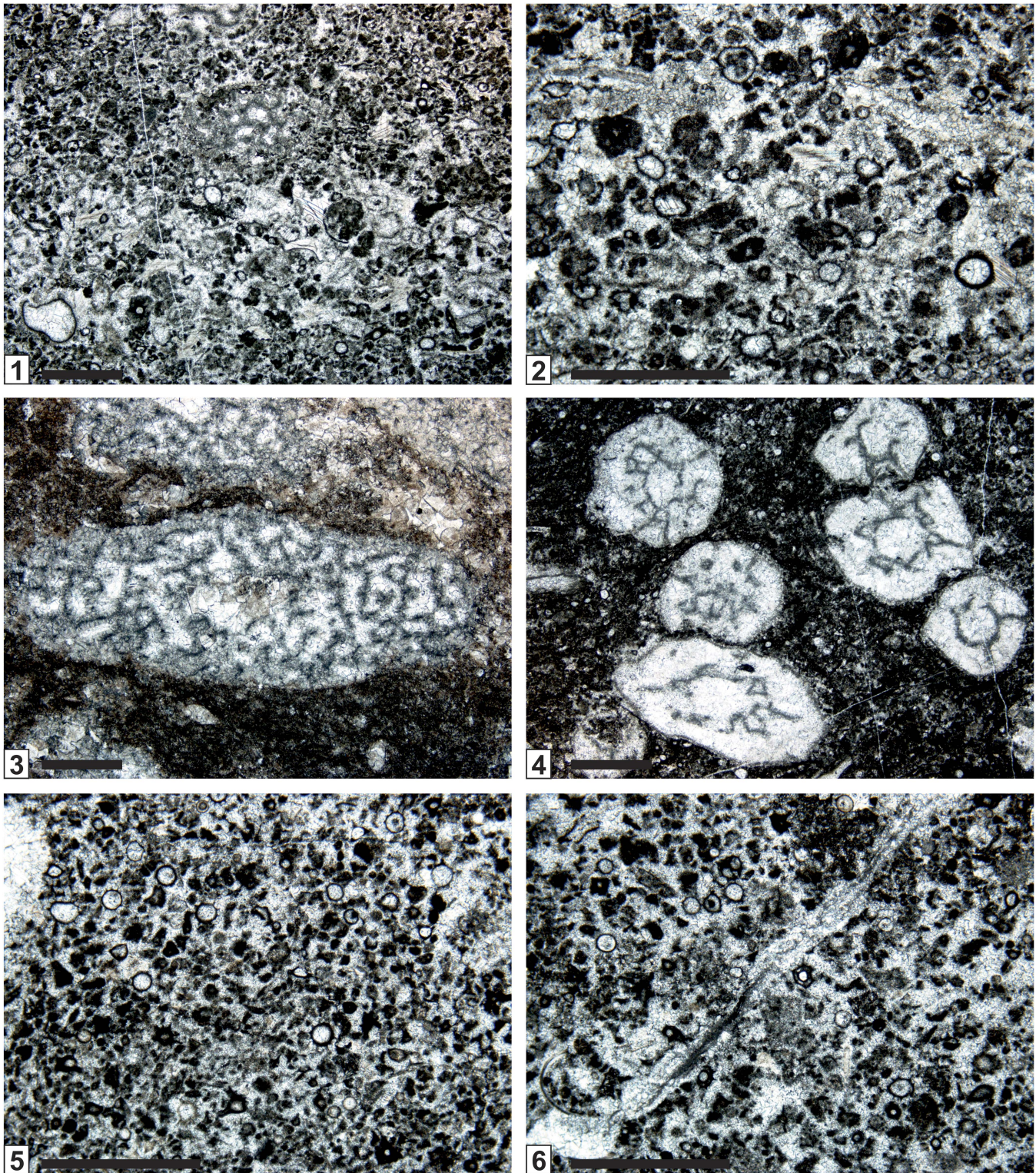
Subclass Afusulinana Vachard, Pille, and Gaillot, 2010

Order Parathuramminida Mikhalevich, 1980 emend.

Vachard, 2016a

**Diagnosis.**—Unilocular (= monothalamous), free to temporarily attached foraminifers showing a large central chamber. Rarely bilocular with two concentric chambers or several chambers built alongside. Apparently, no true plurilocular tests exist, but clusters of unilocular chambers can be encountered (e.g., *Tschernyncevella* Antropov, 1950; *Rauserina* Antropov, 1950; *Uralinella* Bykova, 1952; and various tuberitinoids). Wall thin (*Eovolutina* Antropov, 1950) to thick (*Vicinesphaera* Antropov, 1950), dark-microgranular, occasionally bilayered with an inner hyaline-pseudofibrous layer, rarely more differentiated. Apertures are typically emplaced at the extremity of hollow necks connecting the central chamber with the external environment; often also, the walls are finely perforated by very numerous minute foramina; or the apertures are inconspicuous. Wall thin to moderately thick, dark-microgranular, occasionally bilayered with an inner hyaline-pseudofibrous layer, rarely more differentiated (e.g., *Tubesphaera* Vachard, 1994 and some parathuramminids).

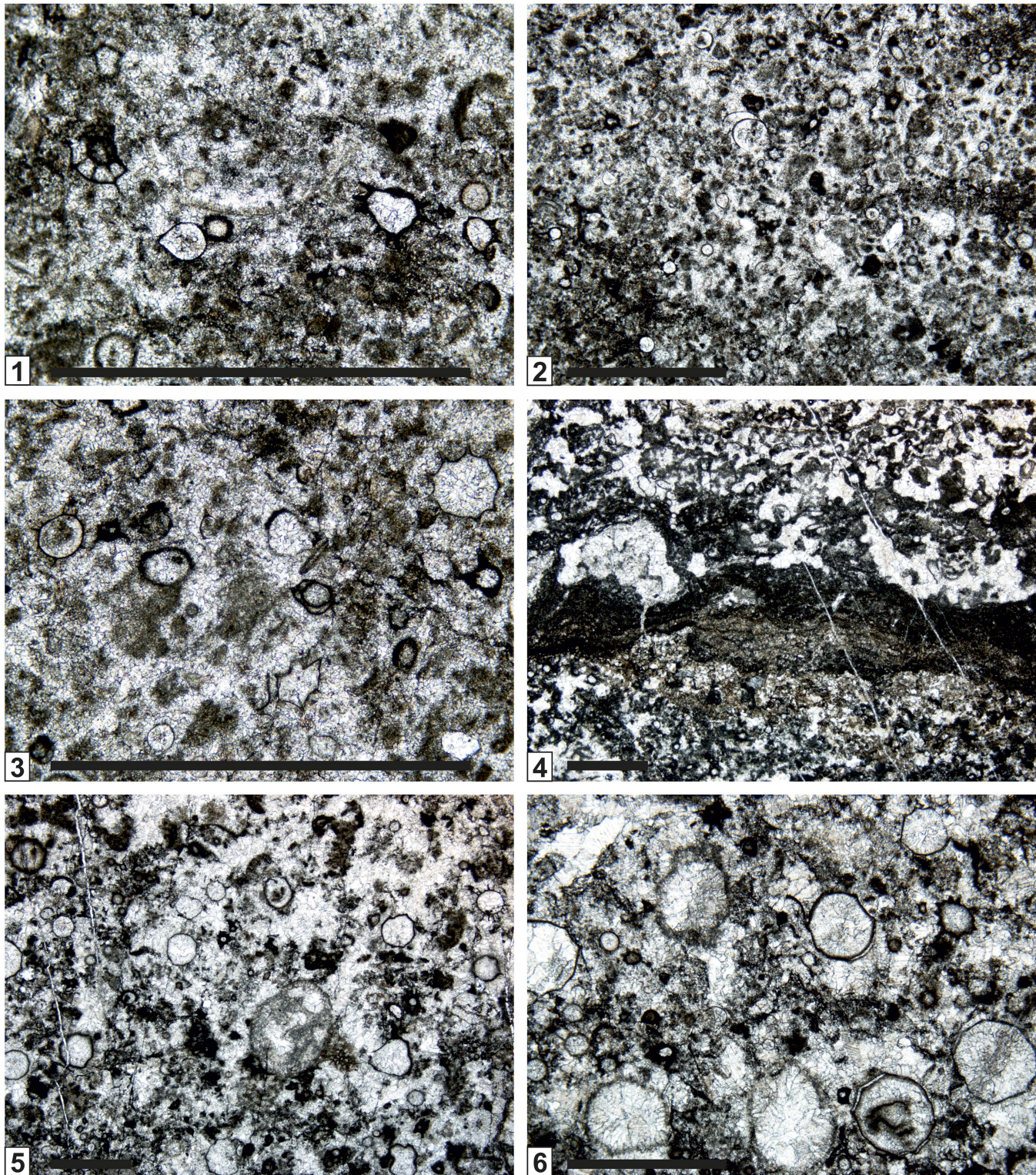
**Occurrence.**—Questionable in the middle Cambrian, rare in the Ordovician–early Silurian, present during the late Silurian–Early Devonian, common during the Middle and Late Devonian, present in the Mississippian, rare in the Pennsylvanian–Permian (except for the tuberitinoids, which remain common during this time interval); very rare in the earliest Triassic, during which only tuberitinids locally subsist (Vachard, 2016a, 2016b, with references therein).



**Figure 4.** (1) Bioclastic and pelloidal grainstone with *Vasicekia?* sp. (tubular specimens with clear wall), *Neoarchaesphaera ellipsoidalis*, *Ivanovella* sp., *Cribrosphaeroides* (*Parphia*) *robusta*, and *Amphipora* sp., sample POL3. (2) Bioclastic and pelloidal grainstone with *Vasicekia?* sp. (tubular specimens with clear wall), *Neoarchaesphaera ellipsoidalis*, *Parathurammina* sp., and *Suleimanovella* sp., sample POL3c. (3) Dolomitized floatstone with *Amphipora* sp., sample POL10a. (4) Floatstone with *Amphipora* cf. *A. perversiculata* and parathuraminids in the matrix, sample POL11. (5) Bioclastic and pelloidal grainstone with *Vasicekia* sp. (tubular specimens with clear wall), *Neoarchaesphaera ellipsoidalis*, *Parathurammina* sp., and *Suleimanovella* sp., sample POL11-10. (6) Bioclastic and pelloidal grainstone with *Uralinella* sp., *Parathurammina* sp., *Neoarchaesphaera ellipsoidalis*, *Suleimanovella* sp., and ostracodes, sample POL11a. Scale bars = 1 mm.

**Remarks.**—Suspected to be micritized envelopes of volvoccean algae by Toomey and Mamet (1979) or acritarchs that underwent an early post-mortem calcification (Kazmierczak and

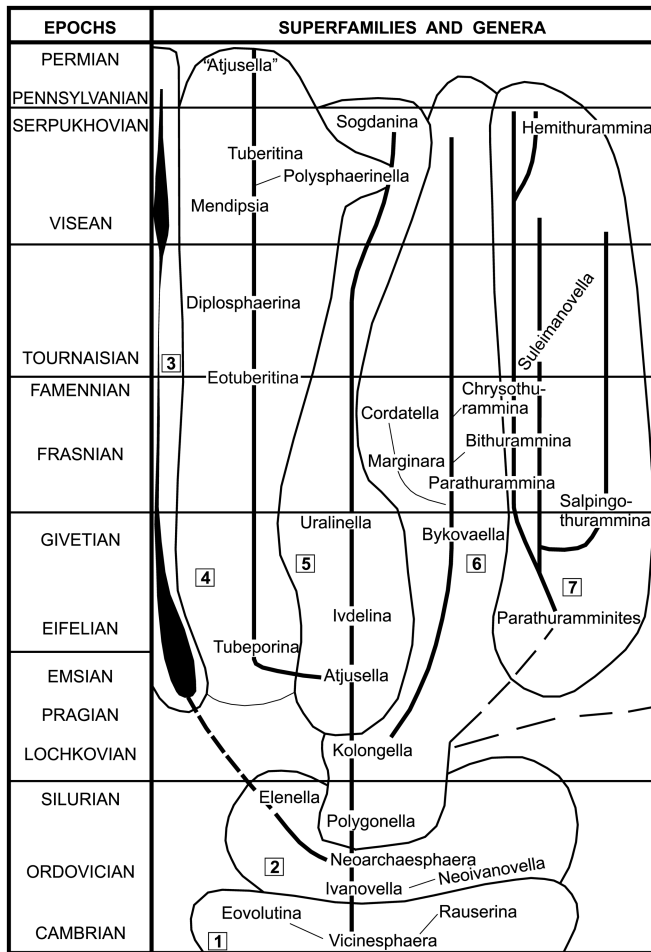
Kremer, 2005), these taxa remain enigmatic; nevertheless, it seems to be possible to reconstruct their phylogeny as follows (Figs. 6, 7). First, the forms with one or two chambers



**Figure 5.** (1) Bioclastic and pelloidal grainstone with *Vasicekia?* sp., *Uralinella* sp., *Radiosphaerella* sp., *Neoarchaesphaera ellipsoidalis*, and *Suleimanovella* sp., sample POL11a-2. (2) Bioclastic and pelloidal grainstone with *Uralinella* sp., *Parathurammina* sp., *Salpingothurammina* sp., *Suleimanovella* sp., and ostracodes, sample POL11d. (3) Bioclastic and pelloidal grainstone with *Uralinella* sp., *Parathurammina* sp., *Neoarchaesphaera ellipsoidalis*, and *Suleimanovella* sp., sample POL11a-7. (4) Three layers of microbialites; two with parathuramminids, sample POL12b. (5) Bioclastic and pelloidal grainstone with *Uralinella* sp., *Parathurammina* sp., *Bykovaella* sp., *Suleimanovella* sp., and *Amphipora* sp., sample POL13a. (6) Bioclastic and pelloidal grainstone with *Uralinella* sp., *Parathurammina* sp., *Bykovaella* sp., *Suleimanovella* sp., and *Vasicekia?* sp., sample POL13c. Scale bars = 1 mm.

and a non-perforated dark-microgranular wall (i.e., the eovolutinoids) appear. After that, the wall thickens and becomes ornamented with necks, with the ivanovellids, which can give

rise, more or less coevally, to the parathuramminids, uralinellids, and tuberitinoids. Eovolutinoids also give rise to the tuberitinoids, whereas the irregularinoids derive either from the

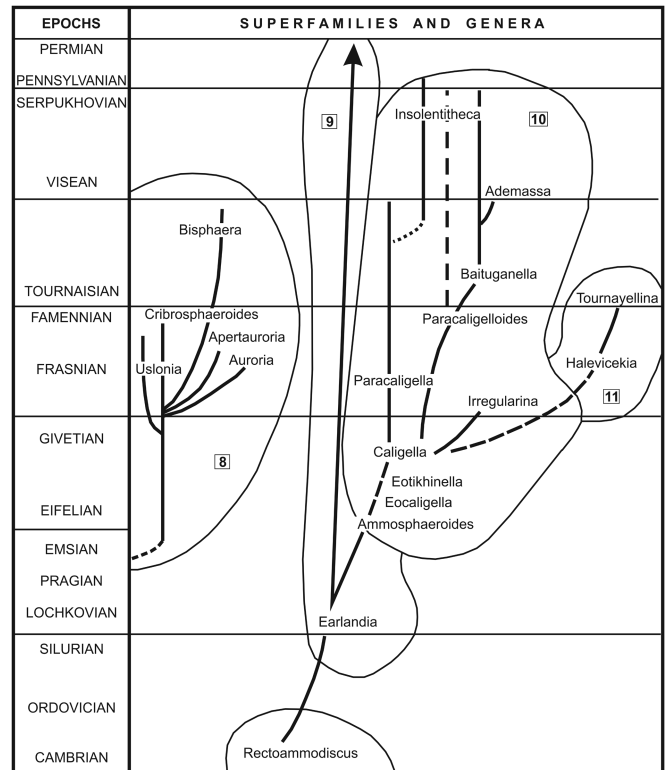


**Figure 6.** Superfamilies, families, and genera of the Parathuramminida. 1: Eovolutinidae; 2: Ivanovellidae; 3: Calcisphaeroidea; 4: Tuberitinoidea; 5: Uralinellidae; 6: Parathuramminidae; 7: Parathuramminitidae.

eovolutinoids, ivanovellids, or parathuramminids (and in this case, “*Parathurammina*” *mirabilis* Saltovskaya, 1981, the diameter of which is 0.80–0.85 mm, may be transitional). The order Parathuramminida encompasses four superfamilies (Vachard, 2016a, and this work: Figs. 6, 7): Parathuramminoidea Rauzer-Chernousova and Fursenko, 1959 nomen correctum Loeblich and Tappan, 1961; Irregularinoidea Gaillot and Vachard, 2007; Tuberitinoidea Gaillot and Vachard, 2007 emend. Vachard, 2016a; and Calcisphaeroidea Vachard, 2016a.

Superfamily Parathuramminoidea Fursenko in Rauzer-Chernousova and Fursenko, 1959 nomen correctum Loeblich and Tappan, 1961 (as Parathuramminacea) and Zadorozhnyi and Yuferev, 1984 (as Parathuramminidea) (non Parathuramminoidea Zadorozhnyi, 1987, described as a suborder) emend. Vachard, 2016a.

**Diagnosis.**—Unilocular free foraminifers. Large central chamber, spherical to polygonal. Apertures inconspicuous or absent (Eovolutinidae emend. herein, even if some intercameral connections may exist in *Rauserina*), perhaps blind (Ivanovellidae)



**Figure 7.** Superfamilies, families, and genera of the Irregularinoidea and Caligelloidea. 8: Irregularinoidea; 9: Earlandioidea; 10: Caligelloidea. 11: Tournayellinidae.

or at the extremity of radiate necks connecting the central chamber with the external environment (Parathuramminidae, Parathurammininae, Parathuramminitinae, and Uralinellidae). Wall thin (e.g., *Eovolutina*) to thick (e.g., *Vicinospaera*), dark-microgranular, occasionally bilayered with an inner hyaline-pseudofibrous layer, rarely more differentiated with possibly three layers. Apertures inconspicuous or absent, some intercameral connections may exist (e.g., *Rauserina*).

**Occurrence.**—Late Silurian–Mississippian, rare to very rare in the Pennsylvanian–Permian; probably cosmopolitan.

**Remarks.**—This superfamily is composed of four families (Fig. 6): Eovolutinidae Loeblich and Tappan, 1986 (synonym of Rauserinidae Sabirov, 1987b); Ivanovellidae Chuvashov and Yuferev in Zadorozhnyi and Yuferev, 1984 emended herein; Parathuramminidae Bykova in Bykova and Polenova, 1955 emend. Vachard, 1994; and Uralinellidae Chuvashov, Yuferev, and Zadorozhnyi in Zadorozhnyi and Yuferev, 1984.

Family Eovolutinidae Loeblich and Tappan, 1986 emend. herein

**Diagnosis.**—Small parathuramminoids, with a proportionally broad central, spherical chamber. Apertures inconspicuous or absent. Wall thin to moderately thick, dark-microgranular.

**Occurrence.**—Questionable in the middle Cambrian, rare in the Ordovician–early Silurian (Vachard, 2016a), present during

the late Silurian–Mississippian, rare to very rare in the Pennsylvanian–Permian.

*Remarks.*—Eovolutinidae (= Rauserinidae) emend. herein encompasses the eovolutinins (with two concentric chambers), rauserinins (with clusters of unilocular chambers), and vicinesphaerins (strictly unilocular) (e.g., the genera *Eovolutina* Antropov, 1950; *Rauserina* Antropov, 1950; *Vicinesphaera* Antropov, 1950; *Archaesphaera* Suleimanov, 1945 [partim]; *Serginella* Pronina, 1963; *Paralagena* Sabirov, 1986; and *?Tscherdyncevella* Antropov, 1950). They are the most primitive parathuramminids due to the presence, among them, of *Vicinesphaera* Antropov, 1950 as early as in the Cambrian of Kazakhstan and the Early Ordovician of Mexico (Vachard et al., 2017). The family Eovolutinidae is often confused with the Archaesphaeridae Poyarkov, 1979 auctorum, which could therefore have priority; nevertheless, it is more probable that *Archaesphaera* Suleimanov, 1945 is a transverse section of *Eotuberitina* Miklukho-Maklay, 1958, and therefore is a tuberitoid rather than a parathuramminoid. However, true *Eotuberitina* seem to appear in Upper Devonian deposits, and an “*Archaesphaera*”, such as that of Flügel and Hötzl (1971, fig. 1.1, 1.2), belongs to another taxon, which are either oblique sections of *Eovolutina* cutting only the external chamber, or oblique sections of *Ivanovella*, which do not pass by the external spines.

Family Ivanovellidae Chuvashov and Yuferev in Zadorozhnyi and Yuferev, 1984

*Diagnosis.*—Small- to moderate-sized unilocular tests with spherical to polygonal central chamber. Radiate to irregularly arranged protuberances of the wall; either unperforated or when possessing a central neck, the latter does not communicate with the external environment. Inconspicuous apertures. Wall dark-microgranular.

*Occurrence.*—Early Ordovician to Late Devonian in Laurussia, Siberia and eastern Paleotethys (Tian Shan and South China).

*Remarks.*—The Ivanovellidae are partly synonymous with Psammosphaeridae sensu Miklukho-Maklay, 1965 (non Haecckel, 1894, nec Cushman, 1927). They are composed of *Ivanovella* Pronina, 1969; *Lechangphaera* Lin, 1984; *Neoivanovella* Chuvashov and Yuferev in Dubatolov, 1981; *Neoarchaesphaera* Miklukho-Maklay, 1963 (non 1958); *Ele-nella* Pronina, 1969; *?Ratella* Kotlyar, 1982; and *?Turcmeniella* Miklukho-Maklay, 1965. The mazzuelloid microproblematika are probably recrystallized (phosphatized) ivanovellids. Mazzuelloids were interpreted as microfossils with an original phosphatized wall (Kozur, 1984), but a secondary phosphatization is more probable (Hüsken and Eiserhardt, 1997; Kremer, 2005; and general discussion of the problems of phosphatization in Porter, 2004 and Zhuralev and Wood, 2008). Hüsken and Eiserhardt (1997) advocated for a phosphatization of the organic wall of acritarchs, but it seems that their illustrations (pl. 1, fig. 15, pl. 2, figs. 1–4) most probably correspond to secondarily phosphatized ivanovellids (perhaps *Neoarchaesphaera* spp.). The material illustrated by Kremer (2005) seems also to belong

to *Neoarchaesphaera*. Moreover, because the mazzuelloids are known from Late Ordovician to Early Devonian, they have a stratigraphic distribution similar to that of the ivanovellids.

Genus *Ivanovella* Pronina, 1969

*Type species.*—*Ivanovella isensis* Pronina, 1969.

*Other species.*—See Chuvashov and Yuferev in Dubatolov (1981) and Zadorozhnyi and Yuferev in Dubatolov (1981).

*Diagnosis.*—Test unilocular, with spherical central chamber and radiate necks, prominent at the periphery and not communicating with the external environment. Inconspicuous apertures. Wall dark-microgranular.

*Occurrence.*—Ludlovian–Pridolian of the central and northern Urals. Late Emsian of Gornyi Altai. Middle Devonian–Frasnian of the Tomsk area (SW Siberia). Late Emsian–Frasnian of southwestern Siberia (the Famennian age indicated by Vdovenko et al., 1993, p. 29, is possibly due to a lapsus calami). Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Ivanovella* sp. 1  
Figure 10.13

*Diagnosis.*—The test is small; the chamber is subhexagonal; the necks are short and subtriangular.

*Occurrence.*—Only one sample in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.08 mm; inner diameter = 0.04 mm; test wall thickness = 0.01 mm.

*Materials.*—Only one specimen (sample POL11a-9).

*Ivanovella* sp. 2  
Fig. 10.14

*Diagnosis.*—The test consists of an irregularly polygonal chamber; the necks are long, thin and triangular.

*Occurrence.*—Only one sample in the Givetian Feldkogel Limestone of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.13 mm; inner diameter = 0.08 mm; test wall thickness = 0.005 mm.

*Materials.*—Only one specimen (sample POL11a-10b).

*Ivanovella* sp. 3  
Figure 10.15

*Diagnosis.*—The test consists of a polygonal chamber with a thick wall; the necks are long, triangular to thin and occasionally curved.

*Occurrence.*—Rare in the Givetian Feldkogel Limestone of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.26 mm; inner diameter = 0.12 mm; test wall thickness = 0.03 mm.

*Materials.*—Three specimens (sample POL11-5).

*Ivanovella reitlingerae* new species

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Figure 10.16, 10.17, 10.22

1965 *Parathuramina* cf. *spinosa* Lipina; Ferrari and Vai, text-fig. 2e.

1971 *Parathuramina aperturata* Pronina; Menner and Reitlinger, p. 29, pl. 8, figs. 2, 7–9.

*Holotype.*—Fig. 10.16 (sample POL11a-38); Institute of Geology, University of Innsbruck, Cat. Nr. P 10139-POL 11a (thin section); early Givetian of Feldkogel Limestone, Polinik Formation, Mount Polinik (Austria).

*Diagnosis.*—An *Ivanovella* with a central chamber subtrapezoidal to subhexagonal, and numerous thin cylindrical necks.

*Occurrence.*—Givetian of Norilsk region (NW Siberia). ?Frasnian of northern Italy. Discovered in the Givetian Feldkogel Limestone of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.21–0.23 mm; inner diameter = 0.12–0.14 mm; test wall thickness = 0.003–0.005 mm; neck diameter (nd) = 0.01–0.02 mm.

*Etymology.*—Named in honor of E.A. Reitlinger who illustrated the taxon.

*Materials.*—A dozen specimens (samples POL11a-23, POL11a-38, and POL11a-40).

*Remarks.*—Differs from *Parathuramina aperturata* by the unilayered wall, the polygonal central chamber, and longer necks; and from the other *Ivanovella* by thinner wall and necks, and more regularly arranged around the central chamber.

*Ivanovella luginensis* Zadorozhnyi and Yuferev in

Dubatolov, 1981

Figure 10.18, 10.20, 10.21

1981 *Ivanovella luginensis* Zadorozhnyi and Yuferev in Dubatolov, p. 56, pl. 1, figs. 5, 9, 10.

1984 *Ivanovella luginensis*; Zadorozhnyi and Yuferev, p. 99, pl. 3, figs. 12, 13.

1988 *Ivanovella luginensis*; Bogush et al., p. 18.

1990 *Ivanovella luginensis* (sic); Bogush and Yuferev, p. 22.

*Holotype.*—Axial section (No. 576/8, IGiG SO AN SSSR) from the Frasnian of the oblast of Tomsk, SW Siberia, Russia (Zadorozhnyi and Yuferev in Dubatolov, 1981, pl. 1, fig. 5).

*Diagnosis.*—Small species characterized by numerous necks, irregularly arranged. Neck short to fairly long. Wall relatively thick.

*Occurrence.*—Late Emsian of Altai, and Frasnian of Tomsk area (SW Siberia, Russia). Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.12–0.15 mm (the type material is even smaller: 0.08–0.13 mm); number of necks: 6–15; length of necks = 0.03–0.05 mm (with a wall from 0.005 to 0.01 mm); test wall thickness = 0.02–0.03 mm.

*Materials.*—25 specimens (samples POL11a-9a, POL11b-18a, and POL11b-21b).

*Ivanovella* sp. 4

Figure 10.19

1994 *Parathuramina stellata* Lipina; Vachard, pl. 2, fig. 8 (only).

*Diagnosis.*—Moderate-size species characterized by few abundant necks, irregularly arranged and short to moderate. Wall relatively thin.

*Occurrence.*—Frasnian of western France. Rare in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.17 mm; inner diameter = 0.09 mm; number of necks: six; length of necks = 0.05–0.06 mm; test wall thickness = 0.01–0.02 mm.

*Materials.*—Three specimens (sample POL11a-8).

Genus *Neoarchaesphaera* Miklukho-Maklay, 1963  
(non 1958)

*Type species.*—*Neoarchaesphaera bykova* Miklukho-Maklay, 1963 (= *Archaesphaera magna* sensu Bykova in Bykova and Polenova, 1955 non Suleimanov, 1945 = *Neoarchaesphaera magna* Miklukho-Maklay sensu Loeblich and Tappan, 1987).

*Other species.*—See Zadorozhnyi and Yuferev in Dubatolov (1981).

*Diagnosis.*—Small-sized Ivanovellidae with an irregular angular-rounded to spherical profile. Central chamber spherical, relatively broad. Fairly abundant papilliform to longer protuberances, as radiate necks, prominent at the periphery and not communicating with the central chamber. Inconspicuous apertures. Wall dark-microgranular.

*Occurrence.*—Early Ordovician of Sonora (Mexico; Vachard et al., 2017). Silurian of the Urals and Poland. Late Emsian of Gornyi Altai. Late Silurian–Early Devonian Zeravshano-Gissar (Saltovskaya, 1981 as *Parathuramina* [partim]). Relatively frequent and probably widespread during the Devonian (with e.g., *Parathuramina* sensu Malakhova, 1969, pl. 48, figs. 330, 331, pl. 49, fig. 337); *Parathuramina?* sensu Racki and



Soboń-Podgórska (1993, text-fig. 9a–c); and “*Thurammina* without marked projections” sensu Holcová and Slavík (2013, text-fig. 3). Late Devonian of the Urals and western Siberia (Russia) Kok Shaal and Tian Shan (Kyrgyzstan), and southern Fergana (Uzbekistan).

**Description.**—See discussions in Loeblich and Tappan (1987) and Vdovenko et al. (1993). *Parathurammina spinosa* sensu Grozdilova and Lebedeva (1954, pl. 2, fig. 3) is a *Neoarchaesphaera*, whereas other specimens figured by Grozdilova and Lebedeva (1954, pl. 2, figs. 1, 2) belong to *Salpingothurammina*.

**Remarks.**—In the literature, *Neoarchaesphaera* has been described under the names *Parathurammina* (partim); *Archaesphaera* (partim), *Salpingothurammina* auctorum, and Calcispheric structure sensu Kaźmierczak and Kremer (2005, figs. 6B, 7B, C).

*Neoarchaesphaera ellipsoidalis* (Poyarkov, 1969)

Figure 9.9

- 1969 *Parathurammina* (*Salpingothurammina*) *ellipsoidalis* Poyarkov, p. 89, pl. 1, fig. 9.  
 1971 *Parathurammina ellipsoidalis*; Menner and Reitlinger, p. 29, pl. 8, figs. 1, 3, 6.  
 1979 *Parathurammina* (*Salpingothurammina*) *ellipsoidalis*; Poyarkov, text-fig. 14.  
 1981 *Parathurammina* (*Salpingothurammina*) *ellipsoidalis*; Petrova, pl. 6, fig. 10.  
 1981 *Parathurammina ellipsoidalis*; Zadorozhnyi, p. 111 (no. 21 of the table).  
 1990 *Bykovaella ellipsoidalis* (Poyarkov); Bogush and Yuferev, p. 20.  
 2008 *Parathurammina ellipsoidales* (sic); Anfimov, p. 78.

**Holotype.**—Axial section (No. 225/70; Akademiya Nauk SSSR) from the Givetian of Fergana, Turkmenistan (Poyarkov, 1969, pl. 1, fig. 9).

**Diagnosis.**—Small species characterized by numerous necks, irregularly arranged, short to moderate. Wall relatively thin.

**Occurrence.**—Eifelian of the northern Urals; Givetian of Norilsk area (NW Siberia); Givetian–Frasnian of southern Fergana (Uzbekistan); Givetian of Mount Polinik (Carnic Alps, Austria).

**Description.**—Outer diameter = 0.22–0.30 mm (type material: 0.23–0.30 mm); number of necks: 10–14; length of necks = 0.17–0.22 mm (with a wall of 0.015–0.045 mm); test wall thickness = 0.01–0.03 mm.

**Materials.**—10 specimens (sample POL11a-29).

*Neoarchaesphaera?* sp.

Figure 9.3

**Diagnosis.**—Small species characterized by numerous necks, irregularly arranged and short to moderate. Wall relatively thin, dark-microgranular; a very thick fibrous inner layer is present, but seems to be more diagenetic than eogenetic. The specimen is questionably assigned to *Neoarchaesphaera*.

**Occurrence.**—Givetian of Mount Polinik (Carnic Alps, Austria).

**Description.**—Outer diameter = 0.13 mm; inner diameter = 0.15 mm; number of necks: 6–9; length of necks = 0.025 mm (with a wall of 0.008 mm); test wall thickness = 0.006 mm. The ontogenetic wall is dark-microgranular; a very thick fibrous inner layer is present, but seems more diagenetic than eogenetic. The specimen is questionably assigned to *Neoarchaesphaera*.

**Materials.**—One specimen (sample POL11a-20).

Genus *Elenella* Pronina, 1969

**Type species.**—*Neoarchaesphaera* (*Elenella*) *multispinosa* Pronina, 1969.

**Other species.**—See Vachard (1991).

**Diagnosis.**—Small-sized Ivanovellidae with a spherical central chamber, relatively broad. Fairly abundant papilliform to longer protuberances, as radiate necks (or trabecules), prominent at the periphery and not communicating with the central chamber. Inconspicuous apertures. Wall dark-microgranular in the protuberances and grayish in the spaces between the protuberances.

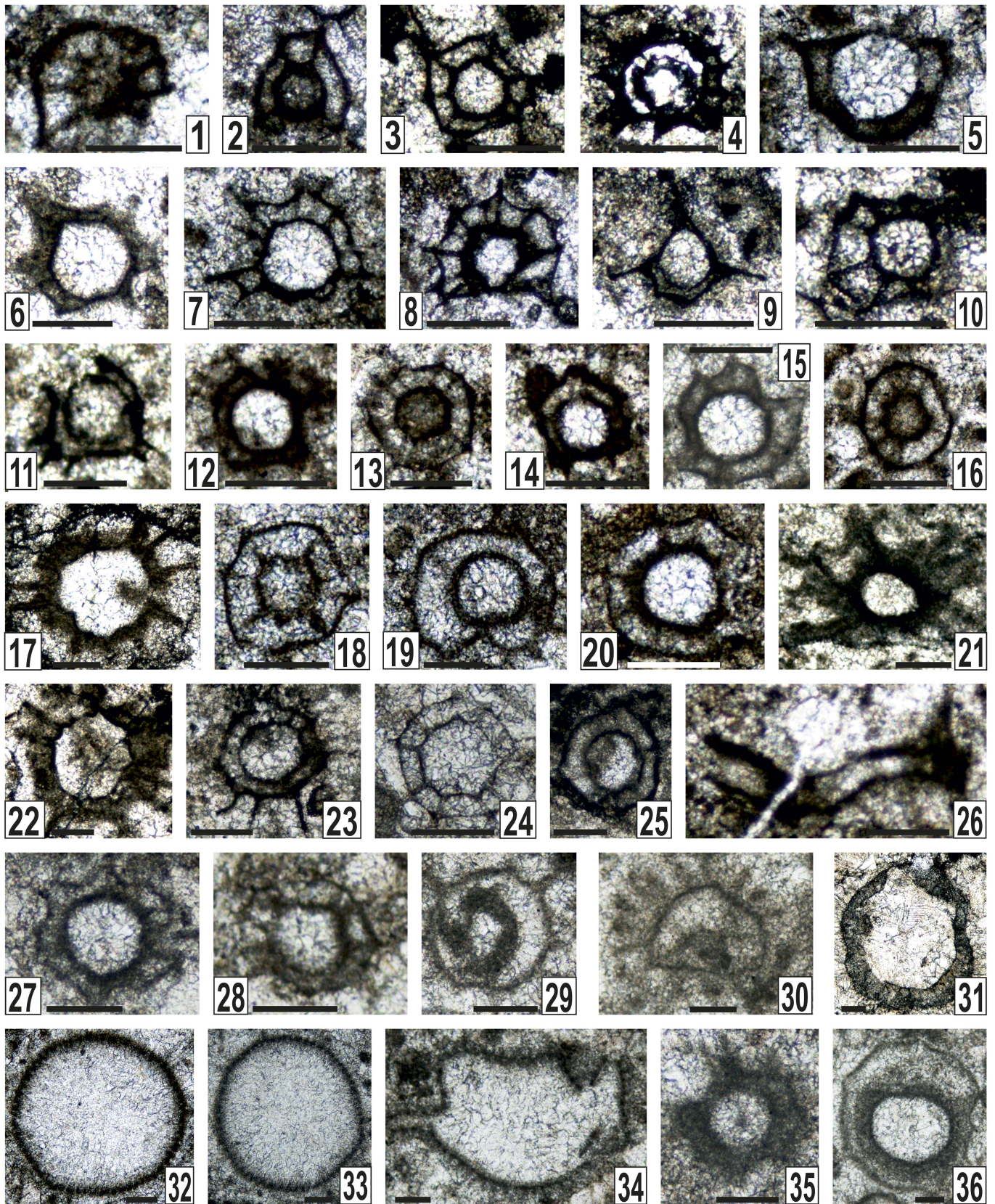
**Occurrence.**—Ludlovian–Pridolian of the Urals (Petrova and Pronina, 1980), and late Emsian of northern Spain (Vachard, 1991).

**Remarks.**—Assigned to “algal spore cysts” by Toomey and Mamet (1979), considered as a foraminifer in the Russian literature and by Loeblich and Tappan (1987) and Vachard (1991), this genus remains poorly known. In the literature, it corresponds partially to some *Archaesphaera* and *Neoarchaesphaera*.

*Elenella* cf. *E. losvica* (Petrova, 1981)

Figure 8.5, 8.6, 8.9, 8.15, 8.35

**Figure 8.** (1–3, 10, 11, 14, 25) *Uralinella antiqua* Petrova, 1981: (1) sample POL11-11; (2) sample POL11a-1; (3) sample POL11a-28; (10) sample POL11a-27; (11) sample POL11a-27; (14) sample POL11b-16; (25) sample POL 13b-3. (4?, 7, 8, 13, 16, 18?, 24?) *Uralinella sabirovi* n. sp.: (4) paratype?, sample POL11a-26; (7) paratype, sample POL11a-5; (8) holotype, sample POL11a-3; (13) paratype, sample POL11b-19c; (16) paratype, sample POL11b-23; (18) paratype?, sample POL13a-2; (24) paratype?, sample POL13b-8. (5, 6, 9, 15, 35) *Elenella* cf. *E. losvica* (Petrova, 1981); (5) sample POL11-8; (6) sample POL11a-26a; (9) sample POL11a-14a; (15) sample POL11b-19c; (35) sample POL14-6a. (12?, 17, 19, 20, 21?, 22, 27, 28) *Elenella polinikensis* n. sp.: (12?) paratype?, sample POL11b-14; (17) paratype, sample POL13a-1a; (18) paratype, sample POL13a-2; (19) paratype, sample POL13a-3; (20) holotype, sample POL13b-4; (21?) paratype?, sample POL 13a-5a (see also the morphotaxon *Ratella*); (22) paratype, sample POL13a-5; (27) sample POL13b-6; (28) paratype, sample POL13b-11. (23) *Elenella* sp. 3, sample POL14-9. (26) *Paracaligella* ex gr. *antropovi* Lipina, 1955, sample POL11b-14a. (29) *Bithurammina?* sp., sample POL14-7. (30) *Auroria* cf. *A. singularis* Poyarkov, 1969, sample POL14-17. (31) *Auroria* cf. *A. triangularis* Saltovskaya, 1981, sample POL13a-4. (32, 33) *Cribrosphaeroides* (*Parphia*) *robusta* Miklukho-Maklay, 1965; (32) sample POL13a-1; (33) sample POL13b-1. (34) *Uslonia* cf. *U. incomposita* (Petrova, 1981), sample POL13b-12. (36) *Auroria?* sp. Givetian of Mount Polinik (Carnic Alps, Austria); sample POL14-8. Scale bars = 0.1 mm.



- 1981 *Parathuramina? losvica* Petrova, p. 89, pl. 7, figs. 13, 14, 16, 17.  
 1984 *Uralinella losvica* (sic); Zadorozhnyi and Yuferev, p. 97, pl. 3, figs. 3–5.  
 1987 *Uralinella losvica*; Zadorozhnyi, pl. 2, figs. 21–23.  
 1988 *Uralinella losvica* (sic); Bogush et al., p. 32.  
 1990 *Uralinella losvica*; Bogush and Yuferev, p. 22.  
 2008 *Parathuramina losvica*; Anfimov, p. 78.  
 2013 *Saltovskajina losvica*; Makarenko and Savina, p. 128.  
 2016a *Ellenella* spp.; Vachard, fig. 3.5, 3.6, 3.9, 3.15, 3.35.

*Holotype*.—Axial section (No. 23/1868, UTGU) from the Eifelian of the northern Urals, Russia (Petrova, 1981, pl. 7, fig. 13).

*Diagnosis*.—Small species for the genus, characterized by a moderate number of necks, a relatively broad inner spherical chamber and a polygonal external chamber.

*Occurrence*.—Eifelian–Givetian of the western slope of the middle and northern Urals. Eifelian of the Tomsk area (SW Siberia). Givetian–Frasnian of the southeastern part of the western Siberian Plain. Discovered in the early Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.18–0.21 mm; inner diameter = 0.06–0.10 mm; number of necks: (3)–6–8; test wall thickness(s) = 0.02–0.05 mm.

*Remarks*.—As for *E. losvica*, the taxon shares a wall of uralinellid with a shape of parathuraminid; our material slightly differs from *E. losvica* by the less acute shape of protuberances. As indicated by our synonymy list, the genus assignment and the species spelling vary in the literature.

*Materials*.—20 specimens (samples POL11-8, POL11a-14a, POL11b-19c, POL11a-26a, and POL14-6a).

*Elenella polinikensis* new species

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Figure 8.12?, 8.17–8.20, 8.21?, 8.22, 8.27, 8.28

- 2014 Parathuraminid; Mörtl, text-figs. 33e, 33g.  
 2016a *Uralinella* spp.; Vachard, fig. 3.12, 3.17–3.20, 3.21, 3.22, 3.27, 3.28.

*Holotype*.—Fig. 8.20 (sample POL13a-4); Institute of Geology, University of Innsbruck, Cat. Nr. P 10141-POL 13a (thin section); early Givetian of Feldkogel Limestone (Polinik Formation); Mount Polinik (Austria).

*Diagnosis*.—*Elenella* relatively large, spherical, but generally peripherally poorly preserved. Central chamber subpolygonal with thick dark-microgranular wall. Necks more regular and thinner than the wall. Peripheral thin, dark-microgranular wall. Intermediary wall grayish recrystallized/filled by microsparite.

*Occurrence*.—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.16–0.36 mm; inner diameter = 0.08–0.17 mm; inner chamber wall thickness = 0.01–0.03 mm; outer chamber wall thickness = 0.06–0.08 mm; number of necks: 8–14 (their width is 0.01–0.02 mm).

*Etymology*.—After Mount Polinik (Carnic Alps, Austria).

*Remarks*.—Similar to the upper Emsian species *E. monielli* Vachard, 1991, the new species differs by a larger central chamber with a thicker wall, and fewer necks/trabecules within the wall.

*Materials*.—25 specimens (samples ?POL11b-14, POL13a-1a, POL13a-2, POL13a-3, POL13a-5, ?POL13a-5a, POL13b-4, POL13b-6, and POL13b-11).

*Elenella* sp. 3  
 Figure 8.23

*Diagnosis*.—The test is composed of two almost spherical, concentric chambers; the necks are long, thin and occasionally curved.

*Occurrence*.—Givetian of Mount Polinik (Carnic Alps, Austria).

*Materials*.—Only one specimen (sample POL14-9).

Family Uralinellidae Chuvashov, Yuferev and Zadorozhnyi in Zadorozhnyi and Yuferev, 1984

*Diagnosis*.—Test bilocular, probably attached, at least temporarily. Inner chamber spherical, central or excentered. Outer chamber, larger, polygonal to ellipsoidal or subspherical. Radiate necks crossing through the space between the two chambers and often prominent at the periphery. Aperture inconspicuous or single at the extremity of each neck. Wall dark-microgranular, although this interpretation is often discussed.

*Occurrence*.—Late Silurian (Ludlovian)–latest Viséan of western and central Europe, former USSR (the Urals, Preural, eastern Russian Platform, western Siberia, Kyrgyzstan, and Tajikistan), up to early Tournaisian in South China, Vietnam, and Australia.

*Remarks*.—The family Uralinellidae encompasses the following taxa: *Uralinella* Bykova, 1952; radiospherid calcispheres forms A and C sensu Veevers (1970, pl. 46, figs. 1–3, pl. 47, figs. 1–5); *Sogdanina* Saltovskaya, 1974; *Arakavaella* Pronina, 1963; *Maclayina* Saltovskaya, 1981; *Ivdelina* Malakhova, 1963 (= “well-preserved radiosphaerid calcispheres” sensu Berkyova and Munnecke, 2010, fig. 3A–D, 3F–I); *?Radiina* Reitlinger, 1957; and *?Algaeformis* Anfimov, 2012. Contrary to Vachard (1994), we consider that the latest Viséan genus *Sogdanina* is not synonymous with the Devonian genus *Uralinella* because its intermediary layer of the wall is entirely calcified (see for example *Sogdanina* sp. illustrated by Sanz-Lopez et al., 2005, pl. 6, fig. 9, under the name of *Uralinella* cf. *U. augusta*

Sabirov). *Ivdelina* and “well-preserved radiosphaerid calcispheres” (sensu Berkyova and Munnecke, 2010, p. 588) belong either to the Uralinellidae or to the Tuberinidae. The genus *Algaeformis*, initially assigned to the Uralinellidae, more probably belongs to the Auroriidae as redefined herein, as well as the genus *Radiina*.

Genus *Uralinella* Bykova, 1952

*Type species.*—*Uralinella bicamerata* Bykova, 1952.

*Other species.*—See Zadorozhnyi and Yuferev (1984) and Vachard (1994).

*Diagnosis.*—Uralinellidae with a well-developed, polygonal to subspherical outer chamber. Radiate necks crossing through the space between the two chambers, and markedly prominent at the periphery. Aperture single at the extremity of each neck. Wall dark-microgranular, apparently formed by an inner layer around the inner chamber, and an outer layer at the periphery. Calcified wall of the necks and hollow intermediary spaces secondarily filled by neosparite.

*Occurrence.*—Early Devonian of Tajikistan. Late Devonian of northern Spain. Middle Devonian of the northern and central Urals, western Siberia, Zeravchan Gissar and Turkestan ranges (Kyrgyzstan, Tajikistan). Givetian of western France and Morocco. Late Devonian of Molotov area, Bashkortostan, Tatarstan, Urals, and SW Siberia (Russia), Moravia (Czech Republic), and Belgium. Latest Famennian–early Tournaisian of Greece (Vachard and Clément, 1994), central Urals (Chuvashov, 1965), Tian Shan (Poyarkov, 1969), South China (Wang, 1987), Vietnam (Doan in Tong et al., 1988) and Australia (Veevers, 1970; Stephens and Sumner, 2003).

*Uralinella antiqua* Petrova, 1981

Figure 8.1–8.3, 8.10, 8.11, 8.14, 8.25

- 1981 *Uralinella antiqua* Petrova, p. 93, pl. 11, figs. 15–18.  
 1984 *Uralinella antiqua*; Sabirov, pl. 2, fig. 6.  
 1984 *Uralinella antiqua*; Zadorozhnyi and Yuferev, p. 97, pl. 3, figs. 6–8.  
 1985 *Uralinella antiqua*; Zadorozhnyi, pl. 17, fig. 15.  
 1987 *Uralinella antiqua*; Zadorozhnyi, p. 34, pl. 3, figs. 1, 2.  
 1988 *Uralinella antiqua*; Bogush et al., p. 32.  
 1990 *Uralinella antiqua*; Bogush and Yuferev, p. 21.  
 2008 *Uralinella antiqua*; Anfimov, p. 78.  
 2008 *Uralinella antique* (sic); Tsyganko, p. 71, text-fig. 3.  
 2008 *Uranovella antique* (sic); Tsyganko, p. 73.  
 2013 *Uralinella antiqua*; Makarenko and Savina, p. 128.

*Holotype.*—Axial section (No. 92/1868, UTGU) from the Middle Devonian of the northern Urals, Russia (Petrova, 1981, pl. 11, fig. 17).

*Diagnosis.*—Small species for the genus, characterized by a relatively broad inner spherical chamber, a relatively small external polygonal chamber, and a few necks.

*Occurrence.*—Early Devonian of Tajikistan and western Siberia. Eifelian of Tomsk area (SW Siberia). Middle Devonian of the northern and central Urals. Frasnian of SW Siberia. Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Test outer diameter = 0.09–0.18 mm (0.09–0.12 mm; rarely 0.18–0.20 mm for the type material); test inner diameter = 0.05–0.12 mm (0.05–0.09 mm for the type material); number of necks: 3–6 (4–5 for the type material); inner diameter of necks = 0.005–0.008 mm; test wall thickness = 0.005–0.001 mm (0.008–0.013 mm for the type material).

*Materials.*—24 specimens (samples POL11-11, POL11-13, POL11a-1, POL11a-27, POL11a-27a, POL11a-28, POL11b-16, 25, and POL13b-3).

*Uralinella sabirovi* new species

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Figure 8.4?, 8.7, 8.8, 8.13, 8.16, 8.18?, 8.24?

2016a *Uralinella* spp.; Vachard, fig. 3.4?, 3.7, 3.8, 3.13, 3.16, 3.18?, 3.24?.

*Holotype.*—Fig. 10.8 (sample POL11a-3); Institute of Geology, University of Innsbruck, Cat. Nr. P 10139-POL 11a (thin section); Givetian of the Feldkogel Limestone (Polinik Formation); Mount Polinik (Austria).

*Diagnosis.*—This species of *Uralinella* is characterized by the greater number of canals; small size; thin wall, and a festooned profile of the second chamber.

*Occurrence.*—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer chamber = 0.12–0.23 mm; inner chamber = 0.06–0.10 mm; number of canals: 9–12, mainly 10; test wall thickness = 0.005–0.006 mm, rarely 0.01 mm.

*Etymology.*—Named in honor of A.A. Sabirov, for his contributions to parathuramminid micropaleontology.

*Materials.*—10 specimens (samples POL11a-3, POL11a-5, ?POL11a-26, POL11b-19c, POL11b-23, ?POL13a-2, and ?POL13b-8).

*Remarks.*—Differs from *U. antiqua* by the greater number of canals, and from *U. bicamerata* and *U. parva* Sabirov, 1974 by a smaller size, more canals, and a festooned profile of the second chamber.

Family Parathuramminidae Bykova in Bykova and Pologova, 1955 emend. Vachard, 1994

*Diagnosis.*—Test free or rarely attached, unilocular with a globular to polygonal chamber with rare to abundant tubular, mamillate, or subconical projections variously arranged and developed; wall dark-microgranular, occasionally with an inner

pseudofibrous layer, or recrystallized and in this case mimicing the agglutinated wall of the homeomorphous *Thurammininae*. Aperture at the end of the projections, on the surface, or inconspicuous.

*Occurrence.*—?Early Cambrian of Russia (Winchester-Seeto and McIlroy, 2006; as *Thurammina?* sp.); Ordovician–Mississippian; probably cosmopolitan at least during their acme during the Givetian–Frasnian. The last, Mississippian, well-represented genus is *Hemithurammina* Mamet, 1973 (see Perret and Vachard, 1977); in younger strata, the parathuramminids are very rare and doubtful (Nguyễn, 1986, pl. 1, fig. 15).

*Remarks.*—Parathuramminidae is synonymous with Thurammininae Miklukho-Maklay, 1963 (partim); Chrysothuramminidae Loeblich and Tappan, 1986; and Dagmarellinae Chuvashov, Yuferev, and Zadorozhnyi in Zadorozhnyi and Yuferev, 1984, which is a nomen nudum because *Dagmarella* is an invalid genus. Parathuramminidae includes two subfamilies: Parathurammininae Bykova in Bykova and Polenova, 1955 emend. Vachard, 1994; and Parathuramminitinae Antropov, 1970. The collective morphogenus *Parathurammina* Suleimanov, 1945 was progressively subdivided into numerous genera or subgenera: *Salpingothurammina* Poyarkov in Purkin et al., 1961; *Parathuramminites* Antropov in Poyarkov, 1969; *Chrysothurammina* Neumann, Pozaryska, and Vachard, 1975; *Saltovskajina* Sabirov, 1982b; *Cordatella* Petrova in Zadorozhnyi and Yuferev, 1984; *Marginara* Petrova in Zadorozhnyi and Yuferev, 1984 (nomen correctum Loeblich and Tappan, 1986 for *Margarinarae*, incorrect name because in the plural); *Suleimanovella* Yuferev in Zadorozhnyi and Yuferev, 1984; *Cushmanella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984 (pre-occupied); *Bykovaella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984; *Radiosphaerella* Yuferev in Zadorozhnyi and Yuferev, 1984; *Kolongella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984; and *Polygonella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984.

All these taxa were considered to be homeomorphs of the extant agglutinating genus *Thurammina* Brady, 1879, which is, however, undoubtedly known only from Jurassic deposits (e.g., Häusler, 1883; Kaźmierczak, 1973; Munk, 1994; Guilbault et al., 2006; Reolid et al., 2008; Reolid and Molina, 2010). *Parathurammina* sensu stricto is one of these Devonian foraminiferal genera, which shows a dark-microgranular wall in shallow water, transformed into an agglutinating and/or recrystallized wall in deeper waters (Vachard et al., 2010; Vachard, 2016a). The name *Parathurammina* is therefore entirely appropriate to replace the Paleozoic *Thurammina* of the literature. Similarly, other names could be given to the Paleozoic representatives of *Saccamina*, *Rhabdammina*, *Bathysiphon*, etc. A parathuramminid character, which is unusual among the foraminifers, is the presence of double chambers joined together; examples are known in *Bithurammina*, *Bisphaera*, *Bituberitina*, *Eovolutina*, and various parathuramminidae and uralinellidae (e.g., Grozdilova and Lebedeva, 1954, pl. 2, fig. 9; Reitlinger, 1962, pl. 2, fig. 1; Miklukho-Maklay, 1965, pl. 2, fig. 2; Chuvashov, 1965, pl. 3, fig. 7; Poyarkov, 1969, pl. 3, fig. 10; Brunner, 1975, pl. 2, fig. 7, 1976, pl. 4, fig. 9; Poyarkov, 1979, pl. 6, fig. 6; Zukalova, 1981, pl. 2, figs. 1, 2; Petrova, 1981, pl. 11,

figs. 3, 5; Kotlyar, 1982, text-fig. 4; Lin and Hao, 1982, pl. 1, fig. 24; Doan in Tong et al., 1988, pl. 1, fig. 4; Vachard and Clément, 1994, pl. 2, fig. 8). If the external additional chamber is often questionable (except for *Parathurammina praetuberculata ramosa* Reitlinger, 1962, pl. 1, fig. 7), internal chambers are most significant, as for example, in *Parathurammina* (?) aff. *P. dagmarae* (sic) sensu Grozdilova and Lebedeva, 1954, pl. 2, figs. 7, 8; and *Parathurammina* sp. (Grozdilova and Lebedeva, 1954, pl. 2, fig. 9; Reitlinger, 1962, pl. 2, fig. 1; and Poyarkov, 1969, pl. 3, fig. 10). These forms have been termed *Bithurammina* Miklukho-Maklay, 1963, even if this taxon remains invalid because its type species, *Parathurammina* (?) aff. *P. dagmarae* sensu Grozdilova and Lebedeva, was never correctly re-named (see Miklukho-Maklay, 1965; Ektova, 1968; Poyarkov, 1969, 1979; Kotlyar, 1982; Doan in Tong et al., 1988; Vachard, 1991).

#### Subfamily Parathurammininae Bykova in Bykova and Polenova; 1955 emend. Vachard, 1994

*Diagnosis.*—Test free, moderate to large in size, globular with many papilliform projections; thin wall unilayered dark-microgranular, or bilayered with an additionally inner pseudofibrous layer. One distal, areal aperture at the end of each projection.

*Occurrence.*—Ordovician–early Viséan; probably cosmopolitan.

*Remarks.*—Synonym of Parathurammininae (sic) Zadorozhnyi, 1987 and Dagmarellinae Chuvashov, Yuferev and Zadorozhnyi in Zadorozhnyi and Yuferev, 1984 (nomen nudum; see earlier), this subfamily encompasses the genera: *Parathurammina* Suleimanov, 1945; *Bykovaella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984; *Kolongella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984; and ?*Bithurammina* Miklukho-Maklay, 1965 non 1963.

#### Genus *Parathurammina* Suleimanov, 1945

*Type species.*—*Parathurammina dagmarae* Suleimanov, 1945.

*Other species.*—*Parathurammina arguta* Pronina, 1960; *P. eodagmarae* Reitlinger, 1954; *P. graciosa* Pronina, 1960; *P. kokschaalica* Ektova, 1968; *P. magna* Antropov, 1950; *P. oldae* Suleimanov, 1945; *P. parabreviradosa* Saltovskaya, 1981; *P. paradagmarae* Grozdilova and Lebedeva, 1954; *P. uralica* Petrova, 1981; ?*P. cordata* Pronina, 1960; ?*P. eoarguta* Sabirov, 1984; ?*P. marginara* Pronina, 1960; ?*P. tamarae* Petrova, 1981 (eventually with a median layer, more or less diaphanothecal, within the external dark layer, supposed characteristic of *Cordatella* and/or *Marginara*); ?*Thurammina adamsi* Conkin and Conkin, 1964; ?*T. arcuata* Moreman, 1930; ?*T. arenacorna* Gutschick, Weiner, and Young, 1961; ?*T. echinata* Dunn, 1942; ?*T. elegans* Dunn, 1942; ?*T. elliptica* Moreman, 1930; ?*T. foerstei* Dunn, 1942 (= *Amphitremonoidea* according to Nestell and Tolmacheva, 2004); ?*T. globosa* Ireland, 1939; ?*T. hexagona* Dunn, 1942; ?*T. ?hexactinellida* Dunn, 1942; ?*T. irregularis* Moreman, 1930; ?*T. inflata* Dunn, 1942; ?*T. jubata* Dunn, 1942; ?*T. lawrencensis* Ireland, 1956; ?*T. limbata* Dunn, 1942; ?*T. limbata* var. *disciformis* Dunn, 1942; ?*T. magna* Dunn, 1942; ?*T. melleni* Dunn, 1942;

?*T. papillata* Moreman, 1930; ?*T. papillata* var. *monticulifera* Ireland, 1939; ?*T. parvituba* Dunn, 1942 (= *Amphitremonoidea* according to Nestell and Tolmacheva, 2004); ?*T. phasela* Moreman, 1930; ?*T. polygona* Ireland, 1939; ?*T. pustulosa* Gutschick, Weiner, and Young, 1961; ?*T. quadrata* Dunn, 1942; ?*T. sphaerica* Ireland, 1939; ?*T. subpapillata* Ireland, 1939; ?*T. tubulata* Moreman, 1930; and ?*T. micropapillata* Blumenstengel, 1961, perhaps belong to *Parathuramina*, even if the microstructure of their wall remains unknown.

**Diagnosis.**—Test free, moderate to large in size, globular with many papilliform projections; thin wall dark-microgranular with an inner pseudofibrous layer. One distal, areal aperture at the end of each projection.

**Occurrence.**—Ordovician–Mississippian; cosmopolitan.

**Remarks.**—*Parathuramina* s.s. is partially synonymous with *Thuramina* (partim), ?*Cordatella* (partim), ?*Marginara* (partim), and ?*Guangxithuramina* Lin et al., 1990. The genus *Chrysothuramina* Neumann, Pozaryska, and Vachard, 1975 differs from *Parathuramina* because the pseudofibrous layer of the wall that surrounds the inner chamber also penetrates the necks.

*Parathuramina graciosa* Pronina, 1960  
Figures 9.4, 9.6, 9.7, 9.15, 9.19–9.23, 9.27, 9.28?, 10.2

- 1960 *Parathuramina graciosa* Pronina, p. 47, pl. 1, figs. 1, 2.  
1969 *Parathuramina graciosa*; Malakhova, pl. 51, figs. 350, 351, 355.  
1969 *Parathuramina* cf. *graciosa*; Malakhova, pl. 48, fig. 329, pl. 51, fig. 361.  
1969 *Parathuramina* (*Salpingothuramina*) *graciosa*; Poyarkov, table 19.  
1971 *Parathuramina graciosa*; Menner and Reitlinger, p. 29, pl. 8, fig. 5.  
1979 *Parathuramina graciosa*; Lavrusevich et al., p. 322.  
1979 *Parathuramina* (*Salpingothuramina*) *graciosa*; Poyarkov, text-fig. 14.  
1981 *Parathuramina graciosa*; Petrova, pl. 8, figs. 4, 5, 8.  
1985 *Parathuramina graciosa*; Zadorozhnyi, p. 126, 131?, pl. 17, fig. 1, pl. 18, figs. 1, 2.  
1990 *Parathuramina graciosa*; Bogush and Yuferev, p. 20.  
2008 *Parathuramina graciosa*; Anfimov, p. 78.  
2011 *Parathuramina graciosa*; Anfimov, p. 16.  
2014 *Parathuraminide*; Mörtl, text-fig. 33b.

**Holotype.**—Axial section (No. 476/3 Museum of the Geological Direction of the Urals) from the early Givetian of the central Urals, Russia (Pronina, 1960, pl. 1, fig. 1).

**Diagnosis.**—Relatively large species characterized by a large central chamber, and numerous necks, asymmetrically arranged. Neck short, with a narrow central channel, entirely cylindrical (i.e., with neither proximal nor distal enlargement). Wall thin, bilayered, dark-microgranular, and hyaline-microgranular.

**Occurrence.**—Middle Eifelian–early Givetian of eastern slope of the central Urals. Givetian of northern and southwestern

Siberia and Zeravshano-Gissar (Tajikistan). Frasnian of SW Siberia (Bogush et al., 1975). Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

**Description.**—Test outer diameter = 0.15–0.31 mm (type material: 0.09–0.27 mm); central chamber diameter = 0.12–0.20 mm; number of necks: 11–13; length of necks = 0.004–0.13 mm (for a wall thickness of 0.008 to 0.01 mm); test wall thickness = 0.003–0.007 mm (type material: 0.004–0.007 mm).

**Materials.**—32 specimens (samples POL3-1a, POL11-1, POL11-2, POL11-7, POL11-9, POL11a-4, POL11a-10, POL11a-14, POL11a-21, POL11a-24, ?POL11a-39).

*Parathuramina* cf. *P. uralica* Petrova, 1981  
Figures 9.13, 9.14, 9.18, 10.1, 10.10

- 1981 *Parathuramina uralica* Petrova, p. 86, pl. 6, figs. 3, 5, 6.  
1990 *Bykovaella uralica*; Bogush and Yuferev, p. 21.  
?2009 *Parathuramina crassithecica* Antropov; Mamet and Pr eat, fig. 1.19 only (non fig. 1.18 = *Kolongella*).  
2011 *Parathuramina uralica*; Anfimov, p. 16.

**Holotype.**—Axial section (No. 3/1868; Geological Museum of the Urals UTGU) from the Eifelian of the northern Urals, Russia (Petrova, 1981, pl. 6, fig. 3).

**Diagnosis.**—Relatively large species characterized by numerous necks, asymmetrically arranged. Neck short, with a narrow central channel, entirely cylindrical (i.e., without proximal or distal enlargement). Wall thin, bilayered, dark-microgranular, and hyaline-microgranular.

**Occurrence.**—Eifelian of the northern and central Urals. Doubtful in the late Eifelian of Belgium. Givetian of SW Siberia. Givetian of Mount Polinik (Carnic Alps, Austria).

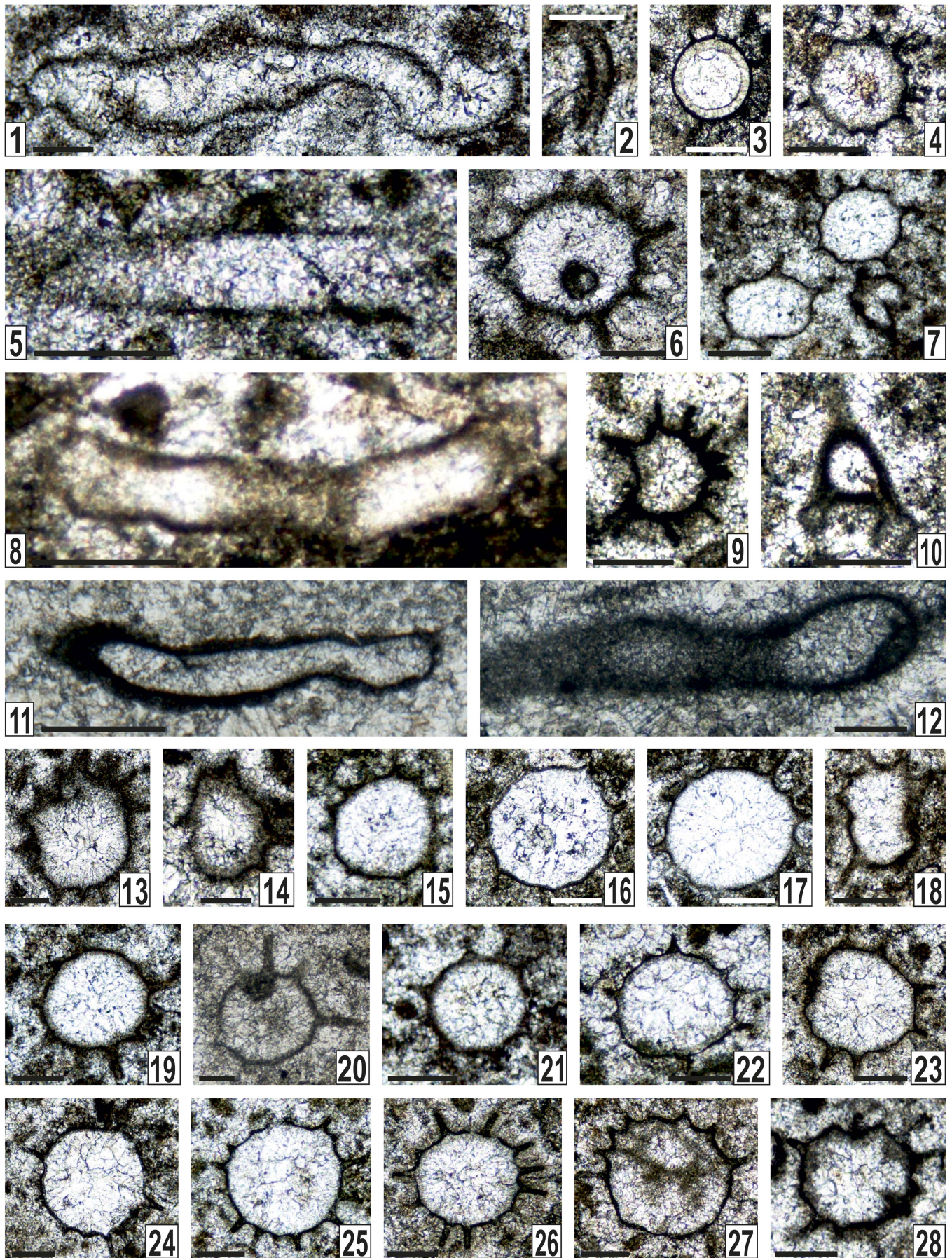
**Description.**—Outer diameter = 0.17–0.40 mm (type material: 0.13–0.24 mm); inner diameter = 0.14–0.30 mm; length of necks = 0.03–0.04 mm (for a wall of 0.01–0.02 mm); test wall thickness = 0.015–0.04 mm (type material: 0.015–0.03 mm).

**Materials.**—12 specimens (samples POL3-1, POL3-2, POL11, POL11b-12a, POL13a-2b).

**Remarks.**—This species might be a homeomorph of *Bykovaella irregulariformis* (Zadorozhnyi and Yuferev, 1984) and/or *B. oblisa* (Petrova, 1981), but it has a bilayered wall and consequently belongs to *Parathuramina*. In this genus, *P. uralica* is the most similar species compared to our taxon.

*Parathuramina arguta* Pronina, 1960  
Figures 9.26, 10.7 (partim), 10.9, 10.10

- 1960 *Parathuramina arguta* Pronina, p. 7, pl. 1, fig. 5.  
1969 *Parathuramina arguta*; Poyarkov, table 12.  
1979 *Parathuramina arguta*; Lavrusevich et al., p. 323.  
1979 *Parathuramina* (*Parathuramina*) *arguta*; Poyarkov, text-fig. 13.



- 1981 *Parathuramina* (*Parathuramina*) *aperturata*; Petrova, pl. 7, figs. 9–11.  
 1985 *Parathuramina arguta*; Zadorozhnyi, p. 127, pl. 17, fig. 6.  
 2013 *Parathuramina arguta*; Makarenko and Savina, p. 128.  
 2014 Parathuraminide; Mörtl, text-fig. 33a.

*Holotype*.—Axial section (No. 476/8 Museum of the Geological Direction of the Urals) from the early Givetian of the central Urals, Russia (Pronina, 1960, pl. 1, fig. 5).

*Diagnosis*.—Relatively large species characterized by numerous necks, regularly, radially arranged. Necks short, papilliform. Wall thin, bilayered, dark-microgranular and clear-pseudofibrous.

*Occurrence*.—Eifelian–early Givetian of the central Urals and Givetian of the northern Urals (Pronina, 1960; Petrova, 1981), Zeravshano–Gissar (Lavrusevich et al., 1979), and Siberia (Zadorozhnyi, 1985, 1987). Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.27–0.50 mm (type material: 0.34–0.52 mm); inner diameter = 0.15–0.37 mm; number of necks: 13–15; length of necks = 0.01–0.06 mm (for a wall of 0.015 mm); test wall thickness = 0.01 mm (type material: 0.01 mm).

*Materials*.—Eight specimens (samples POL11a-6, POL11b-5, POL13a-1, POL13a-7).

Genus *Bykovaella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984

*Type species*.—*Parathuramina aperturata* Pronina, 1960.

*Other species*.—*Parathuramina breviradiosa* Reitlinger in Varsanofieva and Reitlinger, 1962; *P. argensis* Sabirov, 1987a; *P. bykova* Poyarkov in Purkin et al., 1961; *P. crassithec* Antropov, 1950; *P. dagmarae* var. *crassithec* Antropov, 1950; *P. iniqua* Pronina, 1970; *Polygonella irregulariformis* Zadorozhnyi and Yuferev, 1984; *Parathuramina irregularis* Pronina, 1960; *P. khavsakiensis* Sabirov, 1987a; *P. macilenta* Pronina, 1970; *P. mirabilis* (sic *mirabile*) Saltovskaya, 1981; *P. praeaperturata* Saltovskaya, 1981; *P. turgida* Chuvashov, 1965.

*Diagnosis*.—Test free, moderate in size, globular with many tubular projections; thin wall dark-microgranular. One areal aperture at the end of each projection.

*Occurrence*.—Late Silurian, Early–Middle Devonian, Late Devonian (Frasnian–early Famennian), early Tournaisian of Russian Platform, the Urals, western Siberia, Tian Shan (Tajikistan), South China, Spain, western and northern France, ?Germany (see Vachard, 1991). Discovered in the Givetian of Austria.

*Remarks*.—Many *Bykovaella* of the literature have been designated by *Parathuramina* (partim), *Thuramina* (partim), *Salpingothuramina* (partim), and *Polygonella* (partim).

*Bykovaella aperturata* (Pronina, 1960) emend. Zadorozhnyi and Yuferev, 1984

Figure 9.16, 9.17, 9.24, 9.25

- 1928 Calcsphères de La Villedé, formes épineuses; Milon, fig. 35.1, 35.2, 35.4, 35.6 (non 35.3, 35.5, 35.7, 35.8), pl. 2, fig. 1a, 1a’.  
 1960 *Parathuramina aperturata*; Pronina, p. 47, pl. 1, fig. 3.  
 1969 *Parathuramina aperturata*; Poyarkov, p. 87, pl. 1, figs. 2, 5.  
 1969 *Parathuramina aperturata*; Malakhova, pl. 49, figs. 337, 338, pl. 50, fig. 344, pl. 52, fig. 359.  
 non 1971 *Parathuramina aperturata*; Menner and Reitlinger, p. 29, pl. 8, figs. 2, 7–9 (= *Elenella reitlinger* n. sp.).  
 1977 *Parathuramina aperturata*; Petrova, p. 4, text-figs. 1, 2.  
 1979 *Parathuramina aperturata*; Poyarkov, p. 44, pl. 5, fig. 2.  
 1979 *Parathuramina aperturata*; Lavrusevich et al., p. 322.  
 1979 *Parathuramina* (*Salpingothuramina*) *aperturata*; Poyarkov, p. 96, text-fig. 14.  
 1979 *Parathuramina aperturata* (sic); Dubreuil and Vachard, p. 241.  
 non 1981 *Parathuramina aperturata*; Saltovskaya, p. 107, pl. 2, fig. 6, pl. 3, figs. 6, 8 (= *Neoarchaesphaera*).  
 1984 *Bykovaella aperturata*; Zadorozhnyi and Yuferev, p. 79, pl. 1, figs. 3–5.  
 1985 *Bykovaella aperturata*; Zadorozhnyi, p. 126, pl. 17, fig. 2, pl. 18, fig. 3.  
 1987 *Bykovaella aperturata*; Zadorozhnyi, p. 16, pl. 1, figs. 4–7.

←  
**Figure 9.** (1, 8) *Paracaligella* ex gr. *antropovi* Lipina, 1955: (1) longitudinal section of a tubular chamber resembling *Irregularina*, sample POL 3-7; (8) more regular longitudinal section, sample POL 11b-25. (2) *Earlandia* sp. 1, small curved longitudinal section, sample POL11a-30. (3) *Neoarchaesphaera*? sp., sample POL11a-20. (4, 6, 7, 15, 19, 21–23, 27, 28?) *Parathuramina graciosa* Pronina, 1960: (4) sample POL11a-24; (6) sample POL3-1a; (7) with *Bykovaella breviradiosa* (Reitlinger, 1962), sample POL11-2; (15) sample POL11-1; (19) sample POL11-7; (21) sample POL11-9; (22) pseudofibrous, inner layer well visible here, sample POL11a-4; (23) sample POL 11a-10; (27) sample POL11a-14; (28) sample POL11a-39. (5) *Earlandia* sp. 2. Broader, rectilinear, slightly tapering test, sample POL11a-31. (9) *Neoarchaesphaera ellipsoidalis* (Poyarkov, 1969), sample POL11a-29. (10) *Suleimanovella* cf. *S. totaensis* (Petrova, 1981), sample POL11a-16. (11, 12) *Paracaligella* sp. 2: (11) sample POL 13b-9; (12) sample POL13b-14. (13, 14, 18) *Parathuramina* cf. *P. uralica* Petrova, 1981: (13) sample POL3-1; (14) sample POL3-2; (18) sample POL11b-12a. (16, 17, 24, 25) *Bykovaella aperturata* (Pronina, 1960) emend. Zadorozhnyi and Yuferev, 1984: (16) sample POL11-3; (17) sample POL11-6; (24) POL11a-12; (25) sample POL11a-6a. (20) ?*Bithuramina* aff. *B. sphaerica* Ektova, 1968, sample POL.14-33. (26) *Parathuramina arguta* Pronina, 1960, sample POL11a-6. Scale bars = 0.1 mm.



- non 1987 *Parathuramina aperturata*; Loeblich and Tappan, pl. 207, fig. 17.
- 1988 *Bykovaella aperturata*; Bogush et al., p. 5.
- 1990 *Bykovaella aperturata*; Bogush and Yuferev, p. 20.
- 1991 *Parathuramina crassithecica* Antropov; Vachard, p. 261, pl. 1, fig. 25.
- 1994 *Parathuramina aperturata*; Vachard, p. 20, text-fig. 12.6.
- 1994 *Parathuramina crassithecica*; Vachard, p. 20, text-fig. 12.5 only (non pl. 1, figs. 2, 12–23, nec pl. 2, figs. 1, 7) (with 40 references in synonymy).
- 2002 *Bykovaella aperturata*; Kalvoda, p. 26, text-fig. 11.
- 2008 *Bykovaella aperturata*; Tsyganko, p. 70, text-fig. 3.
- 2009 *Parathuramina* du groupe *P. dagmarae* Suleimanov; Mamet and Pr at, pl. 1, figs. 12, 15, 17 (non figs. 11, 14, 16 = other species of *Bykovaella*, nec fig. 13 = *Kolongella*).
- 2011 *Parathuramina aperturata*; Anfimov, p. 16.
- 2013 *Parathuramina aperturata*; Sabirov, p. 115, text-fig. 1.
- 2013 *Parathuramina aperturata*; Makarenko and Savina, p. 128.
- 1962 *Parathuramina breviradiosa* Reitlinger, p. 52, pl. 1, figs. 1, 2.
- 1965 *Parathuramina breviradiosa*; Chuvashov, p. 19, pl. 1, figs. 4–6.
- 1969 *Parathuramina breviradiosa*; Poyarkov, table 12.
- 1969 *Parathuramina breviradiosa*; Malakhova, pl. 51, fig. 356.
- 1979 *Parathuramina breviradiosa*; Poyarkov, pl. 3, fig. 4.
- 1979 *Parathuramina (Parathuramina) breviradiosa*; Poyarkov, text-fig. 13.
- 1981 *Parathuramina breviradiosa*; Petrova, pl. 8, fig. 19.
- 1981 *Parathuramina breviradiosa*; Zadorozhnyi, p. 111 (no. 3 of the table).
- ?1981 *Parathuramina magna* Antropov; Zupalova, pl. 1, fig. 2.
- 1984 *Parathuramina breviradiosa*; Zadorozhnyi and Yuferev, p. 77, pl. 1, figs. 1, 2.
- 1987 *Parathuramina breviradiosa*; Zadorozhnyi, p. 14, pl. 1, figs. 1–3.
- 1988 *Parathuramina breviradiosa*; Bogush et al., p. 22.
- 1989 *Parathuramina dagmarae* Suleimanov; Pr at and Mamet, pl. 6, fig. 5 only (non figs. 4, 6 = *Parathuraminites*).
- 1990 *Parathuramina breviradiosa*; Lin et al., p. 124, pl. 3, figs. 1–4.
- 1990 *Parathuramina breviradiosa*; Bogush and Yuferev, p. 20.
- 1994 *Parathuramina breviradiosa*; Vachard, text-fig. 12.1.
- ?1999 *Parathuramina* du groupe *P. dagmarae* Suleimanov (= *Salpingothuramina breviradiosa* [Reitlinger]) (sic); Mamet et al., pl. 5, figs. 13, 14.
- 2005 Late Devonian calcisphere; Kaźmierczak and Kremer, fig. 6F.
- 2008 *Parathuramina breviradiosa*; Anfimov, p. 80.
- 2013 *Parathuramina breviradiosa*; Makarenko and Savina, p. 128.
- 2014 *Parathuraminide*; M ortl, text-fig. 33b.

*Holotype*.—Axial section (No. 476/6 Museum of the Geological Direction of the Urals) from the early Givetian of the central Urals, Russia (Pronina, 1960, pl. 1, fig. 3).

*Diagnosis*.—Relatively large species characterized by numerous necks, regularly, radially arranged. Necks long with a narrow central channel, entirely cylindrical (i.e., without either proximal or distal enlargement). Wall thin.

*Occurrence*.—Eifelian–early Givetian of the central and southern Urals (Pronina, 1960); Eifelian of the Tomsk area (SW Siberia; Makarenko and Savina, 2013). Givetian of western France (Milon, 1928, re-interpreted here; Dubreuil and Vachard, 1979), Zeravshano-Gissar (Lavrushevich et al., 1979), southern Fergana (Tian Shan; Poyarkov, 1969; Saltovskaya, 1981), Siberia (Menner and Reitlinger, 1971; Zadorozhnyi and Yuferev, 1984; Zadorozhnyi, 1985, 1987; Bogush and Yuferev, 1990), Germany (Fl ugel and H otzl, 1971), South China (Lin and Hao, 1982), and Belgium (Mamet and Pr at, 2009). Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.30–0.35 mm (type material: 0.18–0.34 mm); inner diameter = 0.22–0.25 mm; number of necks: 15–16; length of necks = 0.01–0.07 mm (with a wall of 0.007–0.015 mm); test wall thickness = 0.005 mm (type material: 0.005–0.01 mm).

*Materials*.—Twelve specimens (samples POL11-3, POL11-6, POL11a-6a, POL11a-12).

*Remarks*.—*Bykovaella crassithecica* (Antropov, 1950) differs only by a thicker wall (0.02–0.025 mm) and a Frasnian age.

*Bykovaella breviradiosa* (Reitlinger, 1962)  
Figures 9.7, 10.3

*Holotype*.—Axial section (No. 3456/2 Geological Institute Nauk, Akademiya Nauk SSSR) from the Frasnian of the central Urals, Shezhym oblast, Russia (Reitlinger, 1962, pl. 1, fig. 1).

*Diagnosis*.—Relatively moderate species, characterized by a few necks, irregularly arranged, short to medium-sized, with a narrow central channel, and with a distal enlargement. Wall thin.

*Occurrence*.—Eifelian of the Tomsk area (SW Siberia). Givetian of the northern Urals (Petrova, 1981), and perhaps Moravia (Zupalova, 1981) and Morocco (Mamet et al., 1999). Late Devonian of Siberia (Zadorozhnyi and Yuferev, 1984; Bogush and Yuferev, 1990), Frasnian of the northern Urals, early Famennian of the central Urals (Chuvashov, 1965). Late Famennian of SW Siberia (Bogush and Yuferev, 1990). Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.20–0.40 mm (type material: 0.20–0.48 mm); inner diameter = 0.13–0.41 mm; number of

necks: 4–9; length of necks = 0.70–0.90 mm (with a wall of 0.007–0.015 mm); test wall thickness = 0.003–0.006 mm.

*Materials*.—10 specimens (samples POL11-2 and POL11b-19b).  
*Bykovaella bykova* (Poyarkov in Purkin et al., 1961)  
Figure 10.4–10.6, 10.7 (partim), 10.8

?1955 *Parathuramina magna* Bykova, p. 17, pl. 2, figs. 4, 5, pl. 4, fig. 5.

1961 *Thuramina (Salpingothuramina) bykova* Poyarkov in Purkin et al., p. 31, pl. 1, fig. 1 (non fig. 6).

1969 *Parathuramina (Salpingothuramina) bykova*; Poyarkov, p. 86, pl. 1, figs. 3–6.

?1971 *Parathuramina dagmarae* Suleimanov; Flügel and Hötzl, p. 370, fig. 2.1–2.4.

1979 *Parathuramina (Salpingothuramina) bykova*; Poyarkov, text-fig. 14.

1979 *Parathuramina bykova* (Poyarkov); Lavrusevich et al., p. 322.

?1981 *Parathuramina dagmarae*; Zukalova, pl. 1, fig. 1.

1984 *Bykovaella bykova*; Zadorozhnyi and Yuferev, p. 80, pl. 1, fig. 6.

1988 *Bykovaella bykova*; Bogush et al., p. 5.

?1994 *Parathuramina bykova*; Vachard, p. 22, text-fig. 12.1, pl. 2, figs. 1, 2 (with 11 references in synonymy) (see *B. cf. B. macilenta*).

2002 *Bykovaella bykova*; Kalvoda, text-figs. 11, 12.

?2004 *Parathuramina dagmarae*; Flügel, text-fig. 10.24.

2008 *Bykovaella bykova*; Tsyganko, p. 71, text-fig. 3.

2008 *Bykovaella bykovella* (sic); Tsyganko, p. 74.

2008 *P. bykova* (sic) Poyarkov (sic: without parentheses); Anfimov, p. 78.

2013 *Parathuramina bykova*; Makarenko and Savina, p. 128.

2013 *Parathuramina bykova*; Sabirov, text-fig. 1.

2014 *Parathuraminide*; Mörtl, text-fig. 33c, 33d.

*Holotype*.—Axial section (No. 3935, VNIGRI) from the Givetian of Makarovskii raion, Russia (Poyarkov in Purkin et al., 1961, pl. 1, fig. 1).

*Diagnosis*.—Large species characterized by relatively numerous necks, irregularly arranged. Necks short to long with a broad central channel, and with proximal and distal enlargements. Wall relatively thin.

*Occurrence*.—Eifelian of the Tomsk area (SW Siberia) and the northern Urals. Givetian of Fergana, Tian Shan, Zeravshanogissar, SW Siberia, the central Urals, Germany, western and northern France, and ?Moravia. Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.23–0.60 mm (type material: 0.28–0.47 mm); inner diameter = 0.16–0.55 mm; number of necks: 13–16; length of necks = 0.07–0.13 mm (with a wall of 0.015–0.045 mm); test wall thickness = 0.013–0.016 mm (type material: 0.012–0.03 mm).

*Materials*.—10 specimens (samples POL11b-5, POL11b-19, POL13a-5, POL13a-6, and POL13a-8).

*Remarks*.—Givetian and Frasnian *Parathuramina* specimens assigned to *P. dagmarae* more probably belong to *Bykovaella bykova*, whereas true *P. dagmarae* only appear in the Famennian (Poyarkov, 1969, 1979).

*Bykovaella cf. B. macilenta* (Pronina, 1970)

Figure 10.35, 10.36

1970 *Parathuramina macilenta* Pronina, p. 106, pl. 30, fig. 5.

1994 *Parathuramina bykova* (Poyarkov); Vachard, p. 22, pl. 2, figs. 1, 2.

2013 *Parathuramina macilenta*; Sabirov, text-fig. 1.

*Holotype*.—Axial section (No. 2/1060; Museum of the Geological Direction of the Urals, UTGU) from the Givetian of the northern Urals, Russia (Pronina, 1970, pl. 30, fig. 5).

*Diagnosis*.—Very large species characterized by relatively numerous papillae, short and irregularly arranged. Wall thin.

*Occurrence*.—Givetian of the central Urals and western France. Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.45–0.70 mm (type material: 0.50–0.95 mm); inner diameter = 0.36–0.65 mm, number of papillae: 8–14; tests wall thickness = 0.006–0.012 mm (type material: 0.015–0.022 mm).

*Remarks*.—*Bykovaella turgida* (Chuvashov, 1965), poorly known, probably belongs to the same group of species.

*Materials*.—Three specimens (samples POL14-20 and POL14-21).

Genus *Kolongella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984

*Type species*.—*Parathuramina kolongensis* Pronina, 1969.

*Other species*.—See Zadorozhnyi and Yuferev (1984).

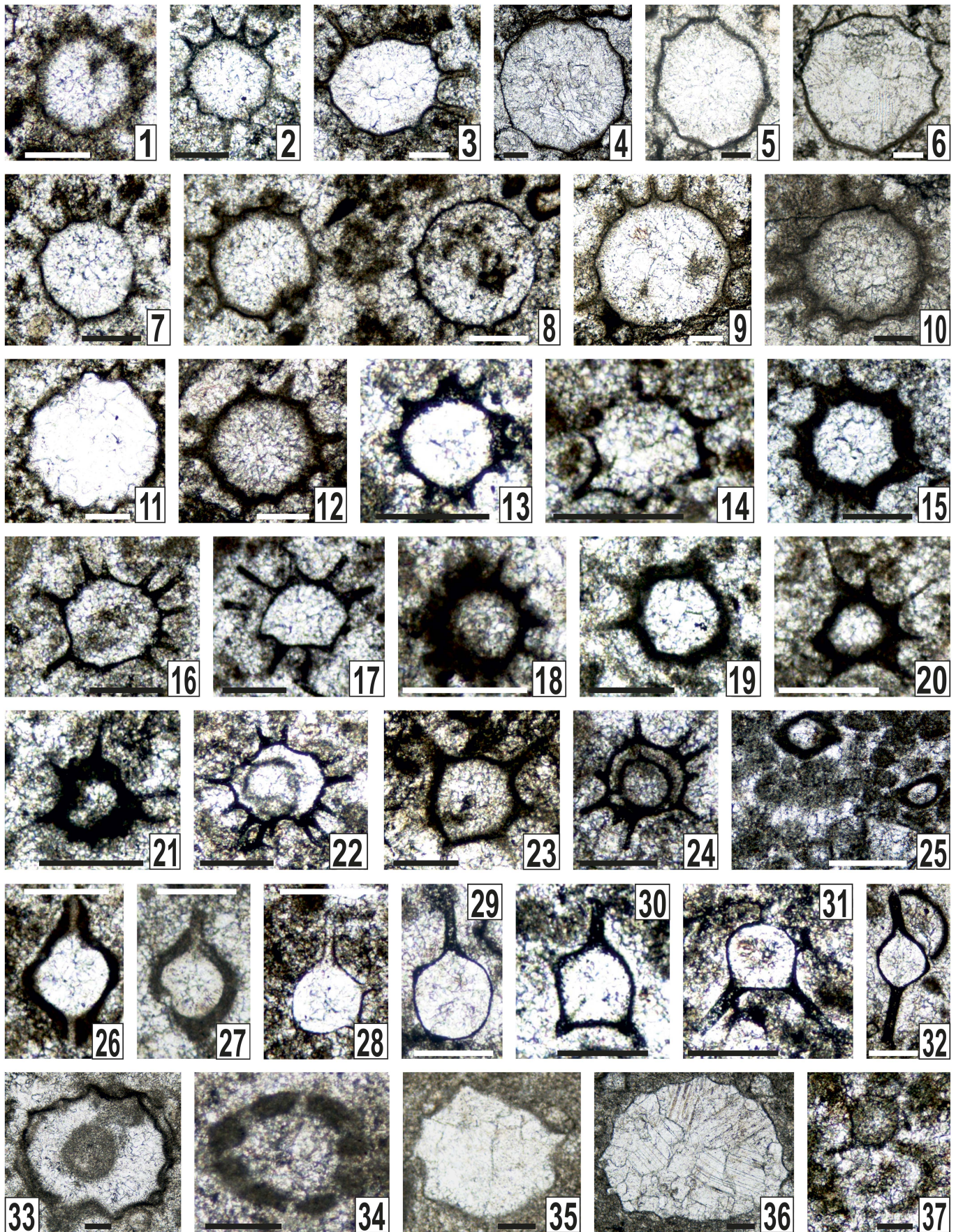
*Diagnosis*.—Test unilocular. Central chamber spherical. Infundibuliform, radiate necks, prominent at the periphery and not communicating with the central chamber. Apertures at the extremities of the necks. Wall dark-microgranular.

*Occurrence*.—Late Silurian–Middle Devonian, eastern slope of the Urals and southwestern Siberia. Late Eifelian of Belgium. Givetian of El Bisani sections (Sonora, Mexico; D.V. unpublished data). Discovered in the early Givetian of the Carnic Alps.

*Kolongella cf. K. pojarkovi* Zadorozhnyi and Yuferev, 1984.  
Figure 10.11

1984 *Suleimanovella (Kolongella) pojarkovi* Zadorozhnyi and Yuferev, p. 89, pl. 2, figs. 6, 7.

1985 *Suleimanovella (Kolongella) pojarkovi*; Zadorozhnyi, p. 126, pl. 17, fig. 4, pl. 18, fig. 4.



- 1987 *Suleimanovella (Kolongella) pojarkovi*; Zadorozhnyi and Yuferev in Zadorozhnyi, p. 27, pl. 2, figs. 9–11.
- 1988 *Suleimanovella (Kolongella) pojarkovi*; Bogush et al., p. 31.
- 1990 *Suleimanovella (Kolongella) pojarkovi*; Bogush and Yuferev, p. 21.
- 2008 *Parathuramina pojarkovi*; Anfimov, p. 78.
- 2009 *Parathuramina* du groupe *P. dagmarae* Suleimanov; Mamet and Pr  at, fig. 1.13 (non fig. 1.11, 1.12, 1.14–1.17 = *Bykovaella* spp.).
- 2009 *Parathuramina crassithecica* Antropov; Mamet and Pr  at, fig. 1.18 (non fig. 1.19 = *Parathuramina uralica*).
- ?2013 *Parathuramina* aff. *pojarkovi* (Zadorozhnyi and Yuferev); Makarenko and Savina, p. 128.

*Holotype*.—Axial section (No. 619/18; Geological Institute of Novosibirsk) from the Givetian of Tomsk oblast, SW Siberia, Russia (Zadorozhnyi and Yuferev, 1984, pl. 2, fig. 6).

*Diagnosis*.—Moderate species characterized by numerous short necks (17), irregularly arranged. Wall relatively thin.

*Occurrence*.—Eifelian of SW Siberia. Givetian of SW Siberia and the central Urals. Late Eifelian of Belgium. Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.32 mm (type material: 0.13–0.28 mm); inner diameter = 0.29 mm; number of necks: 17; test wall thickness = 0.007 mm (type material: 0.004–0.012 mm).

*Materials*.—Three specimens (sample POL11-21).

Genus *Bithuramina* Miklukho-Maklay, 1965 non 1963

*Type species*.—*Bithuramina dagmarae* Miklukho-Maklay, 1965 (= *Parathuramina*? aff. *P. dagmarae* Grozdilova and Lebedeva, 1954).

*Other species*.—*Bithuramina sphaerica* Ektova, 1968; ?*B. angulata* Kotlyar, 1982.

*Diagnosis*.—Test bilocular (or unilocular with daughter-cell?). Inner chamber and outer chamber spherical, similar to *Parathuramina* ex gr. *dagmarae*, with radiate, papilliform protuberances. No apertures at the inner chamber, apertures of outer chamber at extremity of each neck. Wall dark-microgranular, but possibly bilayered as in *Parathuramina*.

*Occurrence*.—Late Early Devonian of northern Spain (Vachard, 1991). Givetian of Vietnam (Doan in Tong et al., 1988), Zeravshano-Gissar (Lavrushevich et al., 1979), and Austria (this paper). Late Devonian of the Pre-Urals, Urals, Russian Platform, Tajikistan and Kyrgyzstan, ?Famennian of Ukraine, ?Tournaisian of NW Mexico (as Foraminifera? sensu Brunner, 1976, pl. 4, fig. 9) and SW Siberia (Kazennov et al., 1975, pl. 1, figs. 13, 14).

*Remarks*.—As defined by its type species, *Bithuramina* is probably a development stage of *Parathuramina* sensu stricto; however, some other atypical species of *Bithuramina* can entail the same stages in the genus *Salpingothuramina*; as, for example, *B. sphaerica* Ektova, 1968 and the material described herein; whereas other ones, like *B. angulata* Kotlyar, 1982, are more difficult to interpret. These stages of development are apparently opposed to assignment of the parathuraminids to the foraminifers, but are more consistent with daughter-cells of volvocales evoked by Ka  mierczak (1976).

*Bithuramina* aff. *B. sphaerica* Ektova, 1968  
Figures 8.29?, 9.20?, 10.24

?1968 *Bithuramina sphaerica* Ektova, p. 98, pl. 34, figs. 2–4.

2016a *Bithuramina*? sp.; Vachard, fig. 3.29.

*Holotype*.—Axial section (No. 1-3a/8283.Ts.GM, Leningrad/Sankt Petersburg) from the the Famennian of Kok-Shaal, Kyrgyzstan (Ektova in Markosvskyi, 1968, pl. 34, fig. 2).

*Diagnosis*.—Test unilocular. Inner chamber apparently spherical. Outer chamber spherical with radiate necks, prominent at the periphery and communicating with the outer chamber. Inconspicuous apertures at the inner chamber. Wall relatively thin.

*Occurrence*.—Famennian of the Kok Shaal Range (Kyrgyzstan). Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Test outer diameter = 0.20 mm (type material: 0.14–0.16 mm); inner chamber diameter = 0.07 mm (type material = 0.07–0.08 mm); test wall thickness = 0.007 mm (type material: 0.006–0.011 mm).

*Materials*.—Three specimens (samples POL11a-34, ?POL14-7, ?POL14-33).

←  
**Figure 10.** (1, 10) *Parathuramina* cf. *P. uralica* Petrova, 1981: (1) sample POL11b-13; (10) sample POL13a-2b. (2) *Parathuramina graciosa* Pronina, 1960, sample POL11a-21. (3) *Bykovaella breviradosa* (Reitlinger, 1962), sample POL11b-19b. (4–8) *Bykovaella bykovaiae* (Poyarkov in Purkin et al., 1961): (4) sample POL13a-5; (5) sample POL13a-6; (6) sample POL13a-8; (7) right, with *P. arguta* (left), sample POL11b-5; (8) sample POL11b-19. (7, 9, 10) *Parathuramina arguta* Pronina, 1960; (7) (with *Bykovaella bykovaiae*), sample POL11-2; (9) sample POL13a-1; (10) sample POL13a-7. (11) *Kolongella* cf. *K. pojarkovi* Zadorozhnyi and Yuferev, 1984, sample POL11b-21. (12) *Salpingothuramina* sp. 1, sample POL13a-3. (13) *Ivanovella* sp. 1, sample POL11a-9. (14) *Ivanovella* sp. 2, sample POL11a-10b. (15) *Ivanovella* sp. 3, sample POL11-5. (16, 17, 22?) *Ivanovella reitlingeriae* n. sp.: (16) holotype, sample POL11a-38; (17) paratype, sample POL11a-40; (22) paratype?, sample POL11a-2. (18, 20, 21) *Ivanovella luginensis* Zadorozhnyi and Yuferev in Dubatolov, 1981: (18) sample POL11b-18a; (20) sample POL11b-21b; (21) sample POL11a-9a. (19) *Ivanovella* sp. 4, sample POL11a-8. (23) *Salpingothuramina* cf. *S. kakvensis* (Petrova, 1981), sample POL13a-3a. (24) *Bithuramina* aff. *B. sphaerica* Ektova, 1968, sample POL11a-34. (25) *Suleimanovella* sp. 2., sample POL4c. (26, 27) *Suleimanovella* sp. 3: (26) sample POL11b-12; (27) sample POL13b-10. (28–32) *Radiosphaerella pojarkovi* n. sp.: (28) holotype, sample POL11b-24; (29) paratype, sample POL11a-25a; (30) paratype, sample POL11a-22; (31) paratype, sample POL11a-17; (32) paratype, sample POL11a-11. (33) *Marginara*? sp., sample POL14-24. (34) *Parathuraminites* sp., sample POL14-1. (35, 36) *Bykovaella* cf. *B. macilenta* (Pronina, 1970): (35) sample POL14-21; (36) sample POL14-20. (37) *Vasicekia*? sp., sample POL3-6. Scale bars = 0.1 mm.

## Subfamily Parathuramminitinae Antropov, 1970

*Diagnosis.*—Test free, globular to polygonal, with few or fairly abundant, papillate prominences; thick to medium-sized, wall dark-microgranular, unilayered wall. One areal aperture at the end of each projection.

*Occurrence.*—Late Silurian–Mississippian; probably cosmopolitan.

*Remarks.*—Parathuramminitinae is a senior synonym of Cushmanellinae Yuferev, Chuvashov, and Zadorozhnyi in Zadorozhnyi and Yuferev, 1984. It is composed of the following genera: *Parathuramminites* Antropov in Poyarkov, 1969; *Salpingothuramina* Poyarkov in Purkin et al., 1961 (= *Saltovskajina* Sabirov, 1982b); *Suleimanovella* Yuferev in Zadorozhnyi and Yuferev, 1984; *Radiosphaerella* Yuferev in Zadorozhnyi and Yuferev, 1984; and ?*Polygonella* Yuferev in Zadorozhnyi and Yuferev, 1984.

Genus *Parathuramminites* Antropov in Poyarkov, 1969

*Type species.*—*Parathuramina cushmani* Suleimanov, 1945.

*Other species.*—*Parathuramina cushmani* var. *minima* Antropov, 1950; *P. clivosa* Pronina, 1963; *P. devonica* Vissarionova, 1950; *P. insolita* Sabirov, 1978; *P. kolongensis* Pronina, 1969; *P. (Parathuramminites) micula* Petrova, 1981; *P. monstrata* Chuvashov, 1965; *P. obnata* Chuvashov, 1965; *P. polygona* Pronina, 1963; *P. regularis* Chuvashov, 1965; *P. suleimanovi* forma *concisa* Chuvashov, 1965; *Parathuramminites mutilatus* Anfimov, 2012; *P. stellaeformis* Anfimov, 2012 nom. correct. (sic: *stelliformis*); *P. subrus* Anfimov, 2012; *P. minutus* Anfimov, 2012; ?*Parathuramina crassa* Pronina, 1970; ?*P. guangxiensis* Lin, Li, and Sun, 1990; ? *P. praetuberculata* Reitlinger, 1954; ?*Thuramina delicata* Ireland, 1939.

*Diagnosis.*—Test free, globular to polygonal, with few papillate prominences, almost not prominent; thick wall dark-microgranular. One areal aperture at the end of each projection.

*Occurrence.*—Late Silurian–Mississippian; probably cosmopolitan.

*Remarks.*—*Parathuramminites* is sometimes attributed to Antropov, 1967, but this publication in reality was published in 1970 (see Vdovenko et al., 1993). Between 1967 and 1970, the genus name was validly introduced by Poyarkov (1969), who correctly attributed it to Antropov; hence, the taxonomy adopted herein is: *Parathuramminites* Antropov in Poyarkov, 1969. It corresponds to *Parathuramina* (partim), *Cushmanella* Zadorozhnyi in Zadorozhnyi and Yuferev, 1984 (this latter genus has the same type species as *Parathuramminites* and moreover it is pre-occupied; see Loeblich and Tappan, 1987), *Salpingothuramina* Poyarkov in Purkin et al., 1961 (partim), and *Saltovskajina* Sabirov, 1982b (partim).

*Parathuramminites?* sp.  
Figure 10.34

*Diagnosis.*—Test ovoid, without prominences with necks limited to the thickness of the wall.

*Occurrence.*—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.22 mm; inner diameter = 0.16 mm; number of necks: 8; diameter of apertures: 0.017 mm; test wall thickness = 0.03 mm.

*Remarks.*—This form resembles some illustrations of *Parathuramminites cushmani*, but apparently differs from the holotype of this species.

*Materials.*—Two specimens (sample POL14-1).

Genus *Suleimanovella* Yuferev in Zadorozhnyi and Yuferev, 1984

*Type species.*—*Parathuramina suleimanovi* Lipina, 1950.

*Other species.*—*Parathuramina ovalis* Brazhnikova and Vdovenko, 1971; *P. paulis* Bykova, 1952; *Suleimanovella (Kolongella) pojarkovi* Zadorozhnyi and Yuferev, 1984; *P. quadrata* Brazhnikova and Vdovenko, 1971; *P. suleimanovi* var. *stellata* Lipina, 1950; *P. (Salpingothuramina) totaensis* Petrova, 1981; *P. triangula* Brazhnikova and Vdovenko, 1971; ?*Thuramina minuscula* Pokorny, 1951, and ?*T. strikeri* Conkin and Conkin, 1964.

*Diagnosis.*—Small-sized Parathuramminidae with a very irregular angular profile, a spherical cavity, fairly abundant papilliform protuberances, very short canals, and a thick, dark-microgranular wall.

*Occurrence.*—Devonian–Mississippian, cosmopolitan.

*Remarks.*—*Suleimanovella* morphologically and microstructurally corresponds to *Parathuramina* (partim), *P. (Salpingothuramina)* (partim), *P. (Parathuramminites)* (partim), and *Suleimanovella (Kolongella)* (partim).

The subgenus *Kolongella* of *Suleimanovella* was rarely described, but probably really exists (see this work and Mamet and Pr at, 2009 as *Parathuramina crassitheca* [pl. 1, figs. 18, 19]).

*Suleimanovella* cf. *S. totaensis* (Petrova, 1981)  
Figure 9.10

- 1981 *Parathuramina (Salpingothuramina) totaensis* Petrova, p. 88, pl. 8, figs. 7, 10, 11, 15.  
?1981 *Palachemonella beckmanni* Fl gel and H tzel; Zadorozhnyi and Yuferev, p. 55, pl. 1, fig. 7.  
1985 *Suleimanovella (Suleimanovella) totaensis*; Zadorozhnyi, p. 126, pl. 17, fig. 11.  
?1988 *Palachemonella beckmanni*; Bogush et al., p. 21.  
1990 *Suleimanovella (Suleimanovella) totaensis*; Bogush and Yuferev, p. 21.  
2008 *Parathuramina totaensis*; Anfimov, p. 78.

2013 *Parathuramina totaensis*; Makarenko and Savina, p. 128.

*Holotype*.—Axial section (No. 35/1868; Museum UTGU) from the Eifelian of the northern Urals, Russia (Petrova, 1981, pl. 8, fig. 7).

*Diagnosis*.—Triangular test with triangular inner chamber. Some necks are ended by rounded parts, and are apparently blind (see also *Irregularina angulata* Poyarkov, 1969, pl. 3, fig. 6).

*Occurrence*.—Eifelian of the central and northern Urals. Eifelian, Givetian, and Frasnian of Tomsk oblast (SW Siberia). Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.13 mm (type material: 0.10–0.18 mm); inner diameter = 0.05 mm (type material: 0.06–0.09 mm); test wall thickness = 0.01 mm (type material = 0.01 mm).

*Materials*.—Four specimens (sample POL11a-16).

*Suleimanovella* sp. 2  
Figure 10.25

*Diagnosis*.—Rhomboidal to subspherical tests, rhombic to ovate inner chamber. Very short prominences.

*Occurrence*.—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.07–0.08 mm; inner diameter = 0.04–0.05 mm; test wall thickness = 0.01 mm.

*Materials*.—Three specimens (sample POL14c).

*Suleimanovella* sp. 3  
Figure 10.26, 10.27

*Diagnosis*.—Subrhombic to ovate tests and inner chambers. Slightly prominent necks relatively well-developed for the genus (morphologically, this taxon is possibly transitional between *Suleimanovella* and *Salpingothuramina*, due to its necks).

*Occurrence*.—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.15–0.17 mm; inner diameter = 0.08–0.10 mm; wall thickness = 0.01 mm.

*Materials*.—Five specimens (samples POL11b-12 and POL13b-10).

Genus *Salpingothuramina* Poyarkov in Purkin et al., 1961

*Type species*.—*Parathuramina tuberculata* Lipina, 1950.

*Other species*.—? *Parathuramina bella* Reitlinger in Bogush and Yuferev, 1962; *P. (Salpingothuramina) elegans* Poyarkov, 1969; *P. gekkeri* Antropov, 1950; *P. horrida* Chuvashov, 1965; *P. hunanensis* Lin and Hao, 1982; *P. ivdelensis* Pronina, 1970; *P. kazankaensis* Pronina, 1970; *P. lipinae* Antropov, 1950; *P. miklukhomaclayi* Saltovskaya, 1974; *P. pachysphaerica* Bogush and Yuferev, 1962; *P. paratuberculata* Zadorozhnyi and Yuferev in Dubatolov, 1981; *P. scitula* Chuvashov, 1965; *P. shishkatica* Sabirov, 1978; *P. spinosa* Lipina sensu Grozdilova and Lebedeva 1954; *P. spinosa kakvensis* Petrova, 1981; *P. stellaeformis* Grozdilova and Lebedeva, 1954; *P. subquadrata* Sabirov, 1978; *P. subvasta* Bykova in Bykova and Polenova, 1955; *P. tansaica* Marfenkova, 1991 (nomen nudum); ? *Thuramina congesta* Gutschick, Weiner, and Young, 1961; ? *T. coronata* Dunn, 1942; *T. diforamens* Ireland, 1956; ? *T. furcata* Gutschick and Treckman, 1959; ? *T. phialaeformis* Crespín, 1958; ? *T. quadritubulata* Dunn, 1942; ? *T. triradiata* Gutschick and Treckman, 1959; ? *T. tubulata fixa* Langer, 1969; ? *T. sp. A* sensu Blumenstengel, 1961; ? *T. sp. B* sensu Blumenstengel, 1961; ? *T. sp. 1* sensu Holcová, 2004; ? *T. sp. 2* sensu Holcová, 2004; and ? *Pseudoastrorhiza obtusiconus* Langer, 1969.

*Diagnosis*.—Medium-sized Parathuraminidae with an irregular angular–rounded profile, fairly abundant papilliform to longer apertural protuberances, broad chamber, and thickness of the wall and around the necks is almost equidimensional. Wall thin to thick, unilayered, dark-microgranular.

*Occurrence*.—Early Ordovician of Sonora, Mexico (Vachard et al., 2017). Relatively frequent in the Devonian–Tournaisian of western Siberia, Italy, Czech Republic, western France, the northern, central, and southern Urals, and southern Fergana; probably up to the Visean (see Vachard et al., 2014); ? Pennsylvanian of Kansas, ? Permian of Australia.

*Remarks*.—See discussions in Loeblich and Tappan (1987), Vdovenko et al. (1993), and Vachard et al. (2014). The differences with *Saltovskajina* seem to be specific and not generic; hence, we synonymized both genera herein. In the literature, *Salpingothuramina* was designated under the names *Saltovskajina* Sabirov, 1982b; *Parathuramina* (partim); *Thuramina* (partim) auctorum; *Irregularina* (partim); *Polygonella* (partim); *Bykovaella* (partim); *Ivanovella* (partim); *Guangxithuramina* Lin et al., 1990 (partim); *Suleimanovella* (partim); *Parathuraminites* (partim); *Cordatella* (partim), *Marginara* (partim); and *Radiosphaerella* (partim).

*Salpingothuramina* sp. 1  
Figure 10.12

*Diagnosis*.—Test spherical with numerous, radiate, triangular necks, wall thick.

*Occurrence*.—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.36 mm; inner diameter = 0.18 mm; number of necks: 13; test wall thickness = 0.02 mm.

*Materials*.—Two specimens (sample POL13a-13).

*Salpingothuramina* cf. *S. kakvensis* (Petrova, 1981)  
Figure 10.23

- 1981 *Parathuramina spinosa kakvensis* Petrova, p. 87, pl. 6, figs. 8, 9.  
1990 *Parathuramina spinosa kakvensis*; Bogush and Yuferev, p. 21.  
?1999 *Parathuramina gekkeri* Antropov; Mamet et al., pl. 5, fig. 12.  
2002 *Salpingothuramina spinosa kakvensis*; Kalvoda, text-figs. 11, 12.  
2008 *Parathuramina kakvensis*; Anfimov, p. 78.  
2011 *Parathuramina kakvensis*; Anfimov, p. 16.

*Holotype*.—Axial section (No. 7/1868; UTGU Museum) from the Middle Devonian of the central Urals (Petrova, 1981, pl. 1, fig. 8).

*Diagnosis*.—Small species characterized by 5–6 long necks, irregularly arranged. Wall relatively thin.

*Occurrence*.—?Early Eifelian–Givetian of SW Siberia and the central and northern Urals. ?Givetian of Morocco. Givetian–Frasnian of SW Siberia. Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.26 mm (type material: 0.12–0.15 mm); inner diameter = 0.12 mm; number of necks: 5–6; test wall thickness = 0.015–0.03 mm.

*Materials*.—Three specimens (sample POL13a-3a).

Genus *Radiosphaerella* Yuferev in Zadorozhnyi and Yuferev, 1984

*Type species*.—*Parathuramina radiosphaerica* Bogush and Yuferev, 1962.

*Other species*.—*Parathuramina radiata* Antropov, 1950; *P. spinosa* Lipina, 1950; *P. tuberculata* sensu Poyarkov, 1969; ?*Palachemonella beckmanni* sensu Zadorozhnyi and Yuferev in Dubatolov, 1981 non Flügel and Hötzl, 1971.

*Diagnosis*.—Medium-sized Parathuraminidae with very thin wall and very long necks, wall unilayered dark-microgranular.

*Occurrence*.—Eifelian of the Tomsk area, SW Siberia (Makarenko and Savina, 2013). Givetian of Austria (this study). Givetian–Frasnian of South China. Givetian–Tournaisian of Tian Shan (Kyrgyzstan). Frasnian–Famennian of Poland, eastern part of Russian Platform, the Urals, SW Siberia, and southern Fergana. Late Devonian–Tournaisian of western and northeastern Siberia (Gagiev and Bogush, 1990).

*Remarks*.—*Radiosphaerella* has been designated as *Parathuramina* (partim); *Salpingothuramina* (partim);

*Suleimanovella* (partim); *Archaelagena* Howchin, 1888 (partim); and acritach sensu Kazmierczak and Kremer, 2005, fig. 6D.

*Radiosphaerella poyarkovi* new species

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Figure 10.28–10.32

- ?1954 *Archaelagena shesmae* (Antropov); Grozdilova and Lebedeva, p. 27, pl. 2, fig. 6.  
?1960 *Archaelagena borealis* (sic *borealia*) Pronina, p. 52, pl. 1, fig. 12.  
?1969 *Parathuramina* (*Salpingothuramina*) *tuberculata* Lipina; Poyarkov, p. 94, pl. 2, fig. 4.  
1969 *Archaelagena shesmae* (Antropov); Poyarkov, p. 137, table 66, pl. 8, figs. 2–4.  
1969 *Archaelagena borealis* (sic *borealia*); Poyarkov, p. 138, table 66, pl. 8, figs. 5, 6.  
1979 *Archaelagena shesmae*; Poyarkov, pl. 4, fig. 8.  
?1982 *Parathuramina horrida* Chuvashov; Lin and Hao, p. 93, pl. 1, fig. 2.  
?1982 *Parathuramina paulis* Bykova; Lin and Hao, p. 93, pl. 1, figs. 10, 11.  
1988 *Archaelagena shesmae*; Doan in Tong et al., p. 144, pl. 1, fig. 2.  
?1999 *Parathuramina spinosa* (Williamson, 1880) (= *Parathuramina spinosa* Lipina) (sic); Mamet et al., pl. 5, fig. 11.

*Holotype*.—Fig. 10.28 (POL11b-24); Institute of Geology, University of Innsbruck, Cat. Nr. P 10140-POL 11b (thin section); Givetian Feldkogel Limestone (Polinik Formation) of Mount Polinik (Austria).

*Diagnosis*.—A species of *Radiosphaerella* characterized by a few necks communicating with each angle of the subpentagonal inner chamber.

*Occurrence*.—?Eifelian–early Givetian of the Urals. ?Givetian of Morocco. Givetian and Frasnian of southern Fergana. Frasnian of Vietnam. Famennian of Russian Platform. Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter = 0.10–0.17 (0.35 mm); inner diameter = 0.07–0.11 mm; number of necks: 1–4 (5?); test wall thickness = 0.007–0.01 mm.

*Etymology*.—Named in honor of B.V. Poyarkov.

*Materials*.—10 specimens (samples POL11a-11, POL11a-17, POL11a-22, POL11b-24, POL11a-25a).

*Remarks*.—Differs from *Parathuramina radiosphaerica* by fewer necks (up to seven for *P. radiosphaerica*) for similar measurements.

?Family Marginaridae Loeblich and Tappan, 1986

*Diagnosis.*—Test globular, with numerous papilliform protuberances at surface. Trilayered wall with a diaphanothecal (?) median layer. Apertures at the end of the protuberances.

*Occurrence.*—Givetian–Famennian of the former SSSR.

*Remarks.*—Only two genera are included in this family: *Marginara* Petrova in Zadorozhnyi and Yuferev, 1984, and *Cor-datella* Petrova in Zadorozhnyi and Yuferev, 1984.

Genus *Marginara* Petrova in Zadorozhnyi and Yuferev, 1984

*Type species.*—*Parathurammina tamarae* Petrova, 1981.

*Diagnosis.*—Parathuramminid-like tests with three layers in the wall.

*Occurrence.*—Givetian of the former SSSR.

*Remarks.*—The initial name *Marginarae* Petrova in Zadorozhnyi and Yuferev, 1984, which is a Latin plural, was emended according to the International Commission on Zoological Nomenclature (ICZN, 1999, article 11), which asks for singular names, into *Marginara* by Loeblich and Tappan (1986, 1987). The original microstructure is discussed, in relation to specimens recrystallized to apatite-quartz (Chuvashov et al., 2012) in the late Eifelian–Givetian of the central Urals.

*Marginara?* sp.  
Figure 10.33

*Diagnosis.*—Large species (the maximal diameter of *M. tamarae* is 0.60 mm; Zadorozhnyi, 1987).

*Occurrence.*—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.70 mm; inner diameter = 0.60 mm; number of necks: 13; test wall thickness = 0.05 mm. A spherical inclusion/chamber measures 0.25 mm in diameter.

*Materials.*—Two specimens (sample POL14-24).

Superfamily Irregularinoidea Gaillot and Vachard, 2007

*Diagnosis.*—Globular to elongate and lobate tests medium- to large-sized for parathuramminids. Wall dark-microgranular, very rarely bilayered with an inner hyaline-microgranular layer (latest Famennian–Tournaisian Bisphaeridae; see for example Herbig and Mamet, 2006, pl. 3, fig. 6). More complex wall microstructures (Auroriidae) are not well understood. Very fine to coarse, numerous apertures through the wall (*Uslonia*; *Cribrosphaeroides*), or a supposed terminal aperture (*Apertauroria*).

*Occurrence.*—Llandoveryan of central and northern Urals–early Tournaisian; genera either cosmopolitan or restricted to the Tethys and Ural oceans. As mentioned above, we reject the

assignment of the middle Permian *Bisphaera? improvisa* to the irregularinoids.

*Remarks.*—The superfamily is composed of five families: Irregularinidae Zadorozhnyi and Yuferev, 1984; Usloniidae Conil and Longerstaey in Conil et al., 1980; Cribrosphaeroididae Sabirov in Zadorozhnyi and Yuferev, 1984 nom. correct. Sabirov, 1987b; Auroriidae Loeblich and Tappan, 1986; and Bisphaeridae Sabirov, 1987b. The irregularinoid genus *Bisphaera* Birina, 1948 was recently synonymized with the algal or cyanobacterial genus *Thaumatoporella* Pia (Schlagintweit et al., 2013), as well as the radiolarian *Trochodiscus* Haeckel (Afanavieva and Amon, 2011). The discussions about this genus and the irregularinoids in general are therefore very difficult. Middle Permian *Bisphaera? improvisa* Nestell and Nestell, 2006, as indicated by these authors, is questionable; in our opinion, it corresponds more to the “Algen Sporen” or cortoid grains described by Flügel (2004). Similarly, some *Parastegnammina* or *Corbiella* are other cortoid grains (see Vachard, 1994), whereas some “*Irregularina*” sensu Schlagintweit et al., 2013 correspond more to fenestrae and other microcavities.

Family Usloniidae Conil and Longerstaey in Conil et al., 1980  
Subfamily Usloniinae Miklukho-Maklay, 1963

*Diagnosis.*—Test relatively large, elongate, irregular, sometimes ramified, with more or less coarsely perforated, dark-microgranular wall.

*Occurrence.*—Early Devonian–Frasnian (first, Uralian–Tethyan; then, cosmopolitan during the Frasnian).

*Remarks.*—Synonyms of Usloniinae are: Groupe 4 sensu Vachard, 1976; Cribrosphaerinae Zadorozhnyi and Yuferev, 1984 (partim); Irregularininae Zadorozhnyi and Yuferev, 1984 (partim, and nomen correctum herein for Irregularinae); Irregularinidae Zadorozhnyi and Yuferev, 1984 sensu Vachard, 1991 and 1994 (partim); and Kalijanellinae Zadorozhnyi and Yuferev, 1984.

Genus *Uslonia* Antropov, 1959

*Type species.*—*Uslonia permira* Antropov, 1959.

*Other species.*—*Uslonia permira* (sic: *Uslonia polymorpha* in Miklukho-Maklay, 1965); *Cribrosphaera novita* Pronina, 1960; *Uslonia orientalis* Miklukho-Maklay, 1965 not 1963; *Vermiporella myna* Wray, 1967; *Kalijanella incomposita* Petrova, 1981; *Kalijanella karpinensis karpinensis* Petrova, 1981; and *K. karpinensis giganteus* Petrova, 1981.

*Diagnosis.*—Test elongate, free or temporarily attached. Slightly undulating wall with two or three large necks with an aperture at each extremity. Wall dark-microgranular, porous.

*Occurrence.*—Eifelian and Givetian of the western slope of the northern and central Urals, Russian Platform, eastern and western slopes of the southern Urals and western Siberian Platform.



Shandinsky horizon of Salair (SW Siberia). Givetian of Belgium (Mamet and Pr  at, 2009), western France (Milon, 1928; Vachard, 1994), Germany (Fl  gel and H  tzel, 1971; May, 1992; Kr  ck, 2016), Poland (Racki and Sobo  n-Podg  rska, 1993), and Morocco (Mamet et al., 1999). Discovered in the Givetian of the Carnic Alps (Austria). Middle–Late Devonian of West Canada (Toomey et al., 1970). Late Devonian of the Urals, eastern part of Russian Platform, Kazakhstan (Kara Tau), Kok-Shaal, southern Fergana, Norilsk area, southwestern Siberia, former “central Asia” (Turkmenistan), England, ?Italy, South China and Australia (Wray, 1967). The specimen from the late Famennian of Omolon (NE Siberia), illustrated by Conil in Shilo et al. (1984, pl. 16, fig. 1), is most probably an *Irregularina* or a deformed *Bisphaera*, as well as the *Uslonia* sp. of Brunner (1975, p. 23, pl. 2, fig. 7), as well as that of Mamet (1976, pl. 57, figs. 3, 4). Unlike Loeblich and Tappan (1987), the earliest Serpukhovian genus *Pachythurammia* Vachard, 1977, totally differs by its spherical morphology, much smaller size, and calcisphaerid wall.

**Remarks.**—*Uslonia* may be synonymized with “Calcisph  res” sensu Milon, 1928 (partim); *Vermiporella* auctorum (partim); *Kalijanella* Petrova, 1981; *Cribrosphaeroides* sensu Chuvashov, 1965 (partim), Fl  gel and H  tzel, 1971 (partim), Mamet et al., 1999, Timokhina and Klets (2002), and Anfimov, 2008 (partim); *Kaljanella* (sic) sensu Anfimov, 2008 and 2011; and *Cribrosphaeroides?* sensu Mamet and Pr  at, 2013. *Uslonia* is clearly a junior synonym of *Kalijanella* due to its Givetian age, elongate and irregular shape, and coarse perforated dark-microgranular wall. Recently, *Kalijanella* was generally used (e.g., Vachard, 1994; Anfimov, 2008, 2011), but *Uslonia* was re-introduced, with good reason, by Mamet and Pr  at (2009, pl. 5, fig. 5). Misinterpretations about *Uslonia* probably resulted in the fact that this genus was indicated with “no aperture observed” by Loeblich and Tappan (1987), while this genus was synonymized with *Cribrosphaeroides* sensu Chuvashov (1965) by Zadorozhnyi (1987). *Uslonia*, *Corbiella* Antropov, 1950, and *Parastegnammina* Poyarkov, 1969 were erroneously interpreted as cortoid grains by Vachard (1994). If *Parastegnammina* really is a cortoid, *Uslonia* and *Corbiella* are two skeletons and probably synonyms of *Kalijanella* and *Irregularina* Vissarionova, 1950, respectively. *Uslonia* sensu Brunner (1975, pl. 2, fig. 7) also differs from true *Uslonia* and are probably synonymous of *Irregularina* cf. *I. karlensis* illustrated on the same plate (Brunner, 1975, pl. 2, fig. 2). The reconstruction in 3D of Racki and Sobo  n-Podg  rska (1993, text fig. 1) was puzzling and surrealistic. As indicated by Mamet and Pr  at (2009), the Devonian *Vermiporella*, especially, *V. myna* Wray, 1967, in reality belongs to *Uslonia*, a genus that, in our opinion, has nothing in common with *Vermiporella*.

*Uslonia* cf. *U. incomposita* (Petrova, 1981)  
Figure 8.34

- ?1971 *Cribrosphaeroides simplex* (Reitlinger); Fl  gel and H  tzel, pl. 1, fig. 7 (only).  
1981 *Kalijanella incomposita* Petrova, p. 90, pl. 11, figs. 1–5.  
1987 *Kalijanella incomposita*; Zadorozhnyi, p. 40, pl. 3, fig. 9.

- 1987 *Pachythurammia incomposita*; Loeblich and Tappan, p. 192, pl. 209, figs. 5, 6.  
1993 *Kalijanella incomposita*; Sabirov in Vdovenko et al., p. 35, pl. 7, fig. 3.  
2011 *Kaljanella* (sic) *incomposita*; Anfimov, p. 78.  
2016a *Uslonia* sp.; Vachard, fig. 3.34.

**Holotype.**—Axial section (No. 77/1868; UTGU Museum) from the Middle Devonian of the central Urals (Petrova, 1981, pl. 1, fig. 1).

**Diagnosis.**—Our specimen is similar to that illustrated by Zadorozhnyi (1987, pl. 3, fig. 9), by its measurements, more than to the type material of Petrova (1981).

**Occurrence.**—Eifelian–Givetian of the northern and central Urals. Shandinsky horizon of Salair (SW Siberia). Givetian of Germany. Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

**Description.**—Test length = 0.70 mm (type material: 0.38–1.20 mm); outer diameter = 0.45 mm; test wall thickness = 0.04 mm (type material: 0.012–0.045 mm).

**Materials.**—One specimen (sample POL13b-12).

Family Cribrosphaeroididae Sabirov in Zadorozhnyi and Yuferev, 1984 nom. correct. Sabirov, 1987b

**Diagnosis.**—Test relatively large, globular with more or less coarsely perforated, dark-microgranular wall.

**Occurrence.**—Silurian–Tournaisian and Uralian–Tethyan.

**Remarks.**—The following taxa are synonyms of the family Cribrosphaeroidae: Stegnammininae Moreman, 1930 (partim); Bisphaeridae Sabirov, 1987b (partim); Cribrosphaeridae Sabirov in Zadorozhnyi and Yuferev, 1984; and Cribrosphaerinae Zadorozhnyi and Yuferev, 1984.

Genus *Cribrosphaeroides* Reitlinger in Rauzer-Chernousova and Fursenko, 1959

**Type species.**—*Cribrosphaera simplex* Reitlinger, 1954.

**Other species.**—*Cribrosphaeroides simplex donica* Brazhnikova and Rostovceva, 1966; *Cribrosphaera crassa* Pronina, 1960; *C. ovalis* Poyarkov in Purkin et al., 1961; *Cribrosphaeroides enormis* Pronina, 1963; *C. incomptus* Chuvashov, 1965; *C. turcmenica* Miklukho-Maklay, 1965; *C. (Cribrosphaeroides?) rariporus* Poyarkov, 1969; *C. semicircularis* Pronina in Petrova and Pronina, 1980; *C. irregularis irregularis* Pronina in Petrova and Pronina, 1980; *C. irregularis serotinus* Petrova, 1981; *C. (Cribrohemisphaeroides) apertus* Pronina in Petrova and Pronina, 1980; *C. multiformis* Saltovskaya, 1981; *C. instabilis* Zadorozhnyi and Yuferev in Dubatolov, 1981; *C. parasimplex* Lin and Hao, 1982; *C. urmitanica* Sabirov in Zadorozhnyi and Yuferev, 1984; *C. beatus* Sabirov, 1984; *C. tschukalikensis* Sabirov, 1984; and ?*C. (Cribrosphaeroides) grandiporus* Poyarkov, 1969 (type of *Cibrauroria* Vachard, 1994).

*Diagnosis.*—Cribrosphaeroididae globular, almost spherical, with coarse perforations in the wall, *C. (Cribrosphaeroides)*, or finer perforations in the wall, *C. (Parphia)*.

*Occurrence.*—Llandoveryan–Ludlovian of the Urals (Pronina, 1963; Petrova and Pronina, 1980). Early Devonian of northern Spain, Tajikistan, western Siberia, and Salair. Eifelian of SW Siberia and Tian Shan. Late Eifelian of the central Urals. Givetian of the northern and central Urals, western Siberia, Tian Shan, western and northern France, Belgium, Germany, Moravia, and the Carnic Alps (this work). Late Devonian of the central Urals, southern France (Vachard, 1974a, b), Czech Republic, Moravia, northern Turkey (Zonguldak: Dil, 1976, pl. 1, figs. 6, 7), western Siberia, Tian Shan, and South China. Early Tournaisian of Donbass (Ukraine) and Tian Shan.

*Remarks.*—“Calcisphères” sensu Milon, 1928 (partim); *Cribrosphaera* Reitlinger, 1954 (pre-occupied); *Bisphaera* Birina, 1948 (partim); and *Cribrosphaerella* sensu Toomey and Mamet (1979: lapsus calami) all belong to *Cribrosphaeroides*. According to Toomey and Mamet (1979), Vachard (1994), Schlagintweit et al. (2013), and Kröck (2016), *Cribrosphaeroides* could be an incertae sedis alga.

Subgenus *Parphia* Miklukho-Maklay, 1965

*Type species.*—*Cribrosphaeroides (Parphia) robusta* Miklukho-Maklay, 1965.

*Diagnosis.*—Test globular, moderate-sized wall, dark-microgranular with numerous fine microperforations.

*Occurrence.*—Middle Devonian of Turkmenistan, Kyrgyzstan, Uzbekistan, Urals, and Morocco. Late Devonian of Turkmenistan and the Urals.

*Cribrosphaeroides (Parphia) robusta* Miklukho-Maklay, 1965  
Figure 8.32, 8.33

- 1965 *Parphia robusta* Miklukho-Maklay, p. 32, pl. 1, figs. 4, 5, 6?  
1969 *Cribrosphaeroides (Parphia) robusta*; Poyarkov, p. 122, pl. 6, fig. 10.  
?1971 *Sphaerella?* sp.; Flügel and Hötzl, p. 378, fig. 3.9.  
?1971 *Radiosphaera* sp.; Flügel and Hötzl, p. 379, fig. 3.6, 3.7.  
1979 *Cribrosphaeroides (Parphia) robusta*; Poyarkov, pl. 8, fig. 4.  
1979 *Cribrosphaeroides robustus*; Yuferev, pl. 1, fig. 8.  
1979 *Cribrosphaeroides robustus*; Lavrusevich et al., p. 322.  
1981 *Cribrosphaeroides robustus*; Petrova, pl. 13, figs. 1, 2.  
1981 *Cribrosphaeroides robusta*; Zadorozhnyi, p. 112 (no. 56 of the table).  
1982a *Cribrosphaeroides robusta*; Sabirov, p. 92, fig. 2.III.b.  
1987 *Parphia robusta* Loeblich and Tappan, p. 195, pl. 211, figs. 6, 7.  
1990 *Cribrosphaeroides robustus*; Gagiev and Bogush, text-fig. 3.  
1994 *Cribrosphaeroides (Parphia) robusta*; Vachard et al., p. 7, pl. 1, fig. 1.

2014 Parathuramminide. Mörtl, text-fig. 33f.

2016a *Cribrosphaeroides* sp.; Vachard, fig. 3.32, 3.33.

*Holotype.*—Axial section (No. 30; Leningrad/Sankt Petersburg University) from the Late Devonian of Turkmenistan (Miklukho-Maklay, 1965, pl. 1, fig. 4).

*Diagnosis.*—Two specimens have the same parameters as *Parphia robusta*.

*Occurrence.*—Middle Devonian of Turkmenistan, Tian Shan, Urals, and western Siberia. Givetian of Morocco. ?Givetian Zerevshano-Gissar (Tajikistan) and Germany. Early Famennian of northeastern Siberia. Late Famennian of the eastern slope of the central Urals. Early Tournaisian of northeastern Siberia (Omolon Massif). Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Outer diameter = 0.57–0.60 mm; inner diameter = 0.55–0.56 mm; wall thickness = 0.017–0.02 mm.

*Materials.*—Two specimens (samples POL13a-1, POL13b-1).

Family Auroriidae Loeblich and Tappan, 1986

*Diagnosis.*—Test globular to ellipsoidal, medium-sized, with a spherical to trapezoidal central chamber, wall dark-microgranular bilayered with an inner thin, dark-microgranular layer, numerous coarse microperforations, and a thick, canaliculate, gray outer layer.

*Occurrence.*—Middle Devonian of Moravia, western Siberia, Tian Shan, Urals, Germany, Morocco. Late Devonian of Moravia, Turkmenistan, Urals, and northeastern Siberia.

*Remarks.*—The family is composed of *Auroria* Poyarkov, 1969, *Apertauroria* Sabirov in Zadorozhnyi and Yuferev, 1984, and *Cribrauroria* Vachard, 1994.

Genus *Auroria* Poyarkov, 1969

*Type species.*—*Auroria singularis* Poyarkov, 1969.

*Other species.*—*Auroria ferganensis ferganensis* Poyarkov, 1969; *A. ferganensis crassa* Poyarkov, 1969; *A. ferganensis globula* Poyarkov, 1969; *A. ferganensis parva* Petrova, 1981; *A. delineata* Petrova, 1981; *A. triangularis* Saltovskaya, 1981; *A. (A.) gissarica* Sabirov in Zadorozhnyi and Yuferev, 1984; *A. (A.) lentisiformis* Sabirov in Zadorozhnyi and Yuferev, 1984; and *A. (A.) sphaerica* Sabirov in Zadorozhnyi and Yuferev, 1984.

*Diagnosis.*—Test unilocular, free, irregularly globular. Internal chamber polygonal to ovoid. Inconspicuous apertures (except for the internal layer of the wall). Bilayered wall, inner layer thin, dark-microgranular, finely porous; external layer apparently spongy, gray, with dark bifurcated pillars or canalicules.

*Occurrence*.—Middle Devonian of the central and northern Urals, Salair, southern Fergana, and Moravia. Middle–Late Devonian of southern Tian Shan, Zeravshano-Gissar, Urals, southwestern Siberia, Moravia, western France (Ancenis Basin), and southern France (Causse de Laurens). ?Tournaisian of Kazakhstan (Marfenkova, 1991, pl. 1, fig. 20). Discovered in the Givetian of the Carnic Alps.

*Auroria* cf. *A. singularis* Poyarkov, 1969  
Figure 8.30

- 1969 *Auroria singularis* Poyarkov, p. 115, pl. 6, figs. 1–3.  
1969 *Auroria* cf. *singularis*; Poyarkov, pl. 6, fig. 11.  
1979 *Auroria singularis*; Lavrusevich et al., p. 323.  
1979 *Auroria singularis*; Dubreuil and Vachard, p. 241.  
1981 *Auroria* ex gr. *singularis*; Saltovskaya, p. 111, pl. 4, fig. 9.  
?1981 *Auroria ferganensis* Poyarkov; Saltovskaya, p. 111, pl. 4, fig. 11.  
1981 *Auroria singularis*; Petrova, p. 96, pl. 9, figs. 1–4.  
1981 *Auroria singularis*; Zadorozhnyi, p. 112 (no. 51 of table).  
1981 *Auroria singularis*; Zupalova, pl. 4, fig. 3.  
1984 *Auroria singularis*; Zupalova, table 1.  
1984 *Auroria singularis*; Sabirov, pl. 2, fig. 2.  
1985 *Auroria singularis*; Zadorozhnyi, pl. 17, fig. 7.  
1987 *Auroria singularis*; Zadorozhnyi, p. 38, pl. 3, fig. 8.  
1987 *Auroria singularis*; Loeblich and Tappan, pl. 210, figs. 16–18.  
1993 *Auroria singularis*; Sabirov in Vdovenko et al., p. 35, pl. 7, fig. 1.  
1999 *Auroria singularis*; Mamet et al., pl. 5, figs. 6, 7.  
2008 *Auroria singularis*; Anfimov, p. 78.  
2008 *Auroria singularis*; Chuvashov, p. 180.  
2009 *Auroria singularis*; Mamet and Pr eat, pl. 5, fig. 4.  
2016a *Cribrosphaeroides* sp.; Vachard, fig. 3.32, 3.33.

*Holotype*.—Axial section (No. 226/26) from the Givetian of Fergana, Kyrgyzstan (Poyarkov, 1969, pl. 6, fig. 1).

*Diagnosis*.—The dimensions correspond to *A. singularis*, but the pillars/canalicules apparently are not bifurcated.

*Occurrence*.—Early Devonian of Tajikistan. Eifelian–Givetian of the northern and central Urals, western Siberia and Zeravshano-Gissar. Givetian of southern Fergana and Moravia. Early Givetian of Belgium (Mamet and Pr eat, 2009). Givetian of western France (Dubreuil and Vachard, 1979). Early Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter =  $0.45 \times 0.32$  mm (type material:  $0.37\text{--}0.88 \times 0.37\text{--}0.84$  mm); inner diameter =  $0.26 \times 0.20$  mm (type material:  $0.16\text{--}0.71 \times 0.16\text{--}0.45$  mm); wall thickness =  $0.05\text{--}0.10$  mm (type material:  $0.03\text{--}0.12$  mm). The dimensions correspond to *A. singularis*, but the pillars/canalicules apparently are not bifurcated.

*Materials*.—Two specimens (sample POL14–17).

*Auroria* cf. *A. triangularis* Saltovskaya, 1981

Figure 8.31

- ?1971 Typus 2 Fl ugel and H otzl, p. 375, pl. 3, figs. 1, 2.  
1981 *Auroria triangularis* Saltovskaya, p. 111, pl. 4, figs. 10, 12.  
?1981 *Polyderma* sp. Zupalova, pl. 4, fig. 2.  
?1984 *Auroria (Auroria) sphaerica* Sabirov in Zadorozhnyi and Yuferev, p. 110, pl. 5, figs. 2, 3.  
?1985 *Auroria sphaerica* Sabirov; Zadorozhnyi, p. 126, pl. 17, fig. 8.  
2016a *Apertauroria?* sp.; Vachard, fig. 3.31.

*Holotype*.—Axial section (No. 320/61, Institut Geologii AN TadjzhSSR) from the Middle Devonian of Zeravshano-Gissar, Tajikistan (Saltovskaya, 1981, pl. 4, fig. 10).

*Diagnosis*.—Parameters seem to correspond with the type material of this species; nevertheless, the inner surface of our specimens is more irregular.

*Occurrence*.—Eifelian of western Siberia. ?Middle Devonian of Zeravshano-Gissar. ?Givetian of Germany. ?Givetian of Moravia. ?Frasnian of Zeravshano-Gissar. Early Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter =  $0.60\text{--}0.66$  mm (type material:  $0.25\text{--}0.42$  mm); inner diameter =  $0.42\text{--}0.60$  mm (type material:  $0.20\text{--}0.31$  mm); test wall thickness =  $0.07\text{--}0.09$  mm (type material:  $0.028\text{--}0.045$  mm).

*Materials*.—Two specimens (sample POL13a-14).

*Auroria?* sp.  
Figure 8.36

2016a *Apertauroria?* sp.; Vachard, fig. 3.36?

*Diagnosis*.—A single oblique section is questionable, but displays some characters of *Auroria*.

*Occurrence*.—Early Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Outer diameter =  $0.66\text{--}0.70$  mm; inner diameter =  $0.30\text{--}0.38$  mm; test wall thickness =  $0.07\text{--}0.13$  mm.

*Materials*.—One specimen (sample POL14-8).

Order Earlandiida Sabirov in Vdovenko et al., 1993  
emend. Vachard et al., 2010

*Diagnosis*.—Tests regularly cylindrical (Earlandiina) to irregularly tubular (Caligellina). Generally, they are bilocular with a spherical or polygonal proloculus followed by a chamber, undivided or with pseudosepta. *Tikhinella* with complete septa is transitional to the Eonodosariina. Wall dark-microgranular on the shallow platforms, recrystallized and convergent with the *Astrorhizata* Hyperamminidae in deeper environments. Aperture terminal simple (Earlandiina) or inconspicuous apertures (Caligellina).

*Occurrence.*—Ordovician–Cretaceous; cosmopolitan.

*Remarks.*—Earlandinitida Reitlinger and Sabirov in Vdovenko et al., 1993 is a junior synonym. Earlandiida is subdivided into three suborders: Earlandiina Vachard, 2016a; Caligellina Vachard, 2016a; and Eonodosariina Vachard, 2016a.

Suborder Earlandiina Vachard, 2016a

Superfamily Earlandioidea Loeblich and Tappan, 1982

Family Earlandiidae Cummings, 1955 emend. Vachard, 1994

*Diagnosis.*—Test free, bilocular, elongate, undivided or with pseudosepta, or very rarely true septa (*Tikhinella*). Wall calcareous, secreted, dark-microgranular. Aperture terminal, round, simple, at the extremity of the tubular chamber.

*Occurrence.*—Ordovician–Cretaceous; cosmopolitan.

*Remarks.*—Junior synonyms are Earlandinitidae Loeblich and Tappan, 1984, and Paratikhinellidae Loeblich and Tappan, 1984.

Genus *Earlandia* Plummer, 1930.

*Type species.*—*Earlandia perparva* Plummer, 1930.

*Diagnosis.*—Earlandiidae undivided, rectilinear, cylindrical to tapering with more or less prominent proloculus.

*Occurrence.*—Silurian (upper Ludlovian; Pronina, 1968; Petrova and Pronina, 1980; Sabirov, 1987a)—Cretaceous (e.g., Arnaud-Vanneau, 1980; Altner, 1991), cosmopolitan (Gaillot and Vachard, 2007).

*Remarks.*—Junior synonyms of *Earlandia* are *Quasiearlandia* Brazhnikova in Brazhnikova and Vdovenko, 1973; *Biorbis* Strank, 1983; *Gigasbia* Strank, 1983; *Aeolisaccus* Elliott, 1958 (partim); *Hyperammia* Brady, 1878 (partim); and *Decastronema* Golubic, Radoicic, and Lee, 2006 (partim). The genus *Hyperammia* sensu lato is a homeomorph among the Astorhizata.

*Earlandia* sp.1

Figure 9.2

*Description.*—A small curved longitudinal section of this genus.

*Occurrence.*—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Length = 0.13 mm; outer diameter = 0.03 mm; wall thickness = 0.01 mm.

*Materials.*—One specimen (sample POL11a-3).

*Earlandia* sp. 2

Figure 9.5

*Diagnosis.*—Broader, rectilinear, slightly tapering test.

*Occurrence.*—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description.*—Length = 0.26 mm; outer diameter = 0.07 mm; wall thickness = 0.007 mm.

*Materials.*—One specimen (sample POL11a-31).

Suborder Caligellina Vachard, 2016b

Superfamily Caligelloidea Gaillot and Vachard, 2007 emend.

Özkan and Vachard, 2015

Family Caligellidae Reitlinger in Rauzer-Chernousova and Fursenko, 1959

Genus *Paracaligella* Lipina, 1955

*Type species.*—*Paracaligella antropovi* Lipina, 1955.

*Diagnosis.*—Test elongate with irregularly curved growth, probably endofaunal, irregularly pseudoseptated. Wall dark-microgranular. Aperture probably terminal simple.

*Occurrence.*—Late Silurian–late Serpukhovian of the Paleotethys; rare in Siberia, Japan, and North America (see Vachard, 1994).

*Remarks.*—As illustrated by Vachard and Cózar (2004), *Caligella* has a more granular wall and a more irregular shape (therefore, it can partially correspond to *Irregularina* Vissarionova, 1950; especially, *Irregularina paradoxica* Lin, Li, and Sun, 1990). *Eocaligella* Pronina in Petrova and Pronina, 1980 is similar in shape to *Paracaligella* with a wall microstructure more similar to *Caligella*. *Eotikhinella* has diaphragms in the tubular chamber. *Areniconulus* and *Serpenulina* theoretically have an agglutinated wall. *Glubkoevella* Pronina, 1970, which apparently has a proloculus, may constitute the transition between *Earlandia* and *Caligella*. This taxon was initially described as a subgenus of *Paracaligella* by Pronina (1970). The family Caligellidae encompasses the following genera: *Caligella* Antropov, 1950 (partim); *Eotikhinella* Pronina in Petrova and Pronina, 1980 (partim); *Eocaligella* Pronina in Petrova and Pronina, 1980 (partim); ?*Areniconulus* Eisenack, 1969; and ?*Serpenulina* Chernyk, 1967.

*Paracaligella* ex gr. *antropovi* Lipina, 1955

Figures 8.26, 9.1, 9.8

- 1955 *Paracaligella antropovi* Lipina, p. 26, pl. 2, figs. 15–17, 20.
- ?1960 *Paracaligella antropovi*; Lipina, p. 19, text-figs. 2, 4, 5, 7, 9 (most probably, due to the stratigraphical distribution, this is a *Paracaligelloides*).
- 1962 *Paracaligella antropovi*; Bogush and Yuferev, p. 97, pl. 1, fig. 35.
- 1964 *Paracaligella antropovi*; Aizenverg and Brazhnikova, pl. 1, fig. 13a, b.
- 1964 *Caligella antropovi*; Loeblich and Tappan, text-fig. 229:5.
- 1965 *Paracaligella antropovi*; Chuvashov, p. 38, pl. 5, fig. 13.

- 1966 *Paracaligella antropovi*; Brazhnikova and Rostovceva, p. 18, pl. 5, figs. 5–7, 9.
- 1969 *Caligella antropovi*; Poyarkov, p. 141, pl. 8, figs. 21, 22.
- 1970 *Paracaligella antropovi*; Bogush et al., pl. 1, fig. 8.
- 1970 *Paracaligella antropovi*; Bogush and Yuferev in Obut, pl. 1, fig. 23.
- 1971 *Paracaligella antropovi*; Brazhnikova and Vdovenko, p. 28, pl. 6, figs. 13, 14.
- 1971 *Paracaligella antropovi*; Menner and Reitlinger, p. 31, pl. 11, fig. 6.
- 1973 *Paracaligella antropovi*; Grozdilova, pl. 1, fig. 13.
- 1973 *Paracaligella antropovi*; Brazhnikova and Vdovenko, p. 110, pl. 1, fig. 11.
- 1975 *Paracaligella antropovi*; Grozdilova et al., p. 28, pl. 1, fig. 4.
- 1975 *Caligella antropovi*; Bogush et al., table 1, pl. 1, figs. 24, 25.
- 1977 *Caligella ex gr. antropovi* (Lipina); Vdovenko, pl. 5.1, fig. 4.
- 1981 *Caligella ex gr. antropovi*; Saltovskaya, p. 113, pl. 1, figs. 14–17, 19.
- 1987 *Paracaligella antropovi*; Loeblich and Tappan, pl. 219, fig. 12.
- 1989 *Paracaligella aff. antropovi*; Skompski et al., pl. 7, fig. 38.
- 1990 *Paracaligella antropovi*; Gagiev and Bogush, text-fig. 3.
- 1991 *Paracaligella antropovi*; Marfenkova, pl. 1, fig. 9.
- ?1992 *Caligella antropovi*; Trifonova, p. 40, pl. 5, figs. 14, 15.
- 2001 *Caligella ex gr. antropovi*; Vdovenko, pl. 1, fig. 3.
- 2002 *Paracaligella antropovi*; Timokhina et al., p. 125, text-figs. 3, 4.
- non ?2008 *Paracaligelloides antropovi* Lipina (sic: without parentheses); Anfimov, p. 80.
- 2011 *Caligella* sp.; Özkan, text-fig. 4, pl. 1, fig. 22.
- ?2011 *Paracaligella* sp.; Özkan, text-fig. 4.
- 2011 *Paracaligella antropovi*; Grechishnikova and Levitskii, p. 27.
- 2013 *Caligella antropovi*; Kulagina, p. 276 (no. 34 of table 1).
- 2016a *Paracaligella* sp.; Vachard, fig. 3.26.

*Holotype*.—Axial section (No. 3415/39; Museum of Institute of Geological Sciences of the SSSR) from the Late Devonian of the European Russian Platform (Lipina, 1955, pl. 2, fig. 15).

*Diagnosis*.—Sinusoidal, cylindrical test, with short pseudosepta and a thin wall.

*Occurrence*.—Early Silurian (Gissar, Tajikistan; Saltovskaya, 1981). Late Devonian of Norilsk area (Siberia, Russia). Famennian of eastern slope of the Urals, Donbass, and western Siberia. Tournaisian of Russian Platform, eastern slope of the Urals, Kazakhstan, Tian Shan, and Donbass. Visean of Kolyma (eastern Siberia), Donbass, and Poland. ?Triassic of Bulgaria. Discovered in the Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Length = 0.85–3.50 mm; outer diameter = 0.15–0.60 mm; wall thickness = 0.01–0.015 mm.

*Materials*.—Six specimens (samples POL3-7, POL11b-14a, and POL11b-25).

*Paracaligella* sp. 2

Figure 9.11, 9.12

*Diagnosis*.—Two elongate longitudinal sections with thick wall. They were possibly named *Irregularina intermedia* Bykova in Bykova and Polenova, 1955.

*Occurrence*.—Givetian of Mount Polinik (Carnic Alps, Austria).

*Description*.—Length = 3.10–5.50 mm, outer diameter = 0.15–0.50 mm, wall thickness = 0.015–0.02 mm.

*Materials*.—Three specimens (samples POL13b-9 and POL13b-14).

## Discussion

*Biostratigraphic results*.—The biostratigraphic scales of Emsian, Eifelian, Givetian, and Frasnian stages, based on foraminifers and algae, have been established by Antropov (1950, 1959, 1970); Bykova (1952); Reitlinger (1954, 1957, 1962); Bykova and Polenova (1955); Pronina (1960, 1963, 1968, 1969, 1970); Chuvashov (1965, 2008); Poyarkov (1969, 1979); Coen et al. (1974); Sabirov (1974, 1978, 1984, 1987a, 1987b, 2013); Saltovskaya (1974, 1981); Pel (1975); Petrova (1977, 1981); Petrova and Pronina (1980); Pr eat and Mamet (1989); Langer (1991, 1997); Vachard (1991, 1994); Mamet and Boulvain (1992); Racki and Sobo n-Podg rska (1993); Vachard and Mouravieff (1994); Mamet et al. (1999); Chuvashov and Anfimov (2005); Mamet and Pr eat (2009); and  zkan (2011). New studies are in progress in Europe (M rtl, 2014; Kr ock, 2016).

As indicated by Vachard et al. (2010), parathuramminids, caligellids, true foraminifers, as well as microproblematical issinellids and moravamminids predominate in the calcareous microfacies since the Givetian (Givetian revolution) after a progressive replacement of the so-called agglutinated foraminifers from late Silurian to Eifelian. As early as the Eifelian, the foraminifers provide their first markers (Poyarkov, 1969) with the genus *Ivdelina* in the Urals, not observed in this study, but mentioned in Western Europe by Berkyova and Munnecke (2010, p. 588) under the name “well-preserved radiosphaerid calcispheres.”

According to the data of Poyarkov (1969), the age of the studied samples from the Feldkogel Limestone (Polinik Formation) at Mount Polinik is late Eifelian to early Givetian, or corresponds to the Eifelian–Givetian boundary interval (samples 1–10) and probably early Givetian, as dated by *Bykovaella bykova* (samples 11 and 12). Early to middle Givetian foraminifers are present in samples 13 and 14 with *Auroria* cf. *A. singularis*, *A. cf. A. sphaerica*, *A.?* sp., etc.

*Depositional environment.*—Kreutzer (1992a, b) interpreted the Feldkogel Limestone as intertidal deposits. Pohler et al. (2015) described the Polinik Formation (including the Feldkogel Limestone) as cyclic, shallow marine (inter- to supratidal) deposits of a sheltered lagoon (see also Bandel, 1972).

The microfacies encountered in this study have been described by numerous authors (Wilson, 1975; Pr at and Mamet, 1989; Vachard, 1993; Pr at and Kasimi, 1995; Fl gel, 2004; Mamet and Pr at, 2005, 2007, 2009; Pr at et al., 2007; Vachard et al., 2010; M rtl, 2014; Kr ock, 2016). They are classically interpreted as follows, from deep lagoonal to intertidal and supratidal: (1) *Amphipora* floatstone to rudstone formed in a low-energy, restricted subtidal environment of an inner platform or lagoon (Machel and Hunter, 1994; Da Silva and Boulvain, 2004); (2) grainstone to packstone with parathuramminids, issinellids, and earlandiids are interpreted as deposits of a high-energy intertidal environment; laminated grain- and packstone are typical intertidal lithologies and may also occur in the shallow subtidal (Pratt, 2010); (3) ostracode wackestone-packstone indicates a low-energy restricted intertidal lagoonal environment; (4) bindstone (stromatolite) formed in an upper intertidal to supratidal environment (e.g., Shinn, 1983; Pratt, 2010); and (5) intraclast breccia represents tidal channel deposits, which are common in the intertidal environment (Shinn, 1983; Pratt, 2010).

The described lithofacies of the Feldkogel Limestone at Mount Polinik are locally arranged to form shallowing-upward cycles, starting with subtidal *Amphipora* limestone, overlain by intertidal wackestone, grainstone and packstone with locally intercalated intraclast breccia and finally by shallow intertidal to supratidal stromatolite.

*Amphipora* grew upright on the bottom in a subtidal lagoonal environment, attached to the carbonate mud, and toppled in situ after death. Their ecology was well explained by M rtl (2014). *Amphipora* floatstone is a typical lithology in the backreef (lagoonal) facies of many Upper Devonian reefal environments, representing relatively shallow- and quiet-water conditions (Machel and Hunter, 1994). The paleoecology of the parathuramminids, issinellids, and earlandiids is more difficult to reconstruct (see below).

*Parathuramminid, issinellid, and earlandiid ecologies.*—As the Devonian foraminifers of the class Fusulinata have no modern representatives, it is preferable to reconstruct the paleoecology of the Devonian foraminifers using the method of the morphogroup rather than that of comparative autoecology. The term morphogroup refers to broad groupings of similar shapes or growth patterns of foraminifers that are independent on the exact taxonomy and of the possible homeomorphs. Morphogroups offer a way of overcoming taxonomic differences and thereby making comparisons between assemblages of different geological ages (Murray et al., 2011); consequently, they have been generally used to reconstruct fossil paleoenvironments (Chamney, 1976; Jones and Charnock, 1985; Murray, 1991; Nagy, 1992; Kaminski et al., 1995; Nagy et al., 1995; Jones, 1999; Preece et al., 1999; Van Den Akker et al., 2000; Mancin, 2001; Jones et al., 2005; Kender et al., 2008a, b; Cetaan et al., 2011). Within the morphogroups, it is also interesting to try to reconstruct the microhabitats of the different components of the morphogroups. As indicated by Sen Gupta (2002, p. 163),

“a ‘microhabitat’ is a microenvironment characterized by a combination of physical, chemical and biological conditions (oxygen, food, toxic substances, biological interactions, etc.).” Several authors have suggested a close relationship between microhabitat and test morphology (Sen Gupta, 2002, with references therein). Because the foraminiferal test morphology is directly controlled by morphofunctional factors such as nutrient strategy and life position (Tyszka, 1994; Coccioni et al., 1995; Reolid et al., 2008), it is easy to admit that the same morphogroups have been present since the Devonian into the Holocene (Coccioni et al., 1995, with references therein). Consequently, in our material, the morphogroups A and C of Charnock and Jones (1985); and their equivalents A-1 and A-2 of Coccioni et al. (1995), ED1, ED2, and ED4 of Holcova and Slavık (2013), A and B1 of Murray et al. (2011), are represented. Morphogroup A is constituted by the earlandiids, which are tubular, epifaunal suspension-feeders. Morphogroup C is represented by the caligellids, which are elongate forms, infaunal herbivores, or detritivores. The pseudoammodiscids (i.e., primitive archaediscaetes) and saccamminids were not encountered in our material, and it is noteworthy that all representatives of morphogroup B are absent. Similarly, the epiphytic foraminifers of morphogroup D are totally absent from the Mount Polinik microfacies.

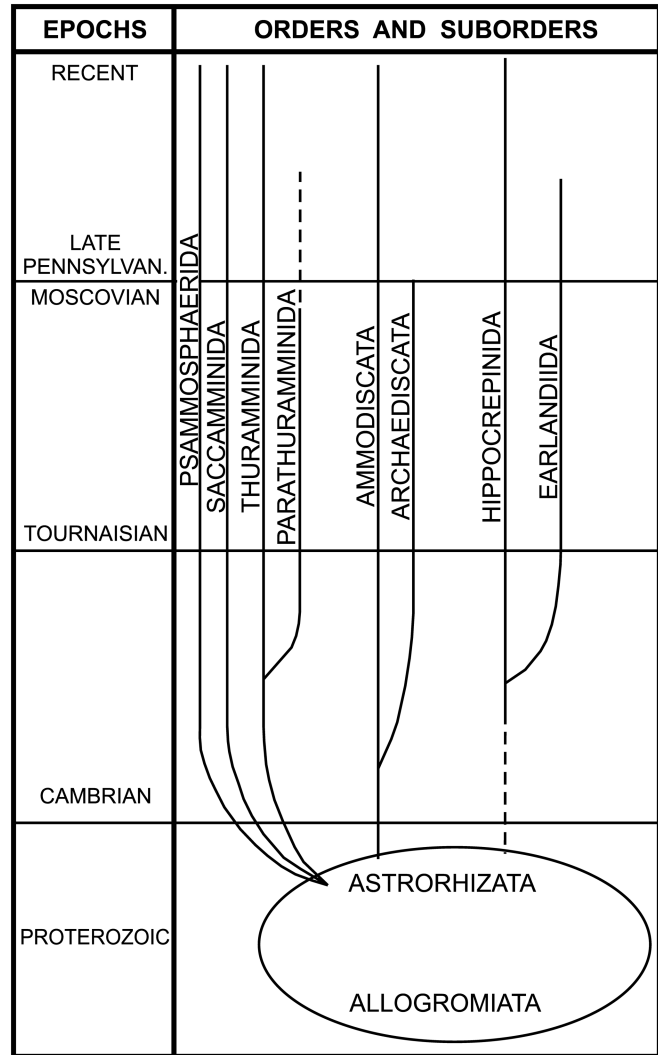
Due to their shape, calcisphaeroids and parathuramminids have often been interpreted as elements of phytoplankton or zooplankton (Munnecke and Servais, 2008; M rtl, 2014), and do not belong to benthic foraminifer morphogroups. Nevertheless, these microorganisms appear related, if not restricted, to confined environments: lagoon and/or microbialitic and even stromatolitic build-ups. They appear more as resistance cysts than as planktonic tests or skeletons. The arguments to justify the assignment to plankton given by Munnecke and Servais (2008) were: (1) abundance; (2) occurrences in different facies; and (3) spherical shape. Finally, the saccamminid and parathuramminid foraminifers, which are possibly detrital/bacterial scavengers, might be partially transported in suspension. Given such hypotheses, it is no wonder that calcisphaeroids and parathuramminids were confused with calcified radiolarians by Vizhnevskaya and Sedaeva (2002a, 2002b) and Afanasieva and Amon (2011).

The other taxon to discuss is *Vasicekia?* sp. This taxon can also correspond to *Palachemonella* (Fl gel and H tzel, 1971, pl. 2, figs. 8–10). It belongs to the incertae sedis Moravammnida and Issinellina (Vachard and C zar, 2010). *Vasicekia* Pokorny, 1951 was erroneously assigned to the Nanicellidae by Poyarkov (1979), who included all the Moravammnidae in the superfamily Hippocrepinoidea, which encompassed: Hippocrepinidae (Astrorhizata), Moravammnidae (incertae sedis in our opinion; see Vachard and C zar, 2010), Earlandiidae, and Caligellidae (also linked together in this paper). Another *Moravammnina* confused with a *Nanicella* was recently published by Pr at et al. (2007). This misinterpretation explains how the *Moravammnina*, which is so frequent in the type Givetian, were almost never mentioned by Pr at or Mamet in their works about this stage: these authors confused the first coiled part of *Moravammnina* with *Nanicella*, and the uncoiled last parts of *Moravammnina* with *Triangulinella* or *Kamaena*.

*Paleobiogeography.*—Similar parathuramminid microfaunas seem to be present in the entire Palaeotethys from western France to Tajikistan and even South China. Our assemblage in particular aligns with those of the calcaires de Chalennes in western France (Dubreuil and Vachard, 1979) and of Causse de Laurens in southern France (Vachard unpublished data), but they seem to be relatively distinct from those of Germany (Körk, 2016) and Moravia (Pokorný, 1951); however, a paleoecologic control is possible, because these latter inhabited deeper seas. In the Carnic Alps, the Givetian sea was probably located between the Armorica-Perunia and Peri-Mediterranean microcontinents, which communicated easily with other shallow seas with the Ural Ocean, Siberia, and Kazakstania on one side, and eastern North America and other parts of Laurussia on the other side (Kalvoda, 2001, 2002; Kalvoda and Bábek, 2010). The shallow-marine Devonian limestone (Feldkogel Limestone; Polinik Formation) was deposited on a shallow shelf that was part of the Noric Composite Terrane (Frisch and Neubauer, 1989), of the Carnic-Dinaric Microplate (Vai, 1991, 1998), or of the Adria-Dinaria Megaterrane (Ebner et al., 2010).

*Foraminiferal macroevolution.*—There are no direct arguments to prove that the parathuramminids, earlandiids, pseudoammodiscids, irregularinoids, and tuberitinids are foraminifers, but two indirect arguments permit this interpretation: (1) all these groups are first agglutinated, and then all become secreted with microgranular tests during the Givetian revolution; and (2) even if monothalamous skeletons exist in different botanical and zoological groups, tests such as those of parathuramminids are only known among foraminifers, with an indisputable extant genus *Thurammina*. It seems also that the Paleozoic foraminifers can display either agglutinated tests or secreted tests (Fig. 11). That is clear for the plurilocular foraminifers (see Vachard, 2016a; particularly with the example of *Rectoseptatournayella* and *Ammobaculites*), but is more disputable for the monothalamous and bilocular taxa in which the nomenclature is double, both for genera (*Thurammina*/*Parathurammina*; *Ammodiscus*/*Pseudoammodiscus*; *Earlandia*/*Hyperammina*; *Archaelagena*/*Paralagena*; etc.), as well as for orders (Fig. 11): (Thuramminida/Parathuramminida; Ammodiscida/Archaeidiscida; Hippocrepinida/Earlandiida); and finally between the classes Fusulinata and/or Textulariata/Astrorhizata (Vachard, 2016a, b). As a result, it is probable that many homeomorphs of different classes have been confused in the foraminiferal literature. Inversely, with the hypothesis of a calcareous foraminiferal test secreted in isotopic equilibrium with ambient seawater (Langer, 1995), it is possible that when calcification is weaker in deeper waters, an agglutinate can replace the deficient calcification of a shallow-water genus. However, it is noteworthy that, because all foraminiferal agglutinated tests are contemporaneously replaced by secreted calcareous forms (Fig. 11) in the five groups (parathuramminids, irregularinoids, tuberitinoids, pseudoammodiscids, and earlandiids) during the Givetian revolution (Vachard et al., 2010), it is possible to conclude: (1) that the five groups have common wall microstructures, (2) consequently all belong to foraminifers, and (3) they belong to distinct orders (Fig. 11).

The initial phase of foraminiferal history, from Cambrian to Early Devonian, was dominated by agglutinated tests. The Givetian



**Figure 11.** Phylogenetic hypothesis about the most primitive lineages of foraminifers (agglutinated and secreted). Abbreviation: Pennsylvan. = Pennsylvanian.

(Middle Devonian) revolution resulted in the replacement of these agglutinated tests by calcareous secreted tests (Vachard et al., 2010). Lower Paleozoic agglutinated foraminifers are considered to belong to the classes Textulariata (Loeblich and Tappan, 1964, 1987) and/or Astrorhizata (Vdovenko et al., 1993; Mikhalevich, 2003), but these so-called agglutinates also could have resulted from recrystallization of secreted tests. With the Frasnian-Famennian crisis, the first evolutionary phase of the foraminifers was completed, and the second phase started and lasted until the Permian-Triassic boundary, where life on the Earth nearly disappeared completely and our biological references almost entirely changed.

**Conclusions**

There are nine main conclusions from this study: (1) a rich microfauna of foraminifers, which is accompanied by an amphiporid macrofauna, has been discovered in the Feldkogel Limestone (Polinik Formation) at Mount Polinik (Carnic Alps, Austria); (2) the limestones of Mount Polinik possibly display the Eifelian–Givetian boundary interval (samples 1–10), the

early Givetian (samples 11 and 12), and possibly the middle Givetian (samples 13 and 14); (3) the microfauna of Mount Polinik is remarkably similar to the microfauna reported from the limestone of the Urals and western Siberia (Russia); (4) the microfauna of Mount Polinik is composed of taxa that are typical dark-microgranular Fusulinata; (5) these atypical Fusulinata have no relationships with the thecamoebians; (6) consequently, the nomenclature of these Paleozoic monothalamous and bilocular taxa is currently double, depending on assignment to Astrorhizata or Fusulinata: there are *Parathurammina* sensu lato (= *Parathurammina* sensu stricto, *Parathuramminites*, and *Salpingothurammina*) or *Thurammina*; *Hyperammina* or *Earlandia*; *Lagenammina* or *Paralagena*; etc.; (7) plurilocular foraminiferal taxa such as *Pseudopalmula*, *Paratextularia*, *Semitextularia*, and *Nanicella* are absent in our material; (8) their absence may result from stratigraphic and/or paleoecologic controls; and (9) planktonic microfossils are absent, but some parathuramminids might be pelagic and/or may have been transported in suspension.

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