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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, thaumatoporellaceans, volvocaleans, or other algae are also discussed. Several taxa are emendated: Parathuramminida, Parathuramminoidea, Irregularinoidea, Eovolutinidae, Ivanovellidae, Parathuramminidae, Uralinellidae, *Ivanovella*, *Elenella*, *Neoarchaesphaera*, *Parathurammina*, *Bykovaella*, *Uralinella*, and *Paracaligella*. The new taxa are: *Ivanovella reitlingerae* n. sp., *Elenella polinikensis* n. sp., *Uralinella sabirovi* n. sp., and *Radiosphaerella poyarkovi* n. sp.

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., *Saccammina*, *Psammosphaera*, *Lagenammina*, *Thurammina*, *Hyperammina* 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 *Parathurammina* is homeomorphous of the extant genus *Thurammina* (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) Préat et al. (2007) included in the calcispheres the genera *Calcisphaera*, *Parathurammina*, 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 Clément (1994) indicated possible morphological and paleobiological similarities between some irregularinids or usloniids with thaumatoporellacean 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 Châtelet (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

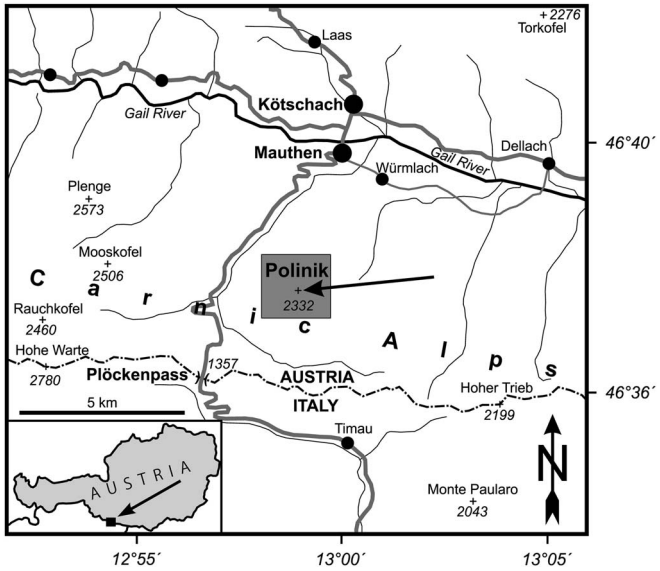

Figure 1. Geographical map of the studied area with location of Mount Polinik.

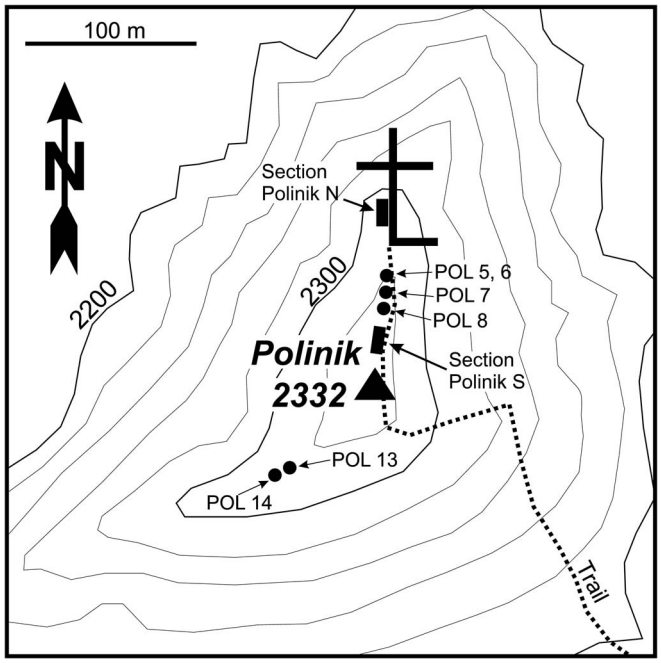

Figure 2. Top of Mount Polinik with locations of the two sections (Fig. 3) and the fossiliferous samples. Contour lines (2200, 2300) in meters.

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.

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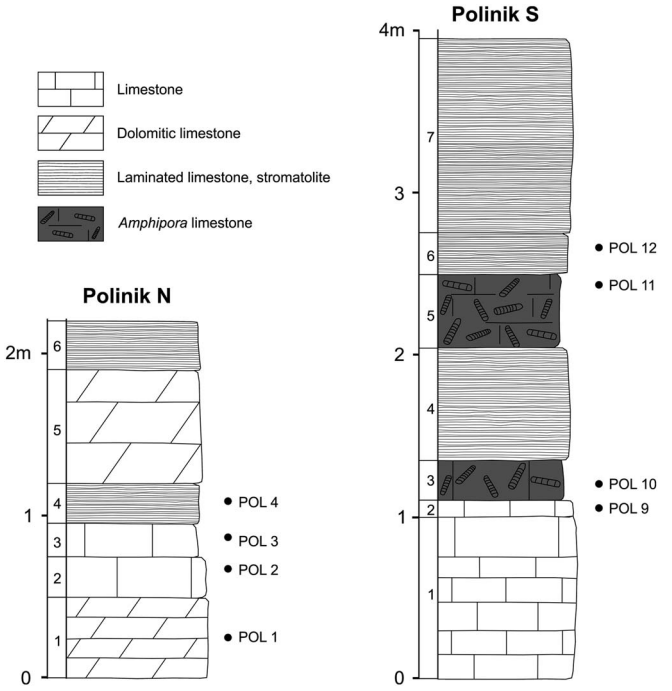

Figure 3. Stratigraphical columns of the studied sections with location of samples (for geographical maps, see Figures 1, 2).

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. pervesiculata* 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).

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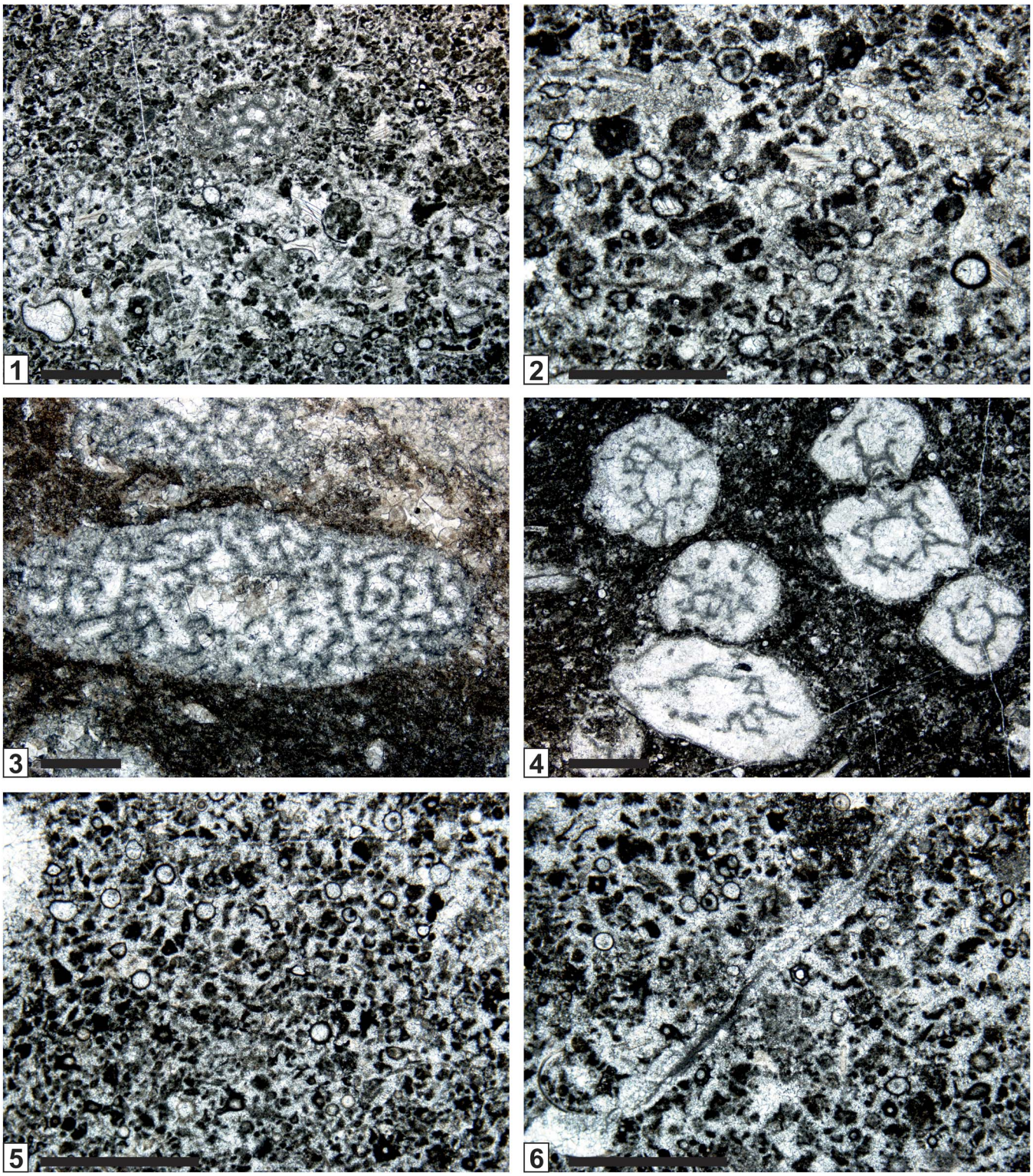

Figure 4. (1) Bioclastic and pelloidal grainstone with *Vasicekia?* sp. (tubular specimens with clear wall), *Neoarchaesphaera ellipsoidalis*, *Ivanovella* sp., *Cribrosphaeroides* (*Parphia*) *robusta*, and *Amphipora* sp., sample POL3. (**2**) Bioclastic and pelloidal grainstone with *Vasicekia?* sp. (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. pervesiculata* and parathuramminids 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 volvocacean algae by Toomey and Mamet (1979) or acritarchs that underwent an early post-mortem calcification (Kaźmierczak 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

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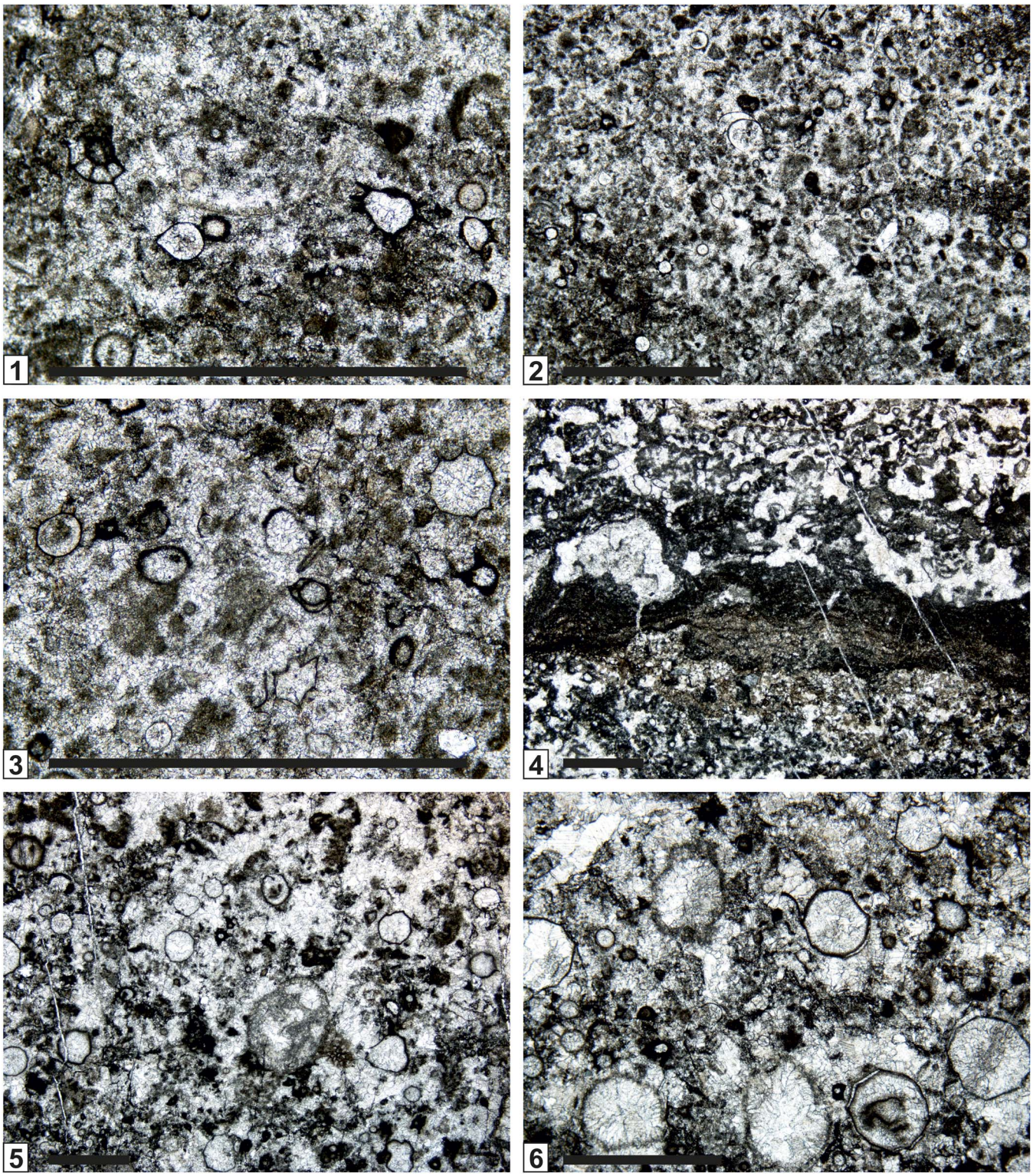

Figure 5. (1) Bioclastic and pelloidal grainstone with *Vasicekia?* sp., *Uralinella* sp., *Radiosphaerella* sp., *Neoarchaesphaera ellipsoidalis*, and *Suleimanovella* sp., sample POL11a-2. (**2**) Bioclastic and pelloidal grainstone with *Uralinella* sp., *Parathurammina* sp., *Salpingothurammina* 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. Eovolutinids also give rise to the tuberitinoids, whereas the irregularinoids derive either from the

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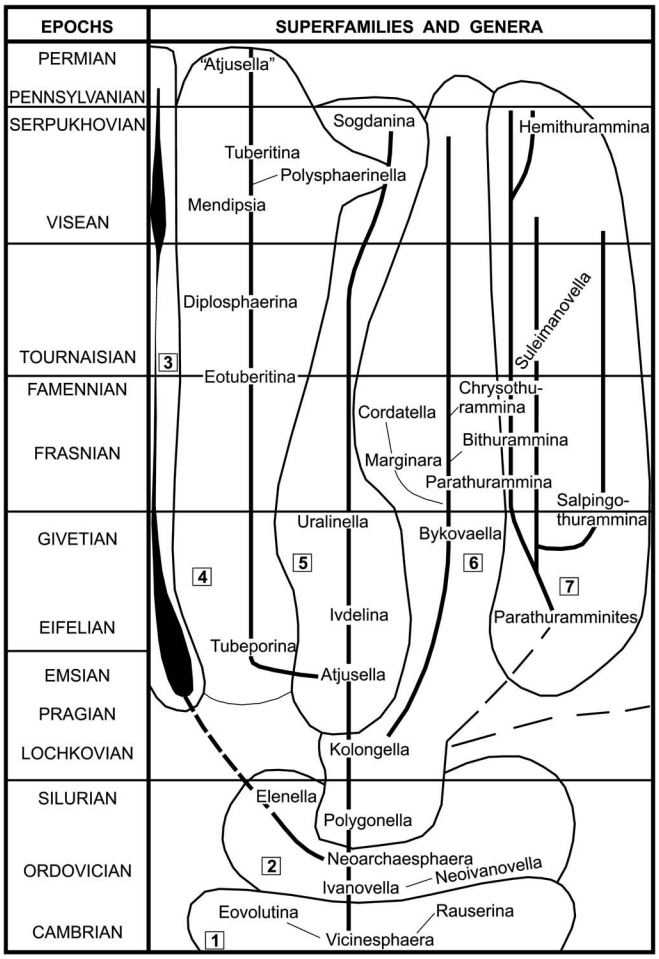

Figure 6. Superfamilies, families, and genera of the Parathuramminida. 1: Eovolutinidae; 2: Ivanovellidae; 3: Calcisphaeroidea; 4: Tuberitinoidea; 5: Uralinellidae; 6: Parathuramminidae; 7: Parathuramminitidae.

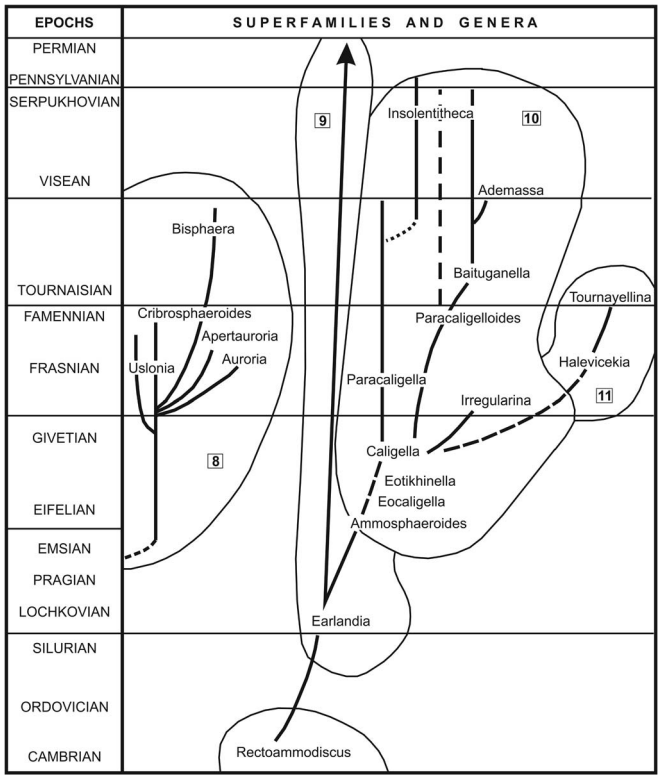

Figure 7. Superfamilies, families, and genera of the Irregularinoidea and Caligelloidea. 8: Irregularinoidea; 9: Earlandioidea; 10: Caligelloidea. 11: Tournayellinidae.

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) or at the extremity of radiate necks connecting the central chamber with the external environment (Parathuramminidae, Parathuramminae, Parathuramminitinae, and Uralinellidae). Wall thin (e.g., *Eovolutina*) to thick (e.g., *Vicinesphaera*), 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

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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 tuberitinoid 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 Haeckel, 1894, nec Cushman, 1927). They are composed of *Ivanovella* Pronina, 1969; *Lechangsphaera* Lin, 1984; *Neoivanovella* Chuvashov and Yuferev in Dubatolov, 1981; *Neoarchaesphaera* Miklukho-Maklay, 1963 (non 1958); *Elenella* Pronina, 1969; ?*Ratella* Kotlyar, 1982; and ?*Turcmeniella* Miklukho-Maklay, 1965. The mazzuelloid microproblematica 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).

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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
urn:lsid:zoobank.org:act:11BF6627-39AF-4F5C-8C30-48A3841DC9DB
Figure 10.16, 10.17, 10.22

1965 *Parathurammina* cf. *spinosa* Lipina; Ferrari and Vai, text-fig. 2e.
1971 *Parathurammina 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 *Parathurammina 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 lunginensis* (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. Necks 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 *Parathurammina 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 bykovae* Miklukho-Maklay, 1965 (= *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 *Parathurammina* [partim]). Relatively frequent and probably widespread during the Devonian (with e.g., *Parathurammina* sensu Malakhova, 1969, pl. 48, figs. 330, 331, pl. 49, fig. 337); *Parathurammina*? sensu Racki and

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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 elipsoidales* (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, 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.

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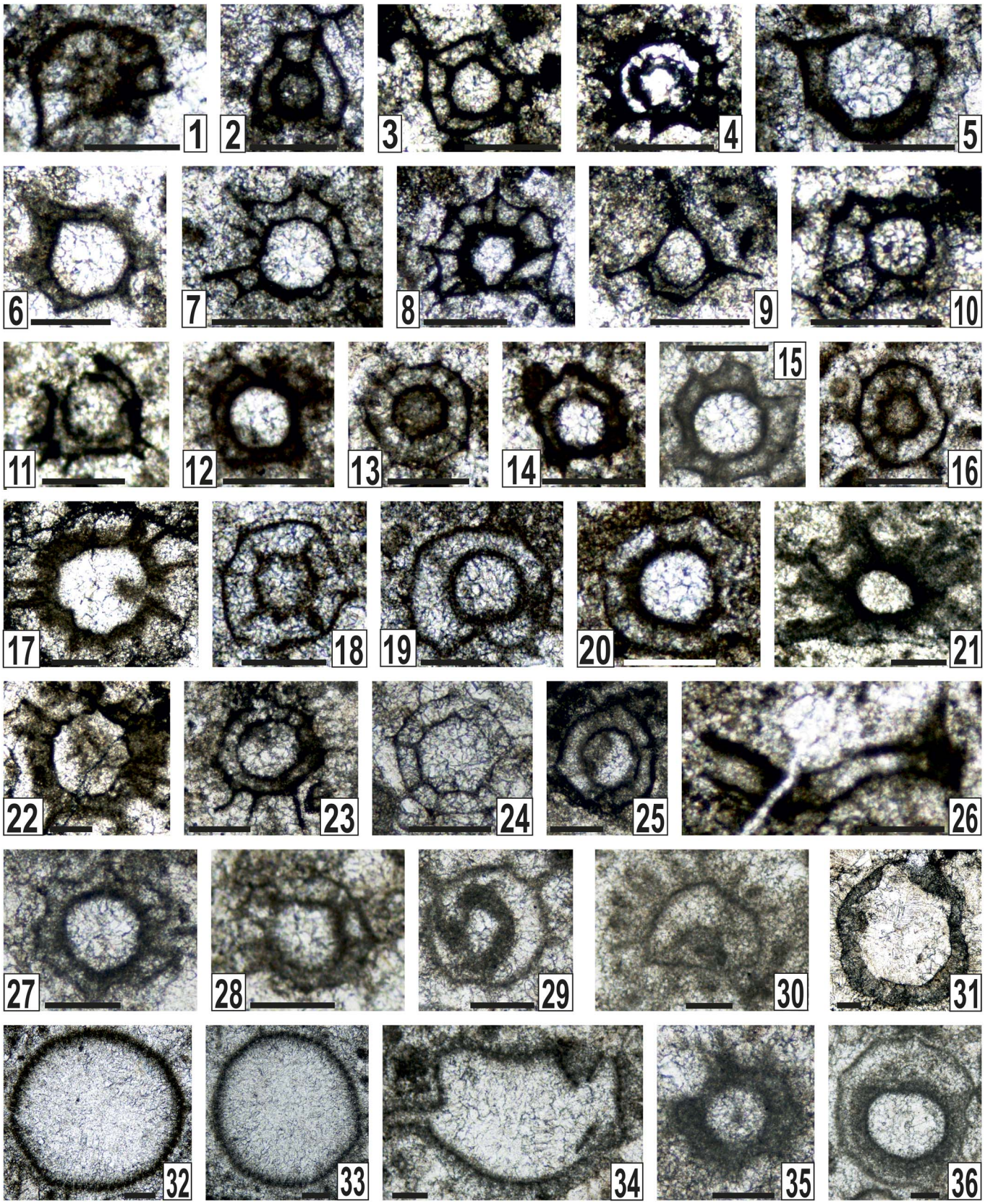

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1981 *Parathurammina*? *losvica* Petrova, p. 89, pl. 7, figs. 13, 14, 16, 17.
1984 *Uralinella lozvica* (sic); Zadorozhnyi and Yuferev, p. 97, pl. 3, figs. 3–5.
1987 *Uralinella losvica*; Zadorozhnyi, pl. 2, figs. 21–23.
1988 *Uralinella lozvica* (sic); Bogush et al., p. 32.
1990 *Uralinella losvica*; Bogush and Yuferev, p. 22.
2008 *Parathurammina lozvica*; Anfimov, p. 78.
2013 *Saltovskajina lozvica*; 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 parathuramminid; 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
urn:lsid:zoobank.org:act:D33F76C5-55F5-4B65-878D-3DD160BCB135
Figure 8.12?, 8.17–8.20, 8.21?, 8.22, 8.27, 8.28

2014 Parathuramminide; Mörtl, text-figs. 33e, 33g.
2016a *Uralinellla* 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 periphically 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*

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Sabirov). *Ivdelina* and "well-preserved radiosphaerid calcispheres" (sensu Berkyova and Munnecke, 2010, p. 588) belong either to the Uralinellidae or to the Tuberitinidae. 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, Bashkorotostan, 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
urn:lsid:zoobank.org:act:48FFF09A-8C87-4A98-8245-131F8158126C
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 Polenova, 1955 emend. Vachard, 1994

Diagnosis.—Test free or rarely atttached, 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

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pseudofibrous layer, or recrystallized and in this case mimicing the agglutinated wall of the homeomorphous Thuramminidae. 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 (Nguyên, 1986, pl. 1, fig. 15).

Remarks.—Parathuramminidae is synonymous with Thuramminidae 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: Parathuramminae 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 *Saccammina*, *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 Parathuramminae 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 Visean; probably cosmopolitan.

Remarks.—Synonym of Parathuramminae (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. parabreviradiosa* 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 (= *Amphitremoidea* 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;

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?*T. papillata* Moreman, 1930; ?*T. papillata* var. *monticulifera* Ireland, 1939; ?*T. parvituba* Dunn, 1942 (= *Amphitremoidea* 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 *Parathurammina*, 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.—*Parathurammina* s.s. is partially synonymous with *Thurammina* (partim), ?*Cordatella* (partim), ?*Marginara* (partim), and ?*Guangxithurammina* Lin et al., 1990. The genus *Chrysothurammina* Neumann, Pozaryska, and Vachard, 1975 differs from *Parathurammina* because the pseudofibrous layer of the wall that surrounds the inner chamber also penetrates the necks.

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

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

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

1981 *Parathurammina uralica* Petrova, p. 86, pl. 6, figs. 3, 5, 6.
1990 *Bykovaella uralica*; Bogush and Yuferev, p. 21.
?2009 *Parathurammina crassitheca* Antropov; Mamet and Préat, fig. 1.19 only (non fig. 1.18 = *Kolongella*).
2011 *Parathurammina 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. Necks 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 *Parathurammina*. In this genus, *P. uralica* is the most similar species compared to our taxon.

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

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

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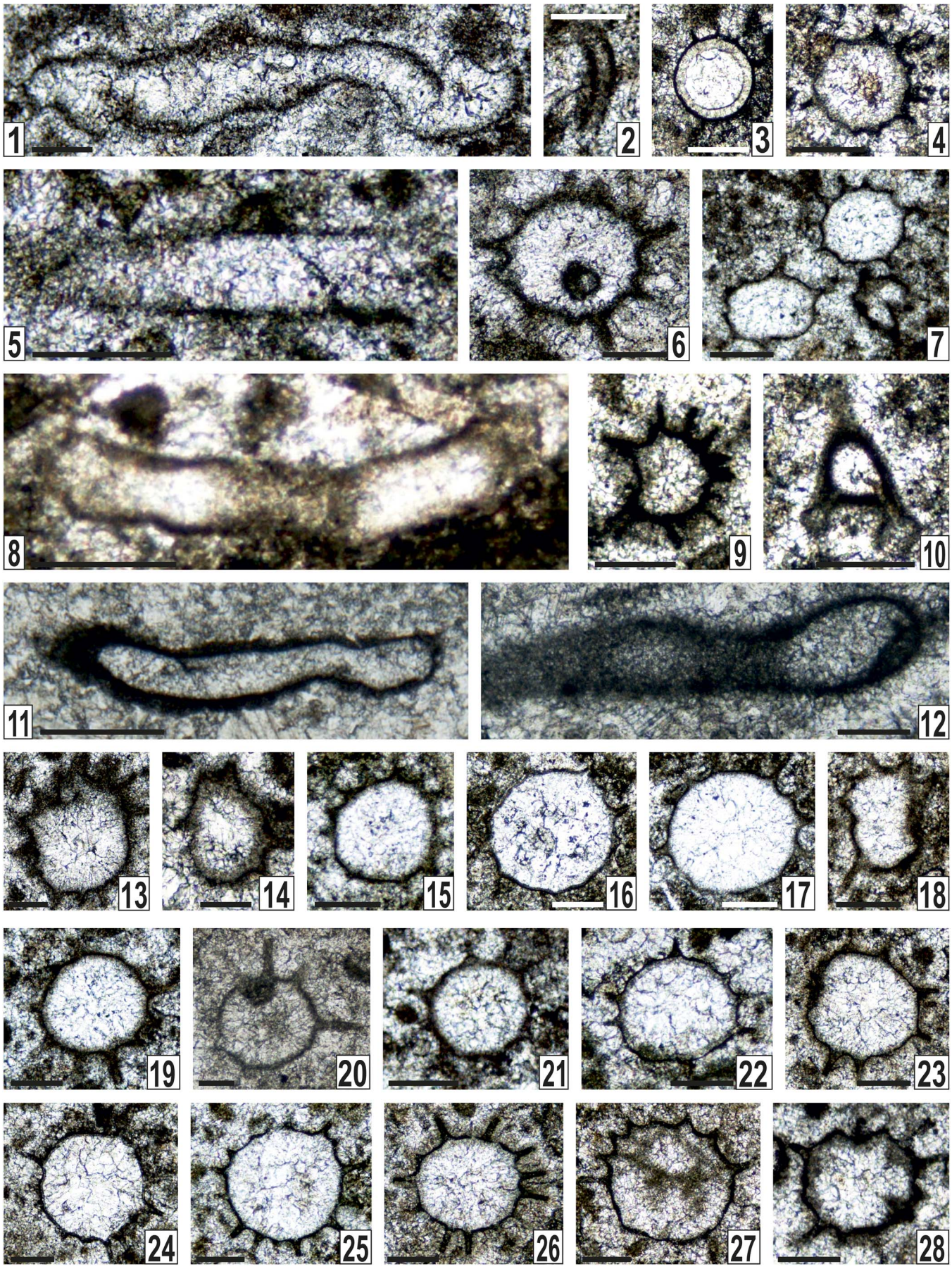

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1981 *Parathurammina* (*Parathurammina*) *aperturata*; Petrova, pl. 7, figs. 9–11.
1985 *Parathurammina arguta*; Zadorozhnyi, p. 127, pl. 17, fig. 6.
2013 *Parathurammina arguta*; Makarenko and Savina, p. 128.
2014 Parathuramminide; Mörtl, text-fig. 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.—*Parathurammina aperturata* Pronina, 1960.

Other species.—*Parathurammina breviradiosa* Reitlinger in Varsanofieva and Reitlinger, 1962; *P. argensis* Sabirov, 1987a; *P. bykovae* Poyarkov in Purkin et al., 1961; *P. crassitheca* Antropov, 1950; *P. dagmarae* var. *crassitheca* Antropov, 1950; *P. iniqua* Pronina, 1970; *Polygonella irregulariformis* Zadorozhnyi and Yuferev, 1984; *Parathurammina 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 *Parathurammina* (partim), *Thurammina* (partim), *Salpingothurammina* (partim), and *Polygonella* (partim).

Bykovaella aperturata (Pronina, 1960) emend. Zadorozhnyi and Yuferev, 1984
Figure 9.16, 9.17, 9.24, 9.25

1928 Calcisphères 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 *Parathurammina aperturata*; Pronina, p. 47, pl. 1, fig. 3.
1969 *Parathurammina aperturata*; Poyarkov, p. 87, pl. 1, figs. 2, 5.
1969 *Parathurammina aperturata*; Malakhova, pl. 49, figs. 337, 338, pl. 50, fig. 344, pl. 52, fig. 359.
non 1971 *Parathurammina aperturata*; Menner and Reitlinger, p. 29, pl. 8, figs. 2, 7–9 (= *Elenella reitlingerae* n. sp.).
1977 *Parathurammina aperturata*; Petrova, p. 4, text-figs. 1, 2.
1979 *Parathurammina aperturata*; Poyarkov, p. 44, pl. 5, fig. 2.
1979 *Parathurammina aperturata*; Lavrusevich et al., p. 322.
1979 *Parathurammina* (*Salpingothurammina*) *aperturata*; Poyarkov, p. 96, text-fig. 14.
1979 *Parathurammina apertura* (sic); Dubreuil and Vachard, p. 241.
non 1981 *Parathurammina 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?**) *Parathurammina 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**) *Parathurammina* 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**) ?*Bithurammina* aff. *B. sphaerica* Ektova, 1968, sample POL.14-33. (**26**) *Parathurammina arguta* Pronina, 1960, sample POL11a-6. Scale bars = 0.1 mm.

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non 1987 *Parathurammina 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 *Parathurammina crassitheca* Antropov; Vachard, p. 261, pl. 1, fig. 25.
1994 *Parathurammina aperturata*; Vachard, p. 20, text-fig. 12.6.
1994 *Parathurammina crassitheca*; 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 *Parathurammina* du groupe *P. dagmarae* Suleimanov; Mamet and Préat, pl. 1, figs. 12, 15, 17 (non figs. 11, 14, 16 = other species of *Bykovaella*, nec fig. 13 = *Kolongella*).
2011 *Parathurammina aperturata*; Anfimov, p. 16.
2013 *Parathurammina aperturata*; Sabirov, p. 115, text-fig. 1.
2013 *Parathurammina aperturata*; Makarenko and Savina, p. 128.

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 (Lavrusevich 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 (Flügel and Hötzl, 1971), South China (Lin and Hao, 1982), and Belgium (Mamet and Préat, 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 crassitheca* (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

1962 *Parathurammina breviradiosa* Reitlinger, p. 52, pl. 1, figs. 1, 2.
1965 *Parathurammina breviradiosa*; Chuvashov, p. 19, pl. 1, figs. 4–6.
1969 *Parathurammina breviradiosa*; Poyarkov, table 12.
1969 *Parathurammina breviradiosa*; Malakhova, pl. 51, fig. 356.
1979 *Parathurammina breviradiosa*; Poyarkov, pl. 3, fig. 4.
1979 *Parathurammina* (*Parathurammina*) *breviradiosa*; Poyarkov, text-fig. 13.
1981 *Parathurammina breviradiosa*; Petrova, pl. 8, fig. 19.
1981 *Parathurammina breviradiosa*; Zadorozhnyi, p. 111 (no. 3 of the table).
?1981 *Parathurammina magna* Antropov; Zukalova, pl. 1, fig. 2.
1984 *Parathurammina breviradiosa*; Zadorozhnyi and Yuferev, p. 77, pl. 1, figs. 1, 2.
1987 *Parathurammina breviradiosa*; Zadorozhnyi, p. 14, pl. 1, figs. 1–3.
1988 *Parathurammina breviradiosa*; Bogush et al., p. 22.
1989 *Parathurammina dagmarae* Suleimanov; Préat and Mamet, pl. 6, fig. 5 only (non figs. 4, 6 = *Parathuramminites*).
1990 *Parathurammina breviradiosa*; Lin et al., p. 124, pl. 3, figs. 1–4.
1990 *Parathurammina breviradiosa*; Bogush and Yuferev, p. 20.
1994 *Parathurammina breviradiosa*; Vachard, text-fig. 12.1.
?1999 *Parathurammina* du groupe *P. dagmarae* Suleimanov (= *Salpingothurammina breviradiosa* [Reitlinger]) (sic); Mamet et al., pl. 5, figs. 13, 14.
2005 Late Devonian calcisphere; Kaźmierczak and Kremer, fig. 6F.
2008 *Parathurammina breviradiosa*; Anfimov, p. 80.
2013 *Parathurammina breviradiosa*; Makarenko and Savina, p. 128.
2014 Parathuramminide; Mörtl, text-fig. 33b.

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 (Zukalova, 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

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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 bykovae (Poyarkov in Purkin et al., 1961)
Figure 10.4–10.6, 10.7 (partim), 10.8

?1955 *Parathurammina magna* Bykova, p. 17, pl. 2, figs. 4, 5, pl. 4, fig. 5.
1961 *Thurammina* (*Salpingothurammina*) *bykovae* Poyarkov in Purkin et al., p. 31, pl. 1, fig. 1 (non fig. 6).
1969 *Parathurammina* (*Salpingothurammina*) *bykovae*; Poyarkov, p. 86, pl. 1, figs. 3–6.
?1971 *Parathurammina dagmarae* Suleimanov; Flügel and Hötzl, p. 370, fig. 2.1–2.4.
1979 *Parathurammina* (*Salpingothurammina*) *bykovae*; Poyarkov, text-fig. 14.
1979 *Parathurammina bykovae* (Poyarkov); Lavrusevich et al., p. 322.
?1981 *Parathurammina dagmarae*; Zukalova, pl. 1, fig. 1.
1984 *Bykovaella bykovae*; Zadorozhnyi and Yuferev, p. 80, pl. 1, fig. 6.
1988 *Bykovaella bykovae*; Bogush et al., p. 5.
?1994 *Parathurammina bykovae*; Vachard, p. 22, text-fig. 12.1, pl. 2, figs. 1, 2 (with 11 references in synonymy) (see *B*. cf. *B*. *macilenta*).
2002 *Bykovaella bykovae*; Kalvoda, text-figs. 11, 12.
?2004 *Parathurammina dagmarae*; Flügel, text-fig. 10.24.
2008 Bykovaella *bykovae*; 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 *Parathurammina bykovae*; Makarenko and Savina, p. 128.
2013 *Parathurammina bykovae*; Sabirov, text-fig. 1.
2014 Parathuramminide; 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 northen Urals. Givetian of Fergana, Tian Shan, Zeravshano-Gissar, 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 *Parathurammina* specimens assigned to *P*. *dagmarae* more probably belong to *Bykovaella bykovae*, whereas true *P*. *dagmarae* only appear in the Famennian (Poyarkov, 1969, 1979).

Bykovaella cf. *B*. *macilenta* (Pronina, 1970)
Figure 10.35, 10.36

1970 *Parathurammina macilenta* Pronina, p. 106, pl. 30, fig. 5.
1994 *Parathurammina bykovae* (Poyarkov); Vachard, p. 22, pl. 2, figs. 1, 2.
2013 *Parathurammina 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.—*Parathurammina 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.

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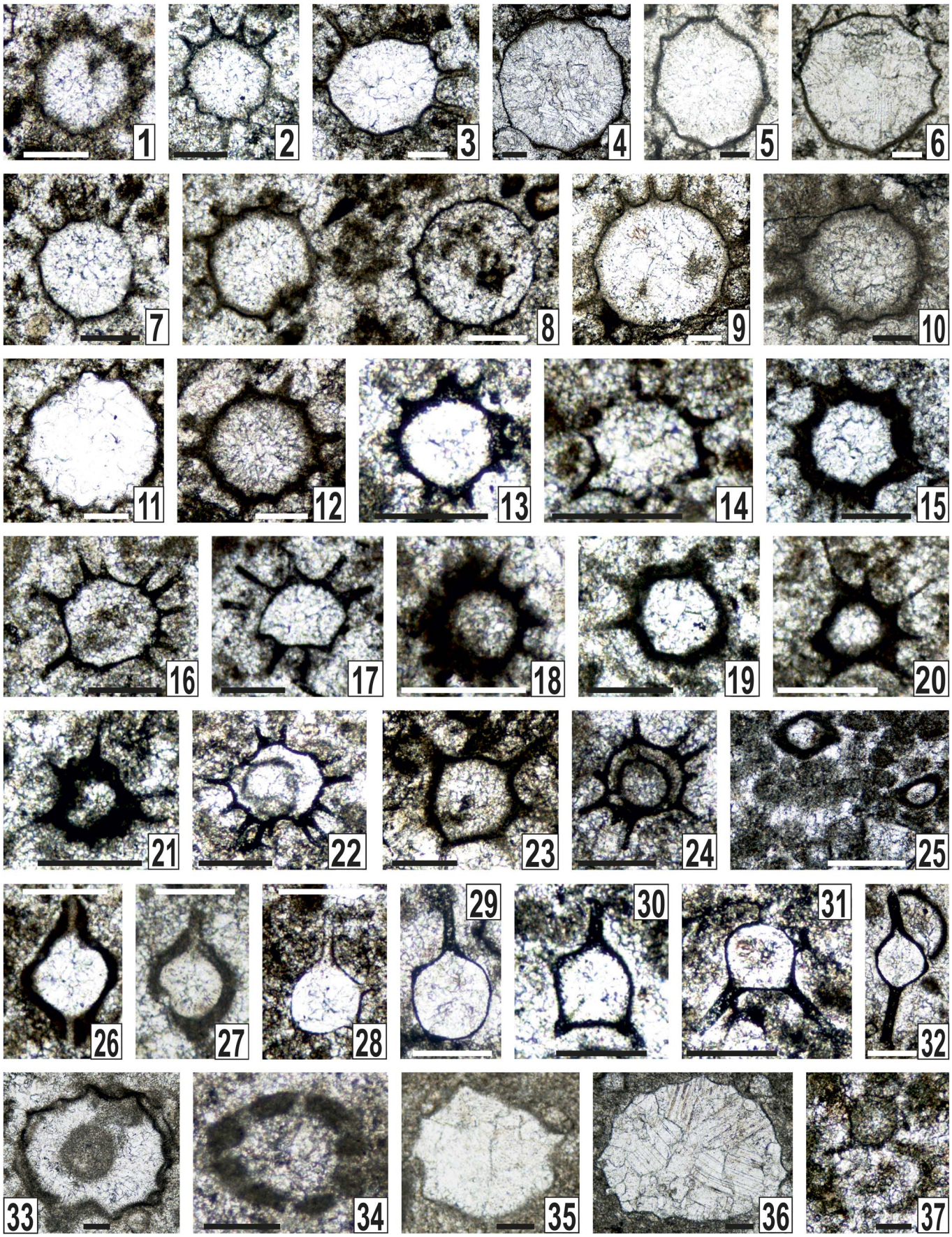

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1987 *Suleimanovella* (*Kolongella*) *pojarkovi*; Zadorozhnyi and Yuferev in Zadorozhnyi, p. 27, pl. 2, figs. 9–11.
1988 *Suleimanovella* (*Kolongella*) *pojarkovi*; Bogush et al., p. 31.
1990 *Suleimanovella* (*Kolongella*) *pojarkovi*; Bogush and Yuferev, p. 21.
2008 *Parathurammina pojarkovi*; Anfimov, p. 78.
2009 *Parathurammina* du groupe *P. dagmarae* Suleimanov; Mamet and Préat, fig. 1.13 (non fig. 1.11, 1.12, 1.14–1.17 = *Bykovaella* spp.).
2009 *Parathurammina crassitheca* Antropov; Mamet and Préat, fig. 1.18 (non fig. 1.19 = *Parathurammina uralica*).
?2013 *Parathurammina* 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 *Bithurammina* Miklukho-Maklay, 1965 non 1963

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

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

Diagnosis.—Test bilocular (or unilocular with daughter-cell?). Inner chamber and outer chamber spherical, similar to *Parathurammina* 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 *Parathurammina*.

Occurrence.—Late Early Devonian of northern Spain (Vachard, 1991). Givetian of Vietnam (Doan in Tong et al., 1988), Zeravshano-Gissar (Lavrusevich 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, *Bithurammina* is probably a development stage of *Parathurammina* sensu stricto; however, some other atypical species of *Bithurammina* can entail the same stages in the genus *Salpingothurammina*; 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 parathuramminids to the foraminifers, but are more consistent with daughter-cells of volvocales evokated by Kaźmierczak (1976).

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

?1968 *Bithurammina sphaerica* Ektova, p. 98, pl. 34, figs. 2–4.
2016a *Bithurammina*? 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) *Parathurammina* cf. *P. uralica* Petrova, 1981: (**1**) sample POL11b-13; (**10**) sample POL13a-2b. (**2**) *Parathurammina graciosa* Pronina, 1960, sample POL11a-21. (**3**) *Bykovaella breviradiosa* (Reitlinger, 1962), sample POL11b-19b. (**4–8**) *Bykovaella bykovae* (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**) *Parathurammina arguta* Pronina, 1960; (**7**) (with *Bykovaella bykovae*), sample POL11-2; (**9**) sample POL13a-1; (**10**) sample POL13a-7. (**11**) *Kolongella* cf. *K. pojarkovi* Zadorozhnyi and Yuferev, 1984, sample POL11b-21. (**12**) *Salpingothurammina* 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 reitlingerae* 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**) *Salpingothurammina* cf. *S. kakvensis* (Petrova, 1981), sample POL13a-3a. (**24**) *Bithurammina* 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 poyarkovi* 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**) *Parathuramminites* 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.

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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; *Salpingothurammina* 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.—*Parathurammina cushmani* Suleimanov, 1945.

Other species.—*Parathurammina 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; ?*Parathurammina crassa* Pronina, 1970; ?*P. guangxiensis* Lin, Li, and Sun, 1990; ? *P. praetuberculata* Reitlinger, 1954; ?*Thurammina 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 *Parathurammina* (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), *Salpingothurammina* 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.—*Parathurammina suleimanovi* Lipina, 1950.

Other species.—*Parathurammina 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.* (*Salpingothurammina*) *totaensis* Petrova, 1981; *P. triangula* Brazhnikova and Vdovenko, 1971; ?*Thurammina 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 *Parathurammina* (partim), *P.* (*Salpingothurammina*) (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 Préat, 2009 as *Parathurammina crassitheca* [pl. 1, figs. 18, 19]).

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

1981 *Parathurammina* (*Salpingothurammina*) *totaensis* Petrova, p. 88, pl. 8, figs. 7, 10, 11, 15.
?1981 *Palachemonella beckmanni* Flügel and Hötzl; 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 *Parathurammina totaensis*; Anfimov, p. 78.

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2013 *Parathurammina 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 *Salpingothurammina*, 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 *Salpingothurammina* Poyarkov in Purkin et al., 1961

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

Other species.—?*Parathurammina bella* Reitlinger in Bogush and Yuferev, 1962; *P.* (*Salpingothurammina*) *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); ?*Thurammina congesta* Gutschick, Weiner, and Young, 1961; ?*T. coronata* Dunn, 1942; *T. diforamens* Ireland, 1956; ?*T. furcata* Gutschick and Treckman, 1959; ?*T. phialaeformis* Crespin, 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 Parathuramminidae 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, *Salpingothurammina* was designated under the names *Saltovskajina* Sabirov, 1982b; *Parathurammina* (partim); *Thurammina* (partim) auctorum; *Irregularina* (partim); *Polygonella* (partim); *Bykovaella* (partim); *Ivanovella* (partim); *Guangxithurammina* Lin et al., 1990 (partim); *Suleimanovella* (partim); *Parathuramminites* (partim); *Cordatella* (partim), *Marginara* (partim); and *Radiosphaerella* (partim).

Salpingothurammina 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.

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

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

1981 *Parathurammina spinosa kakvensis* Petrova, p. 87, pl. 6, figs. 8, 9.
1990 *Parathurammina spinosa kakvensis*; Bogush and Yuferev, p. 21.
?1999 *Parathurammina gekkeri* Antropov; Mamet et al., pl. 5, fig. 12.
2002 *Salpingothurammina spinosa kakvensis*; Kalvoda, text-figs. 11, 12.
2008 *Parathurammina kakvensis*; Anfimov, p. 78.
2011 *Parathurammina 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.—*Parathurammina radiosphaerica* Bogush and Yuferev, 1962.

Other species.—*Parathurammina 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 Parathuramminidae 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 *Parathurammina* (partim); *Salpingothurammina* (partim); *Suleimanovella* (partim); *Archaelagena* Howchin, 1888 (partim); and acritach sensu Kaźmierczak and Kremer, 2005, fig. 6D.

Radiosphaerella poyarkovi new species
urn:lsid:zoobank.org:act:F5040BBB-AA4E-43FB-AD04-3D110B66FAF8
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 *Parathurammina* (*Salpingothurammina*) *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 *Parathurammina horrida* Chuvashov; Lin and Hao, p. 93, pl. 1, fig. 2.
?1982 *Parathurammina 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 *Parathurammina spinosa* (Williamson, 1880) (= *Parathurammina 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 *Parathurammina radiosphaerica* by fewer necks (up to seven for *P. radiosphaerica*) for similar measurements.

?Family Marginaridae Loeblich and Tappan, 1986

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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 *Cordatella* Petrova in Zadorozhnyi and Yuferev, 1984.

Genus *Marginara* Petrova in Zarodzhonyi 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 Zarodzhonyi 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.—Llandoverian 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.

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Shandinsky horizon of Salair (SW Siberia). Givetian of Belgium (Mamet and Préat, 2009), western France (Milon, 1928; Vachard, 1994), Germany (Flügel and Hötzl, 1971; May, 1992; Kröck, 2016), Poland (Racki and Soboń-Podgórska, 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 *Pachythurammina* Vachard, 1977, totally differs by its spherical morphology, much smaller size, and calcisphaerid wall.

Remarks.—*Uslonia* may be synonymized with "Calcisphères" sensu Milon, 1928 (partim); *Vermiporella* auctorum (partim); *Kalijanella* Petrova, 1981; *Cribrosphaeroides* sensu Chuvashov, 1965 (partim), Flügel and Hötzl, 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 Préat, 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 Préat (2009, pl. 5, fig. 5). Misinterpretions 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 Soboń-Podgórska (1993, text fig. 1) was puzzling and surrealistic. As indicated by Mamet and Préat (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); Flügel and Hötzl, 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 *Pachythurammina 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.—*Cribrophaeroides 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 *Cribrauroria* Vachard, 1994).

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

Occurrence.—Llandoverian–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 Tukmenistan, Kyrgyzstan, Uzbekistan, Urals, and Morocco. Late Devonian of Tukmenistan 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, Tukmenistan, 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. Insconpicuous 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.

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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*; Zukalova, pl. 4, fig. 3.
1984 *Auroria singularis*; Zukalova, 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 Préat, 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 Préat, 2009). Givetian of western France (Dubreuil and Vachard, 1979). Early Givetian of Mount Polinik (Carnic Alps, Austria).

Description.—Outer diameter = 0.45 × 0.32 mm (type material: 0.37–0.88 × 0.37–0.84 mm); inner diameter = 0.26 × 0.20 mm (type material: 0.16–0.71 × 0.16–0.45 mm); wall thickness = 0.05–0.10 mm (type material: 0.03–0.12 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 Flügel and Hötzl, p. 375, pl. 3, figs. 1, 2.
1981 *Auroria triangularis* Saltovskaya, p. 111, pl. 4, figs. 10, 12.
?1981 *Polyderma* sp. Zukalova, 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 TadzhSSR) 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 = 0.60–0.66 mm (type material: 0.25–0.42 mm); inner diameter = 0.42–0.60 mm (type material: 0.20–0.31 mm); test wall thickness = 0.07–0.09 mm (type material: 0.028–0.045 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 = 0.66–0.70 mm; inner diameter = 0.30–0.38 mm; test wall thickness = 0.07–0.13 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).

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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; Altıner, 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); *Hyperammina* Brady, 1878 (partim); and *Decastronema* Golubic, Radoicic, and Lee, 2006 (partim). The genus *Hyperammina* sensu lato is a homeomorph among the Astrorhizata.

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 *Irrregularina* 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.

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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); Préat and Mamet (1989); Langer (1991, 1997); Vachard (1991, 1994); Mamet and Boulvain (1992); Racki and Soboń-Podgórska (1993); Vachard and Mouravieff (1994); Mamet et al. (1999); Chuvashov and Anfimov (2005); Mamet and Préat (2009); and Özkan (2011). New studies are in progress in Europe (Mörtl, 2014; Kröck, 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 bykovae* (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.

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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; Préat and Mamet, 1989; Vachard, 1993; Préat and Kasimi, 1995; Flügel, 2004; Mamet and Préat, 2005, 2007, 2009; Préat et al., 2007; Vachard et al., 2010; Mörtl, 2014; Kröck, 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 Mörtl (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 paleocology 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; Cetean 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 Holcová and Slavík (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 archaediscates) and saccamminids were not encountered in our material, and it is noteworthy that all representatives of morphogroup B are absent. Similarly, the epiphytic foraminfers 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; Mörtl, 2014), and do not belong to benthic foraminifer morphogroups. Nevertheless, these microorganisms appear related, if not restricted, to confined enviroments: 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) occcurences 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 calcispheroids 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* (Flügel and Hötzl, 1971, pl. 2, figs. 8–10). It belongs to the incertae sedis Moravamminida and Issinellina (Vachard and Cózar, 2010). *Vasicekia* Pokorny, 1951 was erroneously assigned to the Nanicellidae by Poyarkov (1979), who included all the Moravamminidae in the superfamily Hippocrepinoidea, which encompassed: Hippocrepinidae (Astrorhizata), Moravamminidae (incertae sedis in our opinion; see Vachard and Cózar, 2010), Earlandiidae, and Caligellidae (also linked together in this paper). Another *Moravammina* confused with a *Nanicella* was recently published by Préat et al. (2007). This misinterpretation explains how the *Moravammina*, which is so frequent in the type Givetian, were almost never mentioned by Préat or Mamet in their works about this stage: these authors confused the first coiled part of *Moravammina* with *Nanicella*, and the uncoiled last parts of *Moravammina* with *Triangulinella* or *Kamaena.*

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Paleobiogeography.—Similar pararathuramminid 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 Chalonnes 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 (Pokorny, 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/Archaediscida; 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 contemporeaneously 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

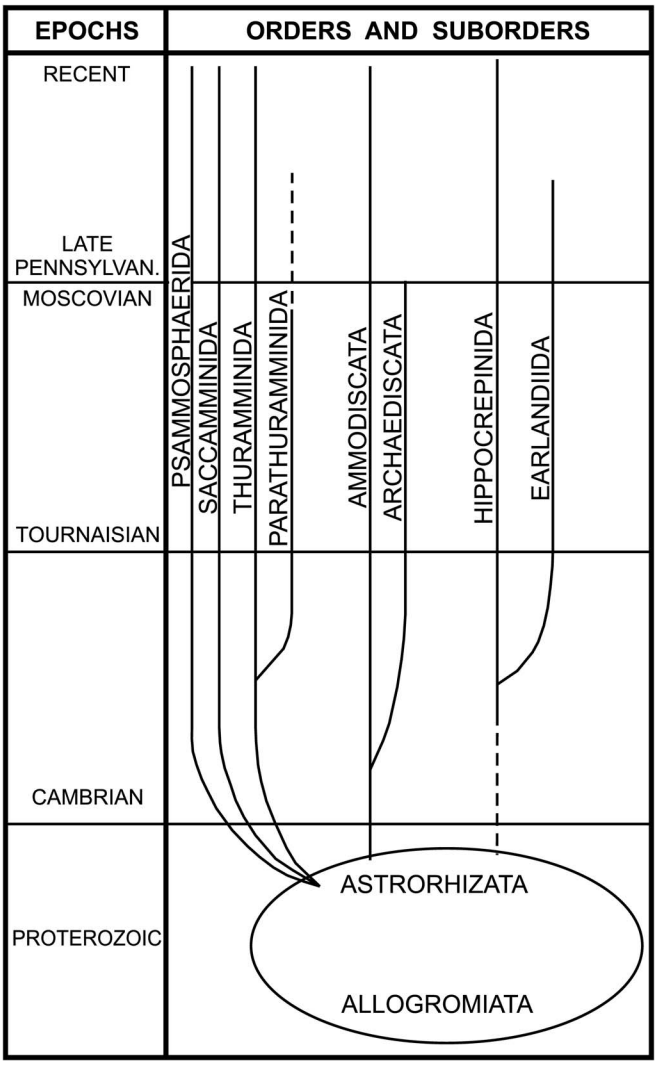

Figure 11. Phylogenetic hypothesis about the most primitive lineages of foraminifers (agglutinated and secreted). Abbreviation: Pennsylvan. = Pennsylvanian.

(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 evolutive 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

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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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References

Afanasieva, M.S., and Amon, E.O., 2011, Devonian radiolarians of Russia: Paleontological Journal, v. 45, p. 1313–1352.

Aizenverg, D.E., and Brazhnikova, N.E., 1964, Donetz basin analogues of Etroeungt strata: 5e Congrès International de Géographie et de Géologie du Carbonifère, 9-12 Septembre 1963, Compte Rendu, v. 1, p. 263–272.

Altıner, D., 1991, Microfossil biostratigraphy (mainly foraminifers) of the Jurassic–Lower Cretaceous carbonate successions in northwestern Anatolia, Turkey: Geologica Romana, v. 27, p. 167–213.

Anfimov, A.L., 2008, Devonian biogeography of the foraminifers of the Urals: Novosti Paleontologii i Stratigrafii, v. 49, p. 78–81. [in Russian]

Anfimov, A.L., 2011, Evolution of the Devonian foraminifers of the Urals, *in* Bogdanova, T.N., ed., Tempi of evolution of organic word and biostratigraphy: Materialy, v. 58, p. 16–18. sessii paleontologicheskogo obscchestva, Sankt-Petersburg. [in Russian]

Anfimov, A.L., 2012, New Emsian foraminifers from the Karpinsky Horizon Limestones Severouralsk Bauxite Mine: Paleontological Journal, v. 46, p. 445–452.

Antropov, C.A., 1950, New Upper Devonian foraminiferal species of some areas of the eastern Russian Platform: Akademiya Nauk SSSR, Izvestiya Kazanskogo Filiala, Geologicheskii Institut, v. 1, p. 21–32. [in Russian]

Antropov, C.A., 1959, Devonian foraminifers of Tataria: Akademiya Nauk SSSR, Izvestiya Kazanskogo Filiala, Geologicheskii Institut, v. 7, p. 11–33. [in Russian]

Antropov, C.A., 1970, On the systematics, phylogeny and stratigraphic range of the parathuramminids: Akademiya Nauk SSSR, Kazanskii Filial, Trudy Geologicheskogo Instituta, v. 26, p. 138–150. [in Russian]

Arnaud-Vanneau, A., 1980, Micropaléontologie, paléoécologie et sédimentologie d'une plate-forme carbonatée de la marge passive de la Téthys: l'Urgonien du Vercors septentrional et de la Chartreuse (Alpes occidentales): Géologie Alpine, Mémoire, v. 11, Second volume, p. 269–874.

Bandel, K., 1972, Paläoökologie und Paläogeographie im Devon und Unterkarbon der Zentralen Karnischen Alpen: Palaeontographica, Abteilung A, v. 141, p. 1–117.

Berkyova, S., and Munnecke, A., 2010, "Calcispheres" as a source of lime mud and peloids—evidence from the early Middle Devonian of the Prague Basin, the Czech Republic: Bulletin of Geosciences, v. 85, p. 585–602.

Birina, L.M., 1948, New species of calcareous algae and foraminifers from the Devonian and Carboniferous boundary beds: Sovetskaya Geologiya, v. 28, p. 154–159. [in Russian]

Blumenstengel, H., 1961, Foraminiferen aus dem Thüringer Oberdevon: Geologie, v. 10, p. 316–335.

Bogush, O.I., and Yuferev, O.V., 1962, Foraminifers and stratigraphy of the Carboniferous deposits of Kara-Tau and Talassky Ala-Tau: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, 234 p. [in Russian]

Bogush, O.I., and Yuferev, O.V., 1970, Foraminifers, *in* Obut, A.M., ed., The Carboniferous of Omolon and southwestern part of Kolyma massifs: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geokhimii, v. 60, p. 1–108. [in Russian]

Bogush, O.I., and Yuferev, O.V., 1990, Characterization and correlation of the Devonian-Carboniferous boundary beds in Siberia and NW USSR based on the foraminifers: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, v. 770, p. 11–118. [in Russian]

Bogush, O.I., Buchmina, L.S., and Domnikova, E.I., 1970, On the boundary beds from Devonian to Carboniferous in the Eltsovsk synclinorium based on microfaunal studies, *in* Problems related to the microfaunal studies in Siberia, Far-East, and other regions: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, v. 71, p. 49–59. [in Russian]

Bogush, O.I., Bochkarev, V.S., and Yuferev, O.V., 1975, The Paleozoic of southern Western Siberia Plain: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, v. 297, p. 1–44. [in Russian]

Bogush, O.I., Zarodozhnyi, V.M., and Ivanova, E.F., 1988, Catalogue of foraminiferal types; Devonian and Carboniferous foraminifers: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, p. 1–40. [in Russian]

Bosak, T., Lahr, D.J.G., Pruss, S.B., Macdonald, F.A., Dalton, L., and Matys, E., 2011, Agglutinated tests in post-Sturtian cap carbonates of Namibia and Mongolia: Earth and Planetary Science Letters, v. 308, p. 29–40.

Bosak, T., Lahr, D.J.G., Pruss, S.B., Macdonald, F.A., Dalton, L., and Matys, E., 2012, Possible early foraminiferans in post-Sturtian (716–635 Ma) cap carbonates: Geology, v. 40, p. 67–70.

Brady, H.B., 1878, On the reticularian and radiolarian Rhizopoda (Foraminifera and Polycystina) on the North Polar Expedition of 1875–76: Annals and Magazine of Natural History, series 5, v. 1, p. 425–440.

Brady, H.B., 1879, Notes on some reticularian Rhizopoda of the Challenger Expedition. Part III. 1. Classification. 2. Further notes on new species. 3. Note on *Biloculina* mud: Quarterly Journal of Microscopical Science, new series, v. 21, p. 31–71.

Brazhnikova, N.E., and Rostovceva, L.F., 1966, Foraminifera, *in* Aizenverg, D.E., and Brazhnikova, N.E., eds., The Fauna of the Lowest Part of Tournaisian (zone C_1^ta) in the Donetz Basin: Akademyia Nauk Ukrainskoi SSR, Institut Geologicheskikh Nauk, p. 9–42. [in Russian]

Brazhnikova, N.E., and Vdovenko, M.V., 1971, Foraminifers, *in* Atlas of Tournaisian fauna of Donetz basin; description of new species: Kiev, Izdatelstvo "Naukova Dumka", p. 21–64. [in Russian]

Brazhnikova, N.E., and Vdovenko, M.V., 1973, Early Visean foraminifers of Ukraine: Kiev, Vidavintsvo "Naukova Dumka", 296 p. [in Ukrainian]

Brunner, P., 1975, Estudio estratigráfico del Devónico en el área de El Bisani, Caborca, Sonora: Revista Instituto Mexicano del Petróleo, v. 7, p. 16–45.

Brunner, P., 1976, Litología y bioestratigrafía del Misisípico en el área de El Bisani, Sonora: Revista Instituto Mexicano del Petróleo, v. 8, p. 7–41.

Bykova, E.V., 1952, Devonian foraminifers from Russian Platform and Preurals: Trudy VNIGRI, 60, Mikrofauna USSR, v. 5, p. 5–64. [in Russian]

Bykova, E.V., and Polenova, E.N., 1955, Foraminifers and radiolaria from the Volga-Ural area and the central Devonian Field and the stratigraphical importance of both groups: Trudy VNIGRI, v. 87, p. 1–141. [in Russian, French translation, CEDP n° 1603, BRGM, 154 p.]

Cavalier-Smith, T., 2002, The phagotrophic origin of eukaryotes and phylogenetic classification of Protozoa: International Journal of Systematic and Evolutionary Microbiology, v. 52, p. 297–354.

Cavalier-Smith, T., 2003, Protists phylogeny and the high-level classification of Protozoa: European Journal of Protistology, v. 39, p. 338–348.

Cetean, C.G., Bălc, R., Kaminski, M.A., and Filipescu, S., 2011, Integrated biostratigraphy and palaeoenvironments of an upper Santonian-upper Campanian succession from the southern part of the Eastern Carpathians, Romania: Cretaceous Research, v. 32, p. 575–590.

Chamney, T.P., 1976, Foraminiferal morphogroup symbol for paleoenvironmental interpretation of drill cutting samples. Arctic America: Maritime Sediments, Special Publication, v. 1B, p. 585–624.

Chernykh, V.V., 1967, New Upper Silurian foraminifers of the Urals: Paleontologicheskii Zhurnal, v. 1967, p. 37–43. [in Russian; translated in Paleontological Journal, 1967, p. 311–317]

Chuvashov, B.I., 1965, Foraminifera and algae from upper Devonian deposits of western slope of the central and southern Urals: Akademiya Nauk SSSR, Trudy Instituta Geologii, Uralskii Filial, v. 74, p. 1–153. [in Russian]

https://doi.org/10.1017/jpa.2017.127 Published online by Cambridge University Press

Chuvashov, B.I., 2008, Devonian foraminifers of Eurasia: assemblage studies and biostratigraphical potential: Novosti Paleontologii i Stratigrafii, v. 49, p. 179–184. [in Russian]
Chuvashov, B.I., and Anfimov, A.L., 2005, Foraminifer zonal scale of the Devonian system—the state-of-art of study and correlative potential, *in* Yolkin, E.A., Izokh, N.G., Obut, O.T., and Kipriyanova, T.P., eds., Contributions of International Conference "Devonian terrestrial and marine environments: from continent to shelf": IGCP 499 Project/SDS joint field meeting, Novosibirsk July 25–August 9, 2005, p. 41–44. [in Russian]
Chuvashov, B.I., and Yuferev, O.V., 1981, New genus of Devonian foraminifer, *in* Dubatolov, V.N., ed., Paleozoic of the western Siberian Plain and its mountainous borderland: Akademiya Nauk SSSR, Sibirskoe Otdelnic, Trudy Instituta Geologii i Geofiziki, p. 52–54. [in Russian]
Chuvashov, B.I., Anfimov, A.L., Soroka, E.I., and Yaroslavtseva, N.S., 2012, Devonian non-carbonate at Saf'yanovka deposit (Middle Ural): Litosfera, v. 5, p. 114–125.
Coccioni, R., Galeotti, S., and Gravili, M., 1995, Latest Albian–earliest Turonian deep-water agglutinated foraminifera in the Botaccione section (Gubbio, Italy)—Biostratigraphic and palaeoecologic implications: Revista Española de Paleontología, N° homenaje al Dr. Guillermo Colom, p. 135–152.
Coen, M., Bultynck, P., and Pel, J., 1974, Excursion E, *in* International Symposium on Belgian micropaleontological limits from Emsian to Visean, Namur 1974: Brussels, Geological Survey of Belgium, p. 1–20.
Conil, R., Longerstaey, P.J., and Ramsbottom, W.H.C., 1980, Matériaux pour l'étude micropaléontologique du Dinantien de Grande-Bretagne: Mémoires de l'Institut Géologique de l'Université de Louvain, v. 30 (dated 1979), p. 1–115.
Conkin, J.E., and Conkin, B.M., 1964, Devonian Foraminifera: Part I. The Louisiana Limestone of Missouri and Illinois: Bulletin of American Paleontology, v. 47, p. 49–105.
Crespin, I., 1958, Permian Foraminifera of Australia: Commonwealth of Australia, Department of National Development, Bureau of Mineral Resources, Geology and Geophysics, v. 48, p. 1–207.
Cummings, R.H., 1955, *Nodosinella* Brady, 1876 and associated upper Paleozoic genera: Micropaleontology, v. 1, p. 221–238.
Cushman, J.A., 1927, An outline of a re-classification of the foraminifera: Contributions Cushman Foundation for Foraminiferal Research, v. 3, p. 1–105.
d'Orbigny, A., 1826, Tableau méthodique de la classe des Céphalopodes: Annales des Sciences Naturelles, v. 7, p. 245–314.
Da Silva, A.C., and Boulvain, F., 2004, From paleosols to carbonate mounds: facies and environments of the middle Frasnian platform in Belgium: Geological Quarterly, v. 48, p. 253–266.
Dil, N., 1976, Assemblages caractéristiques de Foraminifères du Dévonien supérieur et du Dinantien de Turquie (bassin carbonifère de Zonguldak): Annales de la Société géologique de Belgique, v. 99, p. 373–400.
Dubreuil, M., and Vachard, D., 1979, Sur l'âge givétien de la formation de Chalonnes (Bassin d'Ancenis, sud-est du Massif Armoricain) et ses conséquences: Comptes Rendus Académie des Sciences Paris, v. 289, p. 241–244.
Dunn, P.H., 1942, Silurian Foraminifera of the Mississippian Basin: Journal of Paleontology, v. 16, p. 317–342.
Ebner, F., Vozárová, A., Kovács, S., Kräutner, H.-G., Krstic, B., Szederkényi, T., Jamicic, D., Balen, D, Belak, M., and Trajanova, M., 2010, Devonian–Carboniferous pre-flysch and flysch environments in the Circum–Pannonian Region, *in* Ebner, F., Vozárová, A., Haas, J., Kovács, S., Sudar, M, Bielik, M, and Péró, C., eds., Variscan and Alpine terranes of the Circum–Pannonian Region: Bratislava, Slovac Academy of Sciences, Geological Institute, p. 13–49.
Eisenack, A., 1969, Einige ordovizische und silurische Foraminiferen des baltischen Gebietes: Paläontologische Zeitschrift, v. 43, p. 199–204.
Ektova, L.K., 1968, Tip Protozoa, Class Sarcodina, Subclass Foraminifera, Order Astrorhizida, *in* Markovskyi, B.P., ed., Novye vidy drevnykh rasteniy i vespozvonochnykh SSSR, 2 (part 1): Moscow, Izdatelstvo "Nedra", p. 97–99. [in Russian]
Elliott, G.F., 1958, Fossil microproblematica from the Middle East: Micropaleontology, v. 4, p. 419–428.
Ferrari, A., and Vai, G.B., 1966, Ricerche stratigrafiche e paleoecologiche al Monte Zermula: Giornale di Geologia, v. 2 (1965), p. 289–406.
Flügel, E., 2004, Microfacies of Carbonate Rocks: Analysis, Interpretation and Application: Berlin, Springer Verlag, 976 p.
Flügel, E., and Hötzl, H., 1971, Foraminiferen, Calcisphaeren und Kalkalgen aus dem Schwelmer Kalk (Givet) von Letmathe im Sauerland: Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, v. 137, p. 358–395.
Frisch, W., and Neubauer, F., 1989, Pre-Alpine terranes and tectonic zoning in the Eastern Alps: Geological Society of America, Special Publication, v. 230, p. 91–100.
Gagiev, M.Kh., and Bogush, O.I., 1990, Famennian–Tournaisian key-sections of southwestern part of the Prekolyma (northeastern USSR), *in* Elkin, E.A., ed., New data on paleontology and biostratigraphy of the Asian part of the SSSR: Novosibirsk "Nauka", Sibirskoe Otdelenie, p. 119–132. [in Russian]
Gaillot, J., and Vachard, D., 2007, The Khuff Formation (Middle East) and time-equivalents in Turkey and South China: biostratigraphy from Capitanian to Changhsingian times (Permian), new foraminiferal taxa, and palaeogeographical implications: Coloquios de Paleontología, v. 57, p. 37–223.
Golubic, S., Radoicic, R., and Lee, S-.J., 2006, *Decastronema kotori* gen. nov., comb nov.; a mat-forming cyanobacterium on Cretaceous carbonate platforms and its modern counterparts: Carnets de Géologie/Notebooks on Geology, Article 2006/02, p. 1–17.
Grechishnikova, I.A., and Levitskii, E.S., 2011, The Famennian–Lower Carboniferous reference-section Geran-Kalasi (Nakhichevan Autonomous region, Azerbaijan): Stratigraphy and Geological Correlation, v. 19, p. 24–46.
Grozdilova, L.P., 1973, Foraminifers in the study of the Tournaisian sections of the Bashkiria Mountains, *in* Posner, V.M., ed., Foraminifers in the study of the Tournaisian sections of the southern Urals: Trudy VNIGRI, Leningrad, v. 346, p. 68–101. [in Russian]
Grozdilova, L.P., and Lebedeva, N.S., 1954, Foraminifers of the Early Carboniferous and Bashkirian stage of the Middle Carboniferous of the Kolvo-Visher Basin: Trudy VNIGRI, 81, Mikrofauna SSSR, v. 7, p. 4–203. [in Russian]
Grozdilova, L.P., Lebedeva, N.S., Lipina, O.A., Malakhova, N.P., Mikhailova, Z.P., Chermnykh, V.A., Postoyalko, M.V., Simonova, Z.G., Sinitsyna, Z. A., and Shcherbakova, M.V., 1975, Foraminifera, *in* Stepanov, D.L., Krylova, A.K., Grozdilova, L.P., Pozner, V.M., and Sultanaev, A.A., eds., Paleontological atlas of the Carboniferous deposits from the Urals: Izdateltsvo "Nedra", Trudy VSEGEI, Leningrad, v. 383, p. 27–64. [in Russian]
Guilbault, J.P., Krautter, M., Conway, K.W., and Vaughn Barrie, J., 2006, Modern Foraminifera attached to hexactinellid sponge meshwork on the West Canadian Shelf: comparison with Jurassic counterparts from Europe: Palaeontologia Electronica, 9.1.3A. http://palaeo-electronica.org/2006_1/sponge/issue1_06.htm.
Gutschick, R.C., and Treckman, J.F., 1959, Arenaceous foraminifera from the Rockford Limestone of northern Indiana: Journal of Paleontology, v. 23, p. 229–250.
Gutschick, R.C., Weiner, J.L., and Young, L., 1961, Lower Mississippian arenaceous foraminifera from Oklahoma, Texas and Montana: Journal of Paleontology, v. 35, p. 1193–1221.
Haeckel, E., 1894, Systematische Phylogenie: Entwurf eines natürlichen Systems der Organismen auf Grund ihrer Stammesgeschichte. Theil 1. Systematische Phylogenie der Protisten und Pflanzen: Berlin, Georg Reimer, 400 p.
Häusler, R., 1883, On the Jurassic varieties of *Thurammina papillata*, Brady: Annals and Magazine of Natural History, series 5, v. 11, p. 262–266.
Henjes, J., and Assmy, P., 2008, Particle availability controls agglutination in pelagic tintinnids in the Southern Ocean: Protist, v. 159, p. 239–250.
Herbig, H.G., and Mamet, B., 2006, A muddy to clear carbonate ramp, latest Devonian, Velbert Anticline (Rheinisches Schiefergebirge, Germany): Geologica et Palaeontologica, v. 40, p. 1–25.
Holcová, K., 2004, Foraminifers from the Lower/Middle Devonian boundary beds of the Barrandian area, Czech Republic, and their paleoecology: Journal of Foraminiferal Research, v. 34, p. 214–231.
Holcová, K., and Slavík, L., 2013, The morphogroups of small agglutinated foraminifera from the Devonian carbonate complex of the Prague Synform (Barrandian area, Czech Republic): Palaeogeography, Palaeoclimatology, Palaeoecology, v. 386, p. 210–224.
Howchin, W., 1888, Additions to the knowledge of the Carboniferous foraminifera: Journal of the Royal Microscopical Society of London, v. 1888, p. 533–542.
Hüsken, T.C., and Eiserhardt, K.H., 1997, Morphology, ultrastructure and interpretation of Palaeozoic mazuelloids (phosphatic mikroplankton incertae sedis), *in* Fatka, O., and Servais, T., eds., Acritarcha in Praha, 1996: Acta Universitatis Carolinae, Geologica, v. 40, p. 445–455.
ICZN, 1999, International Code of Zoological Nomenclature: London, The Natural History Museum, 306 p.
Ireland, H.A., 1939, Devonian and Silurian Foraminifera from Oklahoma: Journal of Paleontology, v. 13, p. 190–202.
Ireland, H.A., 1956, Upper Pennsylvanian arenaceous foraminifers of Kansas: Journal of Paleontology, v. 30, p. 831–864.
Jones, R.W., 1999, Forties Field (North Sea) revisited; a demonstration of the value of historical micropalaeontological data, *in* Jones, R.W., and Simmons, M.D., eds., Biostratigraphy in Production and Development Geology: Geological Society, London, Special Publication, v. 152, p. 185–200.
Jones, R.W., and Charnock, M.A., 1985, Morphogroups of agglutinated foraminifera, their life positions and feeding and potential applicability in (paleo)ecological studies: Revue de Paléobiologie, v. 4, p. 311–320.

https://doi.org/10.1017/jpa.2017.127 Published online by Cambridge University Press

Jones, R.W., Pickering, K.T., BouDagher-Fadel, M., and Matthews, S., 2005, Preliminary observations on the micropalaeontological characterisation of submarine fan/channel sub-environments, Ainsa system, south-central Pyrenees, Spain, *in* Powell, A.J., and Riding, J.B., eds., Recent Developments in Applied Biostratigraphy: The Micropalaeontological Society, Special Publication, v. 1, p. 55–68.

Kalvoda, J., 2001, Upper Devonian–Lower Carboniferous foraminiferal paleobiogeography and Perigondwana terranes at the Baltica-Gondwana interface: Geologica Carpathica, v. 52, p. 205–215.

Kalvoda, J., 2002, Late Devonian–Early Carboniferous foraminiferal fauna: zonations, evolutionary events, paleobiogeography and tectonic implications: Folia, v. 39, 213 p.

Kalvoda, J., and Bábek, O., 2010, The margins of Laurussia in Central and Southeast Europe and Southwest Asia: Gondwana Research, v. 17, p. 526–545.

Kaminski, M.A., Boersma, A., Tyszka, J., and Holbourn, A, 1995, Response of deep-water agglutinated foraminifera to dysoxic conditions in the California borderland basins, *in* Kaminski, M.A., Geroch, S., and Gasinski, M.A., eds., Proceedings of the Fourth International Workshop on Agglutinated Foraminifera: Grzybowski Foundation Special Publication, 3, p. 131–140.

Kazennov, A.I., Bogush, O.I., and Benediktova, R.N., 1975, Tournaisian stage of the Gorlovsk coalfield, *in* Dubatolov, V.N., and Yuferev, O.V., eds., Paleontology, stratigraphy and paleobiogeography from Devonian and Carboniferous of Siberia: Novosibirsk, Izdaleltsvo "Nauka", p. 10–25, 51–58. [in Russian]

Kaźmierczak, J., 1973, *Tolypammina vagans* (Foraminiferida) as inhabitant of the Oxfordian siliceous sponges: Acta Palaeontologica Polonica, v. 28, p. 95–115.

Kaźmierczak, J., 1975, Colonial Volvocales (Chlorophyta) from the Upper Devonian of Poland and their paleoenvironmental significance: Acta Palaeontologica Polonica, v. 20, p. 73–85.

Kaźmierczak, J., 1976, Volvocacean nature of Paleozoic non-radiosphaerid calcispheres and parathuramminid "Foraminifera": Acta Palaeontologica Polonica, v. 21, p. 245–258.

Kaźmierczak, J., and Kremer, B., 2005, Early post-mortem calcified Devonian acritarchs as a source of calcispheric structures: Facies, v. 51, p. 554–565.

Kender, S., Kaminski, M.A., and Jones, R.W., 2008a, Oligocene deep-water agglutinated foraminifera from the Congo Fan, offshore Angola: palaeoenvironments and assemblage distributions, *in* Kaminski, M.A., and Coccioni, R. eds., Proceedings of the Seventh International Workshop on Agglutinated Foraminifera: Grzybowski Foundation Special Publication, 13, p. 107–156.

Kender, S., Kaminski, M.A., and Jones, R.W., 2008b, Early to middle Miocene foraminifera from the deep-sea Congo Fan, offshore Angola: Micropaleontology, v. 54, p. 477–568.

Kotlyar, O.E., 1982, New Foraminifera from Late Devonian deposits of Ukraine: Paleontologischeskii Zhurnal, v. 16, p. 9–14. [English translation in Paleontological Journal, p. 6–11]

Kozur, H., 1984, Muellerisphaerida, eine neue Ordnung von Mikrofossilien unbekannter systematischer Stellung aus dem Silur und Unterdevon von Ungarn: Geologisch-Paläontologische Mitteilungen Innsbruck, v. 13, p. 125–148.

Kremer, B., 2005, Mazzuelloids: product of post-mortem phosphatization of acanthomorphic acritarchs: Palaios, v. 20, p. 27–36.

Kreutzer, L.H., 1990, Mikrofazies, Stratigraphie und Paläogeographie des Zentralkarnischen Hauptkammes zwischen Seewarte und Cellon: Jahrbuch der Geologischen Bundesanstalt, v. 133, p. 275–343.

Kreutzer, L.H., 1992a, Photo-Atlas of the Variscan carbonate sequences in the Carnic Alps (Austria/Italy): Abhandlungen der Geologischen Bundesanstalt, v. 47, p. 1–129.

Kreutzer, L.H., 1992b, Palinspastische Entzerrung und Neugliederung des Devons in den Zentralkarnischen Alpen Aufgrund von neuen Untersuchungen: Jahrbuch der Geologischen Bundesanstalt, v. 135, p. 261–272.

Kröck, D., 2016, Stratigraphische une paläoökologische untersuchungen zur benthischen Mikrofauna der Eifel: Masterarbeit am Steinmann-Institut für Geologie, Paläontologie und Mineralogie der Rheinischen Friedrich-Wilhelms-Universität Bonn, 80 p.

Kulagina, E.I., 2013, Taxonomic diversity of foraminifers of the Devonian-Carboniferous boundary interval in the South Urals: Bulletin of Geosciences, v. 88, p. 265–282.

Langer, M.R., 1995, Oxygen and carbon isotopic composition of Recent larger and smaller foraminifera from the Madang Lagoon (Papua New Guinea): Marine Micropaleontology, v. 26, p. 215–221.

Langer, W., 1969, Foraminifera aus dem Alt-Paläozoikum der Karnischen Alpen: Carinthia II, v. 79, p. 34–60.

Langer, W., 1991, Beiträge zur Mikropaläontologie des Devons im Rheinischen Schiefergebirge: Geologisches Jahrbuch, v. A128, p. 35–65.

Langer, W., 1997, Neue oder wenig bekannte Mikrofossilien aus dem europäischen Devon: Neues Jahrbuch Geologie, Mikropaläontologie, Abhandlungen, v. 205, p. 129–144.

Lavrusevich, V.I., Lavrusevich, A.I., and Saltovskaya, V.D., 1979, On the characteristics of the Zeravshan-Gissar oblast: Doklady Akademii Nauk Tadzhikiskoi SSSR, v. 22, p. 321–324. [in Russian]

Lecompte, M., 1952, Les stromatoporoïdes du Dévonien moyen et supérieur du bassin de Dinant, 2e partie: Institut Royal des Sciences Naturelles, Mémoires, v. 117, p. 1–359.

Lin, J.X., 1984, Protozoa. *in* Yichan Institute of Geology and Mineral Resources, ed., Biostratigraphy of the Yangtze Gorge area (Late Paleozoic Era): Beijing, Geological Publishing House, p. 110–177. [in Chinese]

Lin, J.X, and Hao, Y.C., 1982, Late Middle Devonian foraminifera from the central Guangxi and southern Hunan: Acta Geologica Sinica, v. 56, p. 91–96. [in Chinese]

Lin, J.X., Li, L.X., and Sun, Q.Y., 1990, Late Paleozoic Foraminifers in South China: Beijing, Science Publication House, 297 p. [in Chinese]

Lipina, O.A, 1950, Late Devonian foraminifers from the Russian Platform: Akademiya Nauk SSSR, Trudy Instituta Geologicheskikh Nauk, 119, geologiskaya seriya, v. 43, p. 110–133. [in Russian]

Lipina, O.A, 1955, Upper Devonian and Tournaisian foraminifers from the Volga-Ural area and from the western slope of central Urals: Akademiya Nauk SSSR, Trudy Instituta Geologii, 163, geologichevskaya seriya, v. 70, p. 1–96. [in Russian; French translation: BRGM n° 1640]

Lipina, O.A., 1960, Stratigraphy of Tournaisian Stage and Devonian and Carboniferous boundary interval of the eastern part of Russian Platform and wertern slope of the Urals: Akademiya Nauk SSSR, Trudy Geologicheskogo Instituta, v. 14, p. 3–135.

Loeblich, A.R., and Tappan, H., 1961, Suprageneric classification of the Rhizopodea: Journal of Paleontology, v. 35, p. 245–330.

Loeblich, A.R., and Tappan, H., 1964, Sarcodina, chiefly "Thecamoebians" and Foraminiferida, *in* Moore, R.C., ed., Treatise of Invertebrate Paleontology, Part C, Protista 2: Boulder, Colorado and Lawrence, Kansas, The Geological Society of America and the University of Kansas Press, 2 volumes, p. C1–C900.

Loeblich, A.R., and Tappan, H., 1982, Classification of the Foraminiferida, *in* Broadhead, T.W., ed., Foraminifera, notes for a short course organized, by M.A. Buzas and B.K. Sen Gupta, University of Tennessee, Department of Geological Sciences: Studies in Geology, v. 6, p. 22–36.

Loeblich, A.R., and Tappan, H., 1984, Suprageneric classification of the Foraminiferida (Protozoa): Micropaleontology, v. 30, p. 1–70.

Loeblich, A.R., and Tappan, H., 1986, Some new and redefined genera and families of Textulariina, Fusulinina, Involutinina and Miliolina (Foraminiferida): Journal of Foraminiferal Research, v. 16, p. 334–346.

Loeblich, A.R., and Tappan, H., 1987, Foraminiferal Genera and Their Classification: New York, Van Nostrand Reinhold Company Publisher, v. 1, 182 p.

Machel, H.G., and Hunter, G., 1994, Facies models for Middle to Late Devonian shallow-marine carbonates, with comparisons to modern reefs: a guide for facies analysis: Facies, v. 30, p. 155–176.

Makarenko, S.N., and Savina, N.I., 2013, New data on Devonian stratigraphy of the central part of the Nyurolka depression (Tomsk region), *in* Krasnov, V.I., ed., Regional stratigraphy of the Late Precambrian and Paleozoic of Siberia: Proceedings of Scientific Papers, Sibirskiy NauchnIsslevo-Vatelskiy Instituta Geologii, Geofiziki i Mineralskogo Syrya, Novosibirsk, p. 124–132. [in Russian)]

Malakhova, N.P., 1963, New genus of Lower Devonian foraminifer from the Urals: Paleontologischeskii Zhurnal, v. 1963, p. 141–144. [in Russian]

Malakhova, N.P., 1969, Fauna of the metalliferous series of the pyritic oucrops of the southern Urals: Akademiya Nauk SSSR, Uralskii Filial, Trudy Instituta Geolologii i Geokhimii, v. 81, p. 1–84. [in Russian]

Mamet, B., 1973, Microfaciès viséens du Boulonnais (Nord, France): Revue de Micropaléontologie, v. 16, p. 101–124.

Mamet, B., 1976, An atlas of microfacies in Carboniferous carbonates of the Canadian Cordillera: Geological Survey Canada, v. 255, 131 p.

Mamet, B., and Boulvain, F., 1992, Microflore des monticules micritiques frasniens "F2j" de Belgique: Revue de Micropaléontologie, v. 35, p. 283–302.

Mamet, B., and Préat, A., 2005, Microfaciès d'une lentille biohermale à la limite Eifélien/Givétien (Wellin, bord sud du synclinorium de Dinant): Geologica Belgica, v. 8, p. 85–111.

Mamet, B., and Préat, A., 2007, Eifelian–Givetian stromatoporoid-coral reefs, Belgium, *in* Vennin, E., Aretz, M., Boulvain, F., and Munnecke, A., eds., Facies from Palaeozoic reefs and bioaccumulations: Mémoires du Muséum National d'Histoire Naturelle, v. 195, p. 191–193.

Mamet, B., and Préat, A., 2009, Algues et microfossiles problématiques du Dévonien moyen du "Fondry des Chiens" (bord sud du synclinorium de Dinant, Belgique): implications paléobathymétriques: Revue de Micropaléontologie, v. 52, p. 249–263.

Mamet, B., and Préat, A., 2013, Essai de description d'algues nouvelles paléozoïques: Geologica Belgica, v. 16, p. 35–48.

Mamet, B., Préat, A., and Lehmami, M., 1999, Algues calcaires marines du Dévonien marocain (Meseta): Revue de Micropaléontologie, v. 42, p. 301–314.

https://doi.org/10.1017/jpa.2017.127 Published online by Cambridge University Press

Mancin, N., 2001, Agglutinated foraminifera from the Epiligurian succession (Middle Eocene/Lower Miocene, Northern Apennines, Italy): scanning electron microscpoic characterization and paleoenvironmental implications: Journal of Foraminiferal Research, v. 31, p. 294–308.
Marfenkova, M.M., 1991, Marine Carboniferous from Kazakhstan: Akademiya Nauk Kazakhskoi SSR, Institut Geologicheskikh Nauk, Alma-Ata, "Zylym": 197 p. + 150 p. [in Russian]
May, A., 1992, Die Kalkalgen-Flora des Ober-Eifeliums and Unter-Givetiums (Devon) des nordwestlichen Sauerlandes (Rheinisches Schiefergebirge): Palaeontographica, v. 228, p. 1–28.
Menner, V.V., and Reitlinger, E.A., 1971, Provincial particularities of Middle and Late Devonian foraminifers from the North Siberian Platform: Voprosy Mikropaleontologii, v. 14, p. 25–38. [in Russian]
Mikhalevich, V.I., 1980, Systematics and evolution of foraminifera in the light of new data on their cytology and ultrastructure: Akademiya Nauk SSSR, Trudy Zoologicheskogo Instituta, v. 94, p. 42–61. [in Russian]
Mikhalevich, V.I., 2003, System of the four foraminiferal subclasses with the agglutinated shell wall (Ammodiscana, Miliamminana, Hormosiniana, Textulariana) (Foraminifera): Rossiiskaya Akademiya Nauk, Izvestiya Zoologicheskogo Instituta, v. 7, p. 5–50.
Miklukho-Maklay, A.D., 1958, A new family of Foraminifera, Tuberitinidae M.-Maclay fam. nov.: Voprosy Mikropaleontologii, v. 2, p. 130–135. [in Russian]
Miklukho-Maklay, A.D., 1963, Late Paleozoic of Central Asia: Leningrad, Izdateltsvo Leningradskogo Universiteta, 328 p. [in Russian]
Miklukho-Maklay, A.D., 1965, Some Middle Paleozoic foraminifers of central Asia: Ezhegodnik Vsesoyuznogo Paleontologicheskogo Obshchestva, v. 17 (1957–1964), p. 30–45. [in Russian]
Milon, Y., 1928, Recherches sur les calcaires paléozoïques et le Briovérien de Bretagne: Thèse Rennes, Imprimerie Oberthur, 151 p.
Moreman, W.L., 1930, Arenaceous Foraminifera from Ordovician and Silurian limestones of Oklahoma: Journal of Paleontology, v. 4, p. 42–59.
Mörtl, A., 2014, Der Amphiporenkalk im Devon der Karnischen Alpen [Bachelor thesis]: Innsbruck, University of Innsbruck, Institute of Geology, 42 p.
Munk, C., 1994, Agglutinierte Foraminiferen aus Schwammriffkalken des Oxfordium und Kimmeridgium der Nördlichen Frankenalb (Bayern): Abhandlungen der geologischen Bundesantalt, v. 50, p. 353–368.
Munnecke, A., and Servais, T., 2008, Paleozoic calcareous plankton: evidence from the Silurian of Gotland: Lethaia, v. 41, p. 185–194, DOI 10.1111/j.1502-3931.2008.00113.x.
Murray, J.W., 1991, Ecology and palaeoecology of benthic foraminifera: Hulow, Longman Publisher, 397 p.
Murray, J.W., Alve, E., and Jones, B.W., 2011, A new look at modern agglutinated benthic foraminiferal morphogroups: their value in palaeoecological interpretation: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 309, p. 229–241.
Nagy, J., 1992, Environmental significance of foraminiferal morphogroups in Jurassic North Sea deltas: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 95, p. 111–134.
Nagy, J., Gradstein, F.M., Kaminski, M.A., and Holbourn, A.E., 1995, Foraminiferal morphogroups, paleoenvironments and new taxa from the Jurassic to Cretaceous strata of Thakkhola, Nepal, *in* Kaminski, M.A., Geroch, S., and Gasinski, M.A., eds., Proceedings of the Fourth International Workshop on Agglutinated Foraminifera: Grzybowski Foundation Special Publication, v. 3, p. 181–209.
Nestell, G.P., and Nestell, M.K., 2006, Middle Permian (Late Guadalupian) foraminifers from Dark Canyon, Guadalupe Mountains, New Mexico: Micropaleontology, v. 52, p. 1–50.
Nestell, G.P., and Tolmacheva, T.Y., 2004, Early Ordovician foraminifers from the Lava River Section, northwestern Russia: Micropaleontology, v. 50, p. 253–280.
Nestell, G.P., Heredia, S., Mestre, A., Beresi, M., and González, M., 2011, The oldest Ordovician foraminifers (*Oepikodus evae* conodont Zone, Floian) from South America (Les plus vieux foraminifères (Zone à conodontes *Oepikodus evae*, Floien) d'Amérique du Sud): Geobios, v. 44, p. 601–608.
Neumann, M., Pozaryska, K., and Vachard, D., 1975, Remarques sur les microfaciès du Dévonien de Lublin (Pologne): Revue de Micropaléontologie, v. 18, p. 38–52.
Nguyên, D.T., 1986, Foraminifera and algae from the Permian of Kampuchea, *in* Fontaine, H. The Permian of Southeast Asia: CCOP Technical Bulletin, v. 18, p. 116–137.
Özkan, R., 2011, Frasnian (Late Devonian) foraminiferal biostratigraphy from Taurides, southern Turkey: Stratigraphy, v. 8, p. 281–292.
Özkan, R., and Vachard, D., 2015, A new early Frasnian (Late Devonian) foraminifer from eastern Taurides (Turkey): evolutionary and paleobiogeographic implications: Revue de Micropaléontologie, v. 58, p. 267–282.
Pel, J., 1975, Etude sédimentologique et stratigraphique du Givétien; Synclinorium de Dinant, de Givet à Liège: Extrait de la Collection des Publications de la Faculté des Sciences Appliquées de l'Université de Liège, v. 53, p. 61–113.
Perret, M.F., and Vachard, D., 1977, Algues et pseudo-algues des calcaires serpoukhoviens d'Ardengost (Hautes-Pyrénées): Annales de Paléontologie (Invertébrés), v. 63, p. 85–156.
Petrova, L.G., 1977, Foraminifers of the family Parathuramminidae from the Lower Eifelian of the eastern slope of the Middle and northern Ural Mountains, *in* New paleontological material from the Ural Mountains: Akademiya Nauk SSSR, Uralskii Nauchnyi Tsentr, Sverdlovsk, p. 3–11. [in Russian]
Petrova, L.G., 1981, Middle Devonian Foraminifers from the eastern slope of the Urals, *in* Dubatolov, V.N., ed., Paleozoic of western Siberia Plain and its mountainous border: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, v. 482, p. 81–101. [in Russian]
Petrova, L.G., and Pronina, T.V., 1980, Silurian and Lower Devonian foraminifers from the eastern slope of the northern and central Urals, *in* Dubatolov, V.N., and Yuferev, O.V., eds., Devonian and Carboniferous of the Asian part of USSR: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, v. 433, p. 43–62. [in Russian]
Pia, J. von, 1937, Die wichtigsten Kalkalgen des Jungpaläozoikums und ihre geologische Bedeutung: Compte Rendu du 2e Congrès Avancement Etudes de Stratigraphie du Carbonifère, Heerlen, 1935, v. 2, p. 765–856.
Plummer, H.J., 1930, Calcareous foraminifera in the Brownwood shale near Bridgeport, Texas: Bulletin University of Texas, Austin, v. 3019, p. 5–21.
Pohler, S.M.L., Bandel, K., Kido, E., Pondrelli, M., Suttner, T.J., Schönlaub, H.P., and Mörtl, A., 2015, Polinik Formation, *in* Corradini, C., and Suttner, T.J., eds., The Pre-Variscan sequence of the Carnic Alps (Austria and Italy): Abhandlungen der Geologischen Bundesanstalt, v. 69, p. 81–84.
Pokorny, V., 1951, The Middle Devonian foraminifera of Celechovice, Czechoslovakia: Vestnik Kráslovske Ceske Spolecnosti Nauk, Trída matematicko-prirodovedécka, v. 9, p. 1–29.
Porter, S.M., 2004, Closing the phosphatization window: testing for the influence of taphonomic megabias on the pattern of small shelly fossil decline: Palaios, v. 19, p. 178–183.
Poyarkov, B.V., 1969, Stratigraphy and foraminifers from the Devonian deposits of Tian Shan: Akademiya Nauk Kirgizskoi SSR, Institut Geologii, Upravlennie Geologii Kirgizskoi SSR, Izdatelstvo "Ilim", Frunze, 186 p. [in Russian]
Poyarkov, B.V., 1977, Biogeography of the Devonian Foraminifera, *in* Dubatolov, V.N., and Yuferev, O.V., eds., Divisions, paleobiogeographic subdivisions and biostratigraphy: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, "Nauka,", v. 347, p. 8–28. [in Russian]
Poyarkov, B.V., 1979, Development and diffusion of the Devonian foraminifers: Akademiya Nauk SSSR, Dalnevostochnyi Nauchnyi Tsentr, Dalnevostochnyi Geologicheskii Insitut, Izdateltsvo "Nauka," Moscow, 172 p. [in Russian]
Pratt, B.R., 2010, Peritidal Carbonates, *in* James, N.R., and Dalrymple, R.W., eds., Facies Models 4: St. John's, Newfoundland, Geological Association of Canada, p. 401–420.
Préat, A., and Kasimi, R., 1995, Sédimentation de rampe mixte silico-carbonatée des couches de transition eifélienes-givétiennes franco-belges. Première partie: microfaciès et modèle sédimentaire: Bulletin Centres Recherches Exploration-Production Elf-Aquitaine, v. 19, p. 329–375.
Préat, A., and Mamet, B., 1989, Sédimentation de la plate-forme carbonatée givétienne franco-belge: Bulletin Centres Recherches Exploration-Production Elf-Aquitaine, v. 13, p. 47–86.
Préat, A., Blockmans, S., Capette, L., Dumoulin, V., and Mamet, B., 2007, Microfaciès d'une lentille biohermale à la limite Eifélien/Givétien ("Fondry des Chiens", Nismes, bord sud du synclinorium de Dinant): Geologica Belgica, v. 10, p. 3–25.
Preece, R.C., Kaminski, M.A., and Dignes, T.W., 1999, Miocene benthonic foraminiferal morphogroups in an oxygen minimum zone, offshore Cabinda, *in* Cameron, N.R., Bate, R.H., and Clure, V.S., eds., The Oil and Gas Habitats of the South Atlantic: Geological Society, London, Special Publications, v. 153, p. 267–282.
Pronina, T.V., 1960, New foraminiferal species of the lower Givetian deposits from the central and southern Urals: Paleontologicheskii Zhurnal, v. 1960, p. 45–52. [in Russian; French translation IFP no. 6425]
Pronina, T.V., 1963, Silurian foraminifers and some associated microorganisms from Ufa Amphitheatre: Paleontologicheskii Zhurnal, 1963, p. 3–13. [in Russian]
Pronina, T.V., 1968, The genus *Earlandia* and some related Silurian foraminifers of the Urals: Paleontologicheskii Zhurnal, 1968, p. 38–46. [in Russian; English translation p. 471–480]
Pronina, T.V., 1969, New Silurian and Devonian foraminifers of the Urals: Paleontologicheskii Zhurnal, v. 1969, p. 3–13. [in Russian]
Pronina, T.V., 1970, Some Silurian and Devonian foraminifers from the Urals, *in* Materials for the paleontology of the Urals: Akademiya Nauk SSSR, Uralskyi Filial, p. 106–115. [in Russian]
Purkin, M.M., Poyarkov, B.V., and Rozhanets, V.M., 1961, Stratigraphy and new species of foraminifers from Tournaisian deposits of the Borkoldy

https://doi.org/10.1017/jpa.2017.127 Published online by Cambridge University Press

Range (Tian Shan): Izvestiya Akademii Nauk Kirgizskoy SSR, Izvestya, seriya estestvvennykh i tekhnicheskikh Nauk, v. 3, p. 15–36. [in Russian]
Racki, G., and Soboń-Podgórska, J., 1993, Givetian and Frasnian calcareous microbiotas of the Holy Cross Mountains: Acta Palaeontologica Polonica, v. 37, p. 255–289.
Rauzer-Chernousova, D.M., and Fursenko, A.B., 1959, Protozoa, *in* Orlov, Y.A., ed., Fundamentals of Paleontology, Part 1: Akademiya Nauk SSSR, Izdatelstvo, Moscow, p. 1–482. [in Russian]
Reitlinger, E.A., 1954, Devonian foraminifers of some sections of the western Russian Platform: Trudy Vsesoyuznogo Neftyanogo Nauchno-Issledovatelskogo Geologorazvedochnogo Instituta (VNIGRI), Paleontologicheskiy Sbornik, 1954, p. 52–81. [in Russian]
Reitlinger, E.A., 1957, Spheres from Devonian deposits of Russian Platform: Doklady Akademiya Nauk SSSR, v. 115, p. 774–776. [in Russian]
Reitlinger, E.A., 1959, Order Endothyrida, in Rauzer-Chernousova, D.M., and Fursenko, A.V., eds. Protozoa, in Orlov, Y.A., ed., Fundamentals of Paleontology, part 1: Moscow, Akademiya Nauk SSSR, Izdatelstvo, p. 190–201. [in Russian].
Reitlinger, E.A., 1962, Foraminifer description, *in* Varsanofeva, V.A., and Reitlinger, E.A., eds., On the characteristics of the Late Devonian–Tournaisian beds from Little Pechora, Byulleten Moskovskogo Obshchestva Ispyatelei Prirody, new series, 67 Otdelenie Geologiya, v. 37, p. 52–60. [in Russian]
Reolid, M., and Molina, J.M., 2010, Serpulid-Frutexites assemblage from shadow-cryptic environments in Jurassic marine caves, Betic Cordillera, Southern Spain: Palaios, v. 25, p. 468–474.
Reolid, M., Nagy, J., Rodríguez-Tovar, F.J., and Olóriz, F., 2008, Foraminiferal assemblages as palaeoenvironmental bioindicators in Late Jurassic epicontinental platforms: relation with trophic conditions: Acta Palaeontologica Polonica, v. 53, p. 705–722.
Ross, C.A., and Ross, J.R.P., 1991, Paleozoic Foraminifera: BioSystems, v. 25, p. 39–51.
Sabirov, A.A., 1974, The genus *Uralinella* (Foraminifera): Paleontologicheskii Zhurnal, 1974, p. 141–145. [in Russian]
Sabirov, A.A., 1978, New Devonian foraminifers of central Tajikistan: Paleontologicheskii Zhurnal, 1978, p. 13–19. [in Russian]
Sabirov, A.A., 1982a, On the classification of bisphers and cribrosphaeroids: Izvestiya Akademii Nauk Tadzhiskoi SSR, Otdelenie Fiziko-Matematicheskikh, Khimicheskikh i Geologicheskikh, v. 2, p. 87–94. [in Russian]
Sabirov, A.A., 1982b, On the classification of parathuramminins: Izvestiya Akademii Nauk Tadzhiskoi SSR, Otdelenie Fiziko-Matematicheskikh, Khimicheskikh i Geologicheskikh, v. 3, p. 62–67. [in Russian]
Sabirov, A.A., 1984, Lower Devonian foraminifers from Urmistan section (northern slope of the Zeravshan Range): Akademiya Nauk Tadzhiskoi SSR, Institut Geologii, Tadzhiskoe Otdelenii Vsessoyuznogo Paleontologicheskogo Obchestva, Dushanbe, 1984, p. 5–13. [in Russian]
Sabirov, A.A., 1986, New genus of foraminifers in the family Parathuraminidae: Paleontologicheskii Zhurnal, 1986, p. 101–102. [in Russian]
Sabirov, A.A., 1987a, New foraminiferal species of the Late Silurian and Devonian of Tajikistan: Paleontologicheskii Zhurnal, 1987, p. 23–29. [in Russian]
Sabirov, A.A., 1987b, On systematics and taxonomic range of parathuramminids (foraminifers): Voprosy Mikropaleontologii, v. 29, p. 60–70. [in Russian]
Sabirov, A.A., 2013, The foraminiferal scale of Devonian system of Tajikistan: Izvestiya Akademiya Nauk Respubliki Tadjikistan, Otdelenie Fiziko-Matematicheskikh, Khimichekikh, Geologicheskikh i Thekhnicheskikh Nauk, v. 4, p. 113–121. [in Russian]
Saltovskaya, V.D., 1974, Stratigraphy of the Carboniferous deposits of the Zeravshano-Gissar mountainous area: Dushanbe, Akademiya Nauk Tadzhikskoi SSR, Institut Geologii, Izvatelstvo "Donizh", 144 p. [in Russian]
Saltovskaya, V.D., 1981, Silurian and Devonian foraminifers from the Zeravshano-Gissar Range: Voprosy Mikropaleontologii, v. 24, p. 105–115. [in Russian]
Sanz-Lopez, J., Vachard, D., and Perret, M.F., 2005, Foraminifers and algae from the reworked late Viséan limestones of the Bellver Formation, eastern Pyrenees, Spain: Annales de la Société Géologique du Nord, v. 12 (2è sér.), p. 47–61.
Schlagintweit, F., Hladil, J., Nose, M., and Salerno, C., 2013, Palaeozoic record of Thaumatoporella Pia, 1927 (incertae sedis)?: Geologica Croatica, v. 66, p. 155–182.
Schönlaub, H.P., 1979, Das Paläozoikum in Österreich: Abhandlungen der geologischen Bundesanstalt, v. 33, p. 1–124.
Schönlaub, H.P., 1980, Carnic Alps. Field Trip A, *in* Schönlaub, H.P., ed., Second European Conodont Symposium, ECOS II, Guidebook, Abstracts: Abhandlungen der geologischen Bundesanstalt, 35, p. 5–57.
Schönlaub, H.P., 1985a, Geologische Karte der Republik Österreich 1:50.000, Blatt 197, Kötschach: Wien, Geologische Bundesanstalt.
Schönlaub, H.P., 1985b, Das Paläozoikum der Karnischen Alpen: Arbeitstagung der Geologischen Bundesanstalt, 1985, Kötschach-Mauthen, Gailtal, p. 34–52.
Schönlaub, H.P., and Heinhisch, H., 1993, The classic fossiliferous units of the Eastern and Southern Alps, *in* von Raumer, J.F., and Neubauer, F., eds., Pre-Mesozoic Geology in the Alps: Berlin, Springer, p. 395–422.
Schönlaub, H.P., and Histon, K., 2000, The Palaeozoic Evolution of the Southern Alps: Mitteilungen der Österreichischen Geologischen Gesellschaft, v. 92 (Aspects of Geology in Austria), p. 15–34.
Sen Gupta, B.K., 2002, Modern Foraminifera: New York, Kluwer Academic Publications, 371 p.
Shilo, N.A., Bouckaert, J., Afanasjeva, G.A., Bless, M.J.M., Conil, R., Erlanger, O.A., Gagiev, M.H., Lazarev, S.S., Onoprienko, Y.I., Poty, E., Razina, T.P., Simakov, K.V., Smirnova, L.V., Streel, M., and Swennen, R., 1984, Sedimentological and paleontological atlas of the late Famennian and Tournaisian deposits in the Omolon region (NE-USSR): Annales de la Société géologique de Belgique, v. 107, p. 137–247.
Shinn, E.A., 1983, Tidal Flat, *in* Scholle, P.A., Bebout, D.G., and Moore, C.H., eds., Carbonate Depositional Environments: AAPG Memoir, v. 33, p. 171–210.
Skompski, S., Conil, R., Laloux, M., and Lys, M., 1989, Etude micropaléontologique des calcaires du Viséen terminal et du Namurien dans le bassin carbonifère de Lublin à l'Est de la Pologne: Bulletin de la Société belge de Géologie, v. 98, p. 453–472.
Stephens, N.P., and Sumner, D.Y., 2003, Famennian microbial reef facies, Napier and Oscar Ranges, Canning Basin, western Australia: Sedimentology, v. 50, p. 1283–1302.
Strank, A.R.E., 1983, New stratigraphically significant Foraminifera from the Dinantian of Great Britain: Palaeontology, v. 26, p. 435–442.
Suleimanov, I.S., 1945, New species of Tournaisian smaller foraminifers from the petroliferous area of Ishimbaev: Doklady Akademiya Nauk SSSR, v. 48, p. 124–127. [in Russian]
Tappan, H., and Loeblich, A.R. Jr., 1968, Lorica composition of modern and fossil Tintinnida (Ciliate Protozoa), systematics, geologic distribution, and some new Tertiary taxa: Journal of Paleontology, v. 42, p. 1378–1394.
Timokhina, I.G., and Klets, A.G., 2002, New data on the distribution of the Upper Devonian foraminifers in the calcareous central areas of of western Siberian Plain: Novosti Paleontologii i Stratigrafii, v. 5, p. 137–143. [in Russian]
Timokhina, I.G., Klets, A.G., and Bochkarev, V.S., 2002, Famennian foraminifers of western Siberian Plain: Novosti Paleontologii i Stratigrafii, v. 5, p. 123–135. [in Russian]
Tong, D.T., Dang, T.H., Nguyen, D.H., Nguyen, D.K., Nguyen, H.H., Nguyen, T.D., Ta, H.P., Pham, K.N., and Doan, N.T., 1988, Devonian Stratigraphy and Coelenterata of Vietnam, vol. 1: Stratigraphy, Akademiya Nauk SSSR, Sibirskoe Otdelenie, Institut Geologii i Geofiziki, Novosibirsk Nauka Sibirskoe, p. 1–184.
Toomey, D.F., and Mamet, B.L., 1979, Devonian Protozoa, *in* House, M.R., Scrutton, C.T., and Bassett M.G., eds., The Devonian System: Special Papers in Paleontology, v. 23, p. 189–192.
Toomey, D.F., Mountjoy, E.W., and MacKenzie, W.S., 1970, Upper Devonian (Frasnian) algae and foraminifera from the Ancient Wall carbonate complex, Jasper National Park, Alberta, Canada: Canadian Journal of Earth Sciences, v. 7, p. 946–981.
Trifonova, E., 1992, Taxonomy of Bulgarian Triassic foraminifera. I. Families Psammosphaeridae to Nodosinellidae: Geologica Balcanica, v. 22, p. 3–50.
Tsyganko, V.S., 2008, Subsurface of Middle Devonian on the Polar Urals western slope: Litosfera, v. 2, p. 67–79.
Tyszka, J., 1994, Response of Middle Jurassic benthic foraminiferal morphogroups to dysoxic/anoxic conditions in the Pieniny Klippen Basin, Polish Carpathians: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 110, p. 55–81.
Vachard, D., 1974a, Remarques sur les Foraminifères des calcaires griottes *sensu lato* (Frasnien inférieur–Tournaisien inférieur) du versant méridional de la Montagne Noire (Aude-Hérault): Comptes Rendus Sommaires de la Société géologique de France, 1973, p. 116–118.
Vachard, D., 1974b, Contribution à l'étude stratigraphique et micropaléontologique (algues et foraminifères) du Dévonien–Carbonifère inférieur de la partie orientale du versant méridional de la Montagne Noire (Hérault, France) [Ph.D. dissertation]: Paris, University of Paris VI, 2 volumes, 408 p.
Vachard, D., 1976, Problématique des micro-organismes du Paléozoïque supérieur: 4è Réunion Annuelle des Sciences de la Terre, Paris, p. 385.
Vachard, D., 1977, Etude stratigraphique et micropaléontologique (algues et foraminifères) du Viséen de la Montagne Noire (Hérault, France): Mémoires Institut Géologique Université Louvain, v. 29, p. 111–195.
Vachard, D., 1991, Parathuramminides et moravamminides (Microproblematica) de l'Emsien supérieur de la Formation Moniello (Cordillères Cantabriques, Espagne): Revue de Paléobiologie, v. 10, p. 255–299.
Vachard, D., 1993, Algues, pseudo-algues et microfaciès carbonatés du Dévonien du domaine Ligérien (Massif Armoricain, France): Palaeontographica B, v. 229, p. 53–113.

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Vachard, D., 1994, Foraminifères et moravamminides du Givétien et du Frasnien du domaine Ligérien (Massif Armoricain, France): Palaeontographica A, v. 231, p. 1–92.
Vachard, D., 2016a, Macroevolution and biostratigraphy of the Paleozoic foraminifers, *in* Montenari, M., ed., Stratigraphy and Timescales: Amsterdam, Elsevier, p. 257–323.
Vachard, D., 2016b, Permian smaller foraminifers; taxonomy, biostratigraphy and biogeography, *in* Lucas, S.G., and Shen, S.Z., eds., The Permian Timescale: Geological Society London, Special Publications, 450. http://doi.org/10.1144/SP450.1.
Vachard, D., and Clément, B., 1994, L'Hastarien (ex-Tournaisien inférieur et moyen) à algues et foraminifères de la Zone Pélagonienne (Attique, Grèce): Revue de Micropaléontologie, v. 37, p. 289–319.
Vachard, D., and Cózar, P., 2004, *Insolentitheca* emend., *Protoinsolentitheca* n. gen., and Caligellidae emend., permanent cysts of Palaeozoic foraminifera?: Rivista Italiana di Paleontologia e Strafigrafia, v. 110, p. 591–603.
Vachard, D., and Cózar, P., 2010, An attempt of classification of the Palaeozoic incertae sedis Algospongia: Revista Española de Micropaleontología, v. 42, p. 129–241.
Vachard, D., and Mouravieff, N., 1994, Nouvelles faunes des Semitextulariinae (Foraminifères) dans le Frasnien franco-belge: Livre jubilaire Conil, Mémoires Institut Géologique Université Louvain, v. 35, p. 213–219.
Vachard, D., Zahraoui, M., and Cattaneo, G., 1994, Parathuramminines et Moravamminides (Foraminifères?) du Givétien du Maroc Central: Revue de Paléobiologie, v. 14, p. 1–19.
Vachard, D., Pille, L., and Gaillot, J., 2010, Palaeozoic Foraminifera: systematics, palaeoecology and responses to the global changes (Les foraminifères paléozoïques: systématique, paléoécologie et réponses aux changements globaux): Revue de Micropaléontologie, v. 53, p. 209–254.
Vachard, D., Haig, D.W., and Mory, A.J., 2014, Lower Carboniferous (middle Visean) foraminifers and algae from an interior sea, Southern Carnarvon Basin, Australia: Geobios, v. 47, p. 57–74.
Vachard, D., Clausen, S., Palafox, J.J., Buitrón, B.E., Devaere, L., Hayart, V., and Régnier, S., 2017, Lower Ordovician microfacies and microfossils from Cerro San Pedro (San Pedro de la Cueva, Sonora, Mexico), as a westernmost outcrop of the newly defined *Nuia* Subprovince: Facies, v. 63. https://doi.org/10.1007/s10347-017-0497-9.
Vai, G.B., 1991, Palaeozoic strike-slip rift pulses and palaeogeography in the circum-Mediterranean Tethyan realm: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 87, p. 223–252.
Vai, G.B., 1998, Field trip through the Southern Alps: an introduction with geologic settings, palaeogeography and Palaeozoic stratigraphy, *in* Southern Alps field trip guidebook. Seventh international conodont symposium held in Europe: Giornale di Geologia, s. 3, v. 60, p. 1–38.
Van Den Akker, T.J.H.A., Kaminski, M.A., Gradstein, F., and Wood, J., 2000, Campanian to Palaeocene biostratigraphy and palaeoenvironments in the Foula Sub-basin, west of the Shetland Islands, UK: Journal of Micropalaeontology, v. 19, p. 23–43.
Vdovenko, M.V., 1977, Late Visean foraminifera from Donbass: Akademiya Nauk Ukrainskoi SSR, Institut Geologicheskikh Nauk, 136 p. [in Russian; unpublished; partly published in Vdovenko, 2001]
Vdovenko, M.V., 2001, Atlas of Foraminifera from the Upper Viséan and Lower Serpukhovian (Lower Carboniferous) of the Donets Basin (Ukraine): Abhandlungen und Berichte für Naturkunde, v. 23, p. 93–178.
Vdovenko, M.V., Rauzer-Chernousova, D.M., Reitlinger, E.A., and Sabirov, A.A., 1993, Reference-book on the systematics of Paleozoic smaller foraminifers: Rossiiskaya Akademiya Nauk, Komissiya po Mikropaleontologii, "Nauka,", 128 p. [in Russian]
Veevers, J.J., 1970, Upper Devonian and Lower Carboniferous algae and stromatolites from the Bonaparte Gulf Basin northwestern Australia: Commonwealth of Australia, Bureau Mineral Resources Geology and Geophysics Bulletin, v. 116, p. 173–188.
Versteegh, G.J.M., Servais, T., Streng, M., Munnecke, A., and Vachard, D., 2009, A discussion and proposal concerning the use of the term calcispheres: Palaeontology, v. 52, p. 343–348.
Vishnevskaya, V.S., and Sedaeva, K.M., 2002a, A revision of some foraminiferal taxa of the Order Parathuramminida and discussion of foraminiferal and radiolarian evolution: Paleontological Journal, v. 36, p. 581–590. [in Russian]
Vishnevskaya, V.S., and Sedaeva, K.M., 2002b, On the zonal divisions of the deposits of the Devonian-Carboniferous boundary based on parathuramminids (foraminiferal or foraminifera-radiolarian scale?), *in* Chuvashov, B.I., and Amon, E.O., eds., Stratigraphy and paleogeography of Carboniferous of Eurasia: Rossiiskaya Institute of Geology and Geochemistry, Akademiya Nauk, Mezhvedomstvennyi Stratigrafichevskii Komitet Rossii, Institut Geologii i Geokhimii, UrO RAN, p. 53–60. [in Russian]
Vissarionova, A.Ya., 1950, Foraminiferal fauna from the Devonian deposits of Bashkiria: Byulleten "Bashkiraya Nefti," Bashgeolgoizdat, v. 1, p. 33–36. [in Russian]
Wang, K.-L., 1987, On the Devonian-Carboniferous boundary based on foraminiferal fauna from South China: Acta Micropaleontologica Sinica, v. 4, p. 161–178.
Williamson, W.C., 1880, On the organisation of the fossil plants of the coal measures, pt X, including an examination of the supposed radiolarians of the Carboniferous rocks: Philosophical Transactions of the Royal Society, London (1880), v. 171, p. 493–539.
Wilson, J.L., 1975, Carbonate Facies in Geologic History: New York, Springer Verlag, 471 p.
Winchester-Seeto, T.M., and McIlroy, D., 2006, Lower Cambrian melanoscleriites and foraminiferal linings from the Lontova Formation, St. Petersburg, Russia: Review of Palaeobotany and Palynology, v. 139, p. 71–79.
Wray, J.L., 1967, Upper Devonian calcareous algae from the Canning Basin, Western Australia: Colorado School of Mines, Professional Contributions, v. 3, p. 1–76.
Yuferev, O.V., 1979, Divisions of the Devonian-Carboniferous boundary deposits based on foraminifers in the Perevalny Creek Basin (the Omolon Massif), 14e Pacific Science Congress, Field Excursion Guidebook tour 9, supplement 4, Magadan, p. 5–25.
Zadorozhnyi, V.M., 1981, Importance of the foraminifers of selected Frasnian deposits in the petroliferous Paleozoic of the southeastern part of the Western Siberian Plate, *in* Dubatolov, V.N., ed., Paleozoic of the western Siberian plain and its mountainous periphery: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, v. 482, p. 110–114. [in Russian]
Zadorozhnyi, V.M., 1985, Diffusion of foraminifers in the Devonian type sections of the periphery of Kuznetsk Basin: Akademiya Nauk SSSR, Trudy Instituta Geologii i Geofiziki, Sibirskoe Otdelenie, v. 619, p. 119–141. [in Russian]
Zadorozhnyi, V.M., 1987, Devonian foraminifers and biostratigraphy of the western Siberian Plate and its folded borderland: Akademiya Nauk SSSR, Trudy Instituta Geologii i Geofiziki, Sibirskoe Otdelenie, v. 680, p. 1–126. [in Russian]
Zadorozhnyi, V.M., and Yuferev, O.V., 1981, New Devonian foraminifers of the family Parathuramminidae, *in* Dubatolov, V.N., ed., Paleozoic deposits of the western Siberian Plain and its mountainous borderland: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, v. 482, p. 54–61, 122, 129–130. [in Russian]
Zadorozhnyi, V.M., and Yuferev, O.V., 1984, Phylum Protozoa, Class Sarcodina, Subclass Foraminifera, *in* Kanygin, A.V., ed., Paleozoic of southeastern part of the western Siberian Plate Akademiya Nauk SSR, Sibirskoe Otdelenie, Trudy Instituta Geologii i Geofiziki, v. 568, p. 70–113. [in Russian]
Zhuravlev, A.Yu., and Wood, R., 2008, Eve of biomineralization: Controls on skeletal mineralogy: Geology, v. 36, p. 923–926.
Zukalova, V., 1981, Prehled mikorofosilií v givetskych a frasnskych rifovych vápencich vápencích na Morave: Zemni Plyn a Nafta, v. 26, p. 561–570, 793–821.
Zukalova, V., 1984, Biostratigrafie devonu ve vrtu Ostravice NP-824 jizne od Ostravy: Acta Universalis Carolinae, Geologica, v. 3, p. 219–236.

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