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The Early Vendian Microfossils First Found in the Russian Plate: Taxonomic Composition and Biostratigraphic Significance

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Abstract—The microfossils studied are discovered for the first time in the Riphean–Lower Vendian deposits, which have been recovered in 2002 by the Kel'tminskaya-1 deep parametric borehole in the Vychegda depression, the northeastern margin of the East European platform. The sampled interval of core section (4825–2347 m) consists of three units: the lower (depth range 4825–3995 m, 5 samples) and middle (depth range 3687–2961 m, 17 samples) carbonate successions overlain by sandstone–siltstone beds (depth range 2907–2347 m, 58 samples). Based on lithological criteria and/or composition of stromatolites, the carbonate successions are correlative with the Yshkemes and Vapol formations of the Upper Riphean of the Timan ridge succession, while the overlying, mostly siltstone succession was correlated with the Vychegda Formation of the southern Timan according to similarity in lithology and mineral composition. Microfossils found in 56 samples occur at 20 microphytological levels and represent different microbiotas. The Yshkemes and Vapol microbiotas of low diversity characterize six lower levels and represent one assemblage, while the diverse and abundant Vychegda microbiota typical of fourteen upper levels is divisible into three successive assemblages. The Vapol stromatolites *Inzeria djejimii* and *Poludia polymorpha* along with giant *Chuaria* and *Navifusa* present in the Yshkemes–Vapol assemblage suggest that their host deposits correspond to the upper Upper Riphean. The Vychegda assemblages, each of peculiar biostratigraphic specifics and unique in composition, consist of different morphotypes, primarily of large acanthomorphic acritarchs *Cavaspina, Polyhedrosphaeridium, Cymatiosphaeridium, Asterocapsoides*, and *Tanarium*, which are known in Scandinavia, Siberia, China, Australia, and India only in the Lower Vendian microbiotas of the Perthatataka type. The comprehensive microphytological characterization of the Lower Vendian in the Vychegda depression and earlier data on the Middle–Upper Riphean microbiotas from the adjacent Mezen syneclise enable a high-resolution biostratigraphic subdivision of the Riphean and Vendian successions in the vast region under consideration.

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Key words: Lower Vendian, acanthomorphic acritarchs, Perthatataka assemblage, biostratigraphy, East European platform.

Investigation history of Riphean and Vendian microfossils in the East European platform lasted over 50 years, but only featureless assemblages of simple acritarchs and filamentous morphotypes have been known here for a long time despite a plentiful material recovered by deep drilling in many platform areas (*Microfossils of the Precambrian…,* 1989). Representative microbiotas, which determined microphytological specifics and reliably substantiated discrimination of the Redkino, Kotlin, and Rovny horizons, were discovered in some sections only. The results of the Upper Vendian subdivision based on microphytological data changed insignificantly the negative attitude toward biostratigraphic potential of microfossils from the Riphean and Lower Vendian successions of the East European platform, because organic remains detected in these intervals still corresponded to taxonomically impoverished microfossil assemblages of transit taxa. This situation contrasting with data on abundant and diverse microfossils from concurrent deposits of the southern Urals and Siberia gave birth to skeptical viewpoint relative to stratigraphic value of microphytology in European areas of Russia. Diverse microbiotas discovered recently from Riphean deposits of the Mezen syneclise, the northeast of the platform under consideration (Sivertseva, 1993; Golubkova, 2002; Veis et al., 2004), changed the stereotyped attitude toward the relevant successions, but they did not eliminate the lacunas in microphytological characterization of the Lower Vendian all over Russia (except for some inner areas of the Siberian platform).

Microfossils from Upper Riphean and Lower Vendian deposits recovered by borehole Kel'tminskaya-1 in Vychegda depression, the northeastern margin of the

† Deceased.

Russian plate, which are studied and described in this work, can be regarded as closing the above lacunas. The representative microbiota of the Perthatataka type comprising morphotypes of different structure, the large acanthomorphic acritarchs included, is discovered here in the Lower Vendian siliciclastic deposits discordantly resting on the Riphean carbonate strata the borehole penetrated through. In distinction from comparable microbiotas known from Scandinavia, Siberia, China and Australia (Zhang and Walter, 1989, 1992; Knoll, 1992; Zhang et al., 1998; Tiwari and Knoll, 1994), microfossils are confined in the Vychegda depression not to separate thin interlayers in disjointed exposures or drill holes. They occur here in a single half-kilometer thick rock succession, which is underlain and overlain respectively by thick Riphean and Upper Vendian deposits containing paleontological remains. In the Vychegda section, microfossils are detected at twenty microphytological levels that yielded different morphotypes representing 40 species of more than 30 genera. The studied microbiota includes large acanthomorphic acritarchs *Polyhedrosphaeridium, Cavaspina, Cymatiosphaeridium, Asterocapsoides*, and many other morphotypes of intricate structure, the new taxa included, which belong to several discrete assemblages valuable in biostratigraphic aspect.

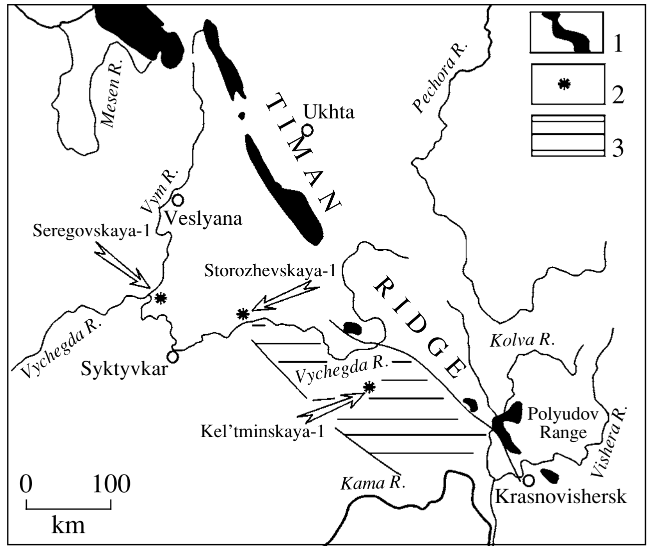


Fig. 1. Drilling sites in the Mezen syneclise and Vychegda depression: (1) rocks of the Upper Precambrian; (2) drilling site; (3) Vychegda depression with Phanerozoic sediments at the day surface.

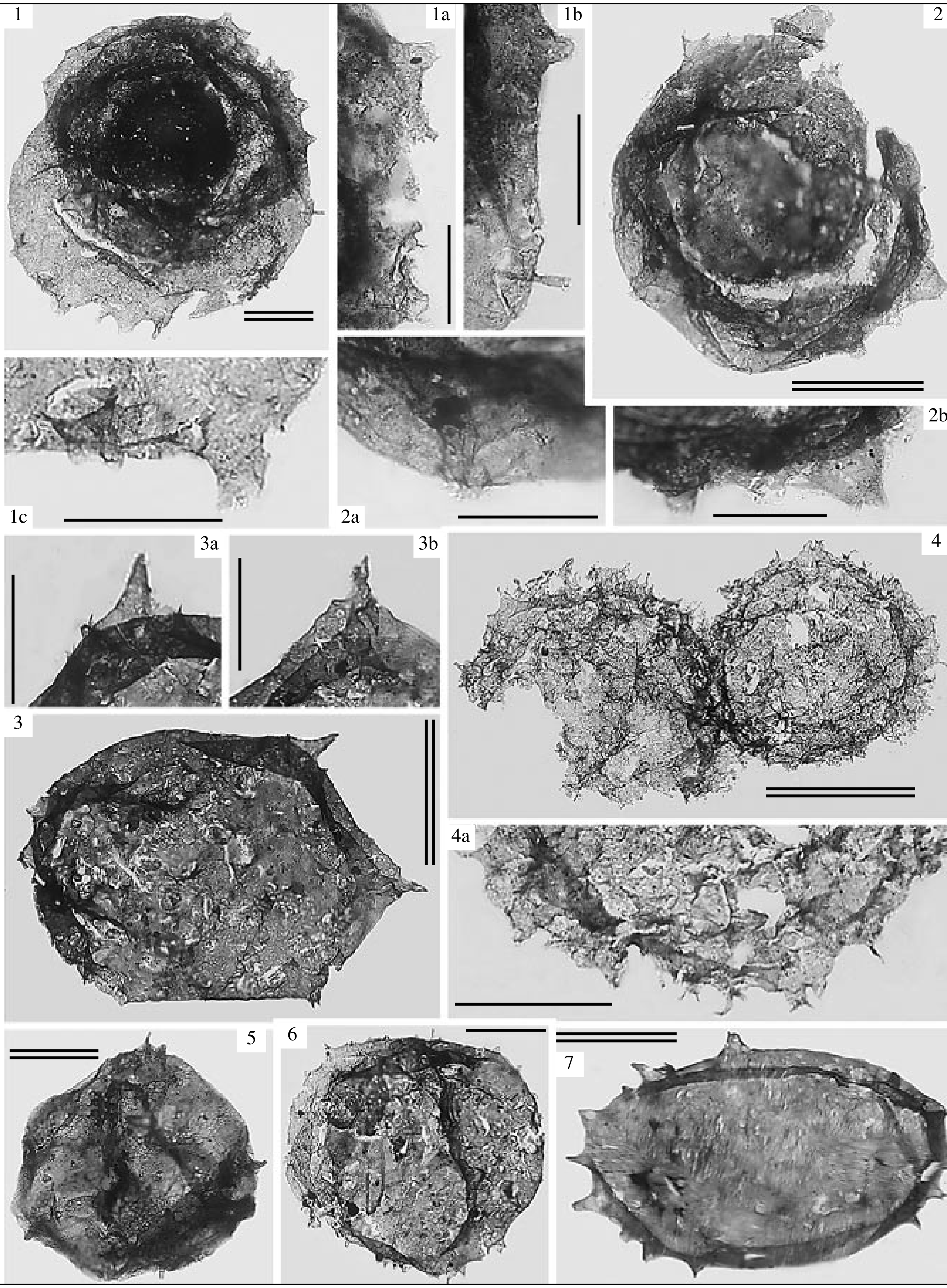
GEOLOGY OF STUDY AREA

In the northeastern margin of the East European platform, there are the vast Mezen syneclise and adjacent intricate area of pericratonic downwarping near the Timan Ridge. In both structures, thick Riphean–Vendian successions are concealed under overlying Phanerozoic deposits. In addition to geophysical research carried out in the Vychegda depression during the last decade, two parametric boreholes Storozhevskaya-1 and Seregovskaya-1 have been drilled in its northern area (Fig. 1). According to results of geological and geophysical investigations, the pre-Devonian rock succession penetrated by boreholes is divisible in two the Riphean–Lower Vendian(?) and Upper Vendian–Cambrian structural stages separated by unconformity (Olovyanishnikov, 1998). The lower stage (over 1 km thick) is composed predominantly of alternating sandstones and compact variegate or dark-colored siltstones and shales, all intercalated with limestone and marl interlayers. Discordance separating the upper stage (up to 2.5 km thick) from the lower one is emphasized by the basal sandstone–gravelstone member (up to 70 m thick) traceable for a long distance in lateral directions. Dominant rocks of the upper stage are splintery siltstones and shales less compact than below, which are colored red-brown or greenish gray, being intercalated with rare thin sandstone and gravelstone beds. Paleontological remains from the lower stage have been unknown until recent time, while basal horizons of the upper stage have been attributed to the Redkino Horizon of the Upper Vendian based on rare trace fossils and impressions of small medusoids discovered in them (Olovyanishnikov, 1997, 1998). Thus it was established that the rock succession of the Vychegda depression is divisible into the Upper Vendian and underlying Riphean–Lower Vendian deposits, but paleontological information has been obtained for the Upper Vendian strata only, while microphytological characteristics of all underlying Upper Proterozic strata remained unknown.

In 2002, the Kel'tminskaya-1 deep parametric borehole drilled in eponymous rampart, the southwestern area of the Vychegda depression, recovered a representative succession of Riphean–Vendian rocks below Upper Devonian deposits within the depth interval of 4902–1330 m (Fig. 1). We studied microfossils from the lower part of this interval (4902–2312 m), which is composed of two conformable carbonate successions (4902–3943 and 3943–2910 m) discordantly overlain by sandstone–siltstone succession (2910–2312 m). Above the erosion surface, the latter is overlain by siltstones and shales of the Upper Vendian Ust-Pinega Formation (2312–1880 m) containing acritarchs and filamentous microfossils of the Redkino Horizon, and higher in the succession there are mostly clayey deposits of the Krasavino (1880–1725 m), Mezen (1725–1527 m) and Padun (1527–1330 m) formations of the Kotlin Horizon with representative microfossil assemblages (M.B. Burzin, oral communication of 2002).

Geologists of the Timan–Pechora Research Center (town of Ukhta) termed the above formations penetrated by borehole Kel'tminskaya-1 in accord with an earlier stratigraphic scheme elaborated for Upper Precambrian deposits of the Dzhezhim–Parma Uplift in the southern Timan (Tereshko and Kirillin, 1990). In this

Plate I



scheme based on contradictory data (see Gnilovskaya et al., 2000), the pre-Vendian part of the borehole section is divided into three formations. The *Yshkemes Formation* 959 m thick (depth interval 4902–3943 m) is represented by light gray microcrystalline dolostones of microrhythmical structure and by clayey dolostones with thin interlayers of dark-colored siltstone, shale and sandstone. The *Vapol Formation* 1033 m thick (interval 3943–2910 m) is composed of light to greenish gray and brown dolomitized limestones enclosing interlayers of stromatolitic varieties and associated intercalations of dark-colored calcareous shales and siltstones. The *Vychegda Formation* is 598 m thick (interval 2910–2312 m), being composed of alternating sandstones, siltstones and shales above its basal conglomerates. Gray to light gray sandstones are bedded, containing glauconite at several levels. Siltstones calcareous sometimes are mostly greenish to dark gray in color, less frequently green or red-brown. Among shales, there are dark gray, grayish green and red-brown varieties. None of the formations has been studied in isotopic-geochronological or chemostratigraphic aspect, and paleontological materials were restricted by rare stromatolites *Inzeria djejimii* determined by M.E Raaben in the Vapol Formation. This taxon is characteristic of the Minka Horizon of the upper Upper Riphean in the Timan and southern Urals (*Stratotype of the Riphean*, 1982). We detected microfossils of low diversity in the Yshkemes and Vapol formations and a representative and diverse microbiota in the Vychegda Formation.

MATERIALS AND INVESTIGATION METHODS

For microphytological analysis of pre–Upper Vendian deposits recovered by the Kel'tminskaya–1 borehole (depth interval 4825–2347 m), we selected 80 samples of gray and darker-colored shales, siltstones, silty sandstones, and clayey carbonate rocks. Only one of 5 samples selected from the Yshkemes Formation (depth interval 4825–3993 m) yielded microfossils (sampling interval 4825–4820 m). Among 17 samples characterizing the Vapol Formation (depth interval 3687–2961 m), five turned out to be containing microfossils (sampling intervals 3495–3490, 3106–3092, 3049–3044, 3013–3006, and 2968–2961 m). Besides, we studied 58 samples from the Vychegda formation (depth interval 2907–2347 m), and microfossil assemblages were identified in 50 samples from 14 sampling intervals (2907–2900, 2861–2857, 2824–2820, 2799–2792, 2779–2772, 2733–2728, 2692–2685, 2649–2647, 2607–2600, 2559–2556, 2509–2502, 2452–2445, 2401–2394, and 2354–2347 m). Other collected samples either contained unidentifiable small fragments of microfossils, or were completely lacking organic remains. Samples containing microfossils have been considered as characterizing discrete microphytological levels. The most abundant and morphologically diverse microfossils are identified in four sampling intervals of the Vychegda Formation (2907–2900, 2779–2772, 2649–2647, and 2607–2600 m), which are described below as 7th,11th,14th, and15th levels. The less representative assemblages are encountered in six intervals of this formation (2861–2857, 2824–2820, 2799–2792, 2692–2685, 2566–2559, and 2509–2502 m), at the levels 8–10th, 13th, 16th, and 17th. Single specimens of microfossils are determined in the depth range 4825–4820 m of the Yshkemes Formation and in several sampling intervals of the Vapol (3495–3490, 3106–3092, 3049–3044, 3013–3006, and 2968–2961 m) and Vychegda formations (2733–2728, 2452–2445, 2401–2394, and 2354–2347 m), which correspond to 1–6th, 12th, and 18–20th levels. Sampling intervals of 3158–3151, 2799–2792, and 2452–2445 m are lacking dispersed organic matter. Abundant decomposed organic material (sapropelic films) are detected in the intervals of 4390–4385, 3996–3993, 3049–3044, 2968–2961, 2779–2772, 2649–2647, 2607–2600, and 2401–2394 m. In the other intervals, this material is of moderate abundance.

The best-preserved microfossils, which are of the light yellow to light orange color, occur in the Vychegda Formation (depth interval 2900–2354 m) and suggest that their host deposits have not been heated over 80–100°C. In the underlying Yshkemes and Vapol formations, they are brown to dark brown (to black sometimes), implying heating of rocks up to the temperature of 160–180°C (Hayes et al., 1983). The preservation state of studied microfossils can be determined as good in general and as satisfactory in certain cases. Nevertheless, many acritarchs, colonial coccoidal microfossils, filamentous and other forms of intri-

All figured specimens are stored at the Geological Institute, Russian Academy of Sciences, Moscow, collection no. 14700 (ordinary and doubled scale bars correspond to 50 and 100 μm respectively).

Plate I. Microfossils from the Lower Vendian Vychegda Formation, the Vychegda depression near the Timan Ridge, borehole Kel'tminskaya-1.

(1, 2) *Polychedrosphaeridium echinatum* Zang et Walter: (1) two superimposed vesicles; specimen no. 2649-47/001, (1a, 1b, 1c) magnified fragments; (2) specimen no. 2649-47/002, (2a, 2b) magnified fragments. (3) "Unnamed form 3," polygonal vesicle with empty processes arranged regularly and communicating with inner cavity; specimen no. 2649-47/003; (3a, 3b) magnified fragments. (4) "Unnamed form 2," two aggregated vesicles with relatively frequent processes solitary and bifurcate, freely communicating with inner cavity; specimen no. 2649-47/004, (4a) magnified fragment. (5, 6) *Cavaspina acuminata* (Kolosova) emend. Moczydlovska: (5) specimen no.2789-72/001, (6) specimen no. 2649-47/005. (7) *Cavaspina* sp., specimen no. 2649-47/006. (1, 2, 3, 4, 6, 7) microphytological level 14, interval 2649–2647 m, upper Vychegda assemblage of microfossils; (5) microphytological level 11, interval 2779–2772 m, lower Vychegda assemblage of microfossils.

Plate II

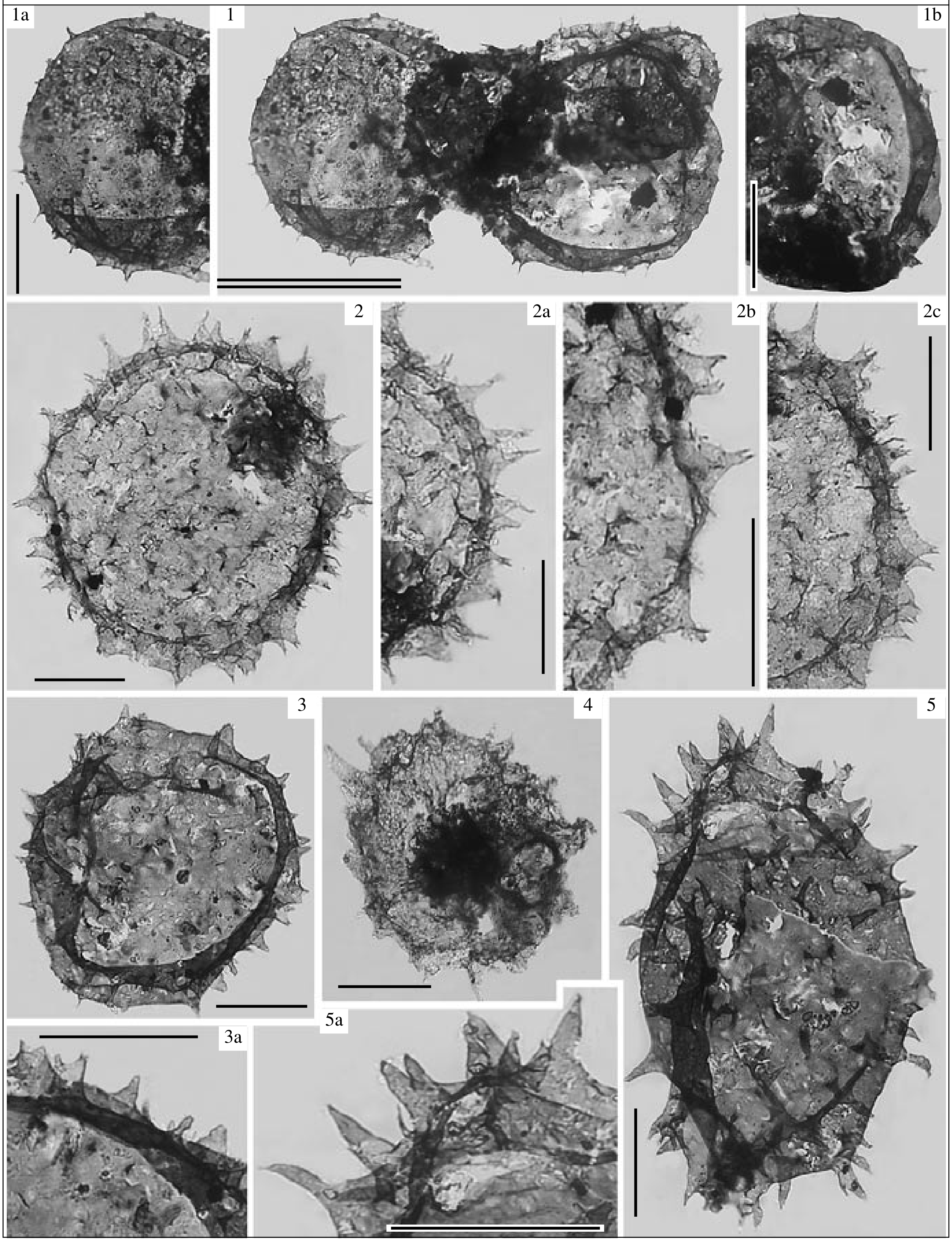


Plate II. Microfossils from the Lower Vendian Vychegda Formation, the Vychegda depression near the Timan Ridge, borehole Kel'tminskaya-1.

(1) *Cavaspina acuminata* (Kolosova) emend. Moczydlovska; specimen no. 2649-47/007, several aggregated vesicles with small rare processes, (1a, 1b) magnified fragments. (2) "Unnamed form 2," spheroidal vesicle with relatively frequent processes solitary and bifurcate, freely communicating with inner cavity, specimen no. 2649-47/008; (2a, 2b, 2c) magnified fragments. (3, 5) *Cavaspina* sp.: (3) specimen no. 2649-47/009, (3a) magnified fragment; (5) specimen no. 2649-47/010, (5a) magnified fragment. (4) *Tanarium* sp., specimen no. 2509–02/001. (1, 2, 3, 5) microphytological level 14, interval 2649–2647 m, upper Vychegda assemblage of microfossils; (4) microphytological level 17, interval 2509–2502 m, upper Vychegda assemblage of microfossils.

cate morphology reveal signs of mineral and/or bacterial destruction.

The laboratory treatment of microfossils from the Kel'tminskaya-1 borehole was performed in accord with methods and procedure described earlier (Veis and Vorob'eva, 1993, 2002). Systematics of the Upper Precambrian microfossils corresponds to taxonomy accepted in other works (Veis et al., 2003, 2004), and acanthomorphic acritarchs are classed with common taxa described in a series of monographs (Zang and Walter, 1992; Zhang et al., 1998; Xunlai and Hofmann, 1998). The most characteristic morphotypes are figured in Plates I–IV.

RESULTS OF MICROPHYTOLOGICAL ANALYSIS

Yshkemes Formation. *Level 1* (interval 4825–4820 m, one sample). Microfossils occurring here are only rare *Leiosphaeridia jacutica* (Tim.)[1] up to 260 μm in diameter and *Germinosphaera tadasii* A. Weiss, the vesicles up to 130 μm across with solitary process. Both morphotypes are opaque and considerably altered.

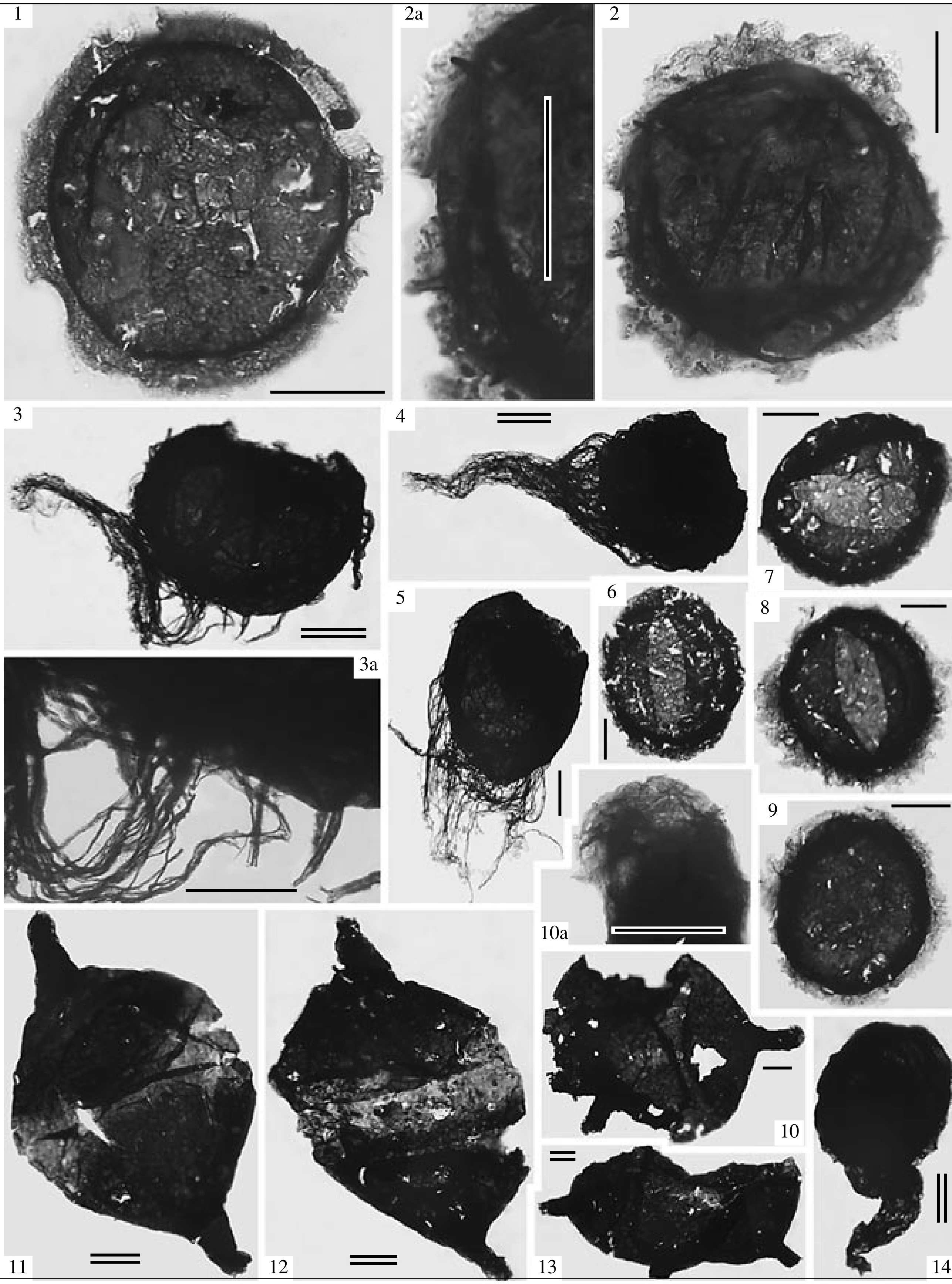
Vapol formation. *Levels 2–6* (intervals 3495–3490, 3106–3092, 3049–3044, 3013–3006, and 2968–2961 m; one sample per each level). Characteristic of these levels are *Chuaria circularis* Walc. and *Navifusa* sp. (up to 2 and 1,5 mm, respectively, in longer dimension), the most remarkable Vapol morphotypes, which occur in association with impoverished sets of acritarchs. In addition, accumulations of structureless taeniate ? thalluses up to 100 μm wide are present at the third, fourth and sixth levels. Dominant among acritarchs are small and medium-sized thickened *Leiosphaeridia crassa* (Naum.) (70–110 μm), *L. jacutica* (Tim.) (up to 240 μm) and *L.* sp. II representing clusters of envelopes (up to 50 μm); ellipsoidal *Konderia elliptica* A. Weiss (up to 500 μm) and spongy *Spumosina rubiginosa* (Andr.) (200–220 μm) are less frequent at the mentioned levels.

Vychegda Formation. *Level 7* (interval 2907–2900 m, three samples) contains one of the most representative microfossil assemblages of the Vychegda Formation. Species encountered here among acritarchs are large *Leiosphaeridia jacutica* (up to 300 μm), *L. incrassatula* Jank. (up to 240 μm), *L. crassa* (up to 70 μm), *L. tenuissima* Eisenack (up to 240 μm), *L.* sp. I corresponding to dividing vesicles (aggregates up to 500 μm in size), clusters of vesicles *L.* sp. II (up to 80 μm each), *Nucellosphaeridium nordium* (Tim.) with inner bodies, *Pterospermopsimorpha pileiformis* Tim., *Simia nerjenica* A. Weiss with peripheral thickening (up to 300 μm), *Spumosina rubiginosa*, ellipsoidal *Navifusa majensis* (Pjat.) (220 × 500 μm), *Cucumiforma vanavaria* Mikh. having longitudinal structural patterns (80 × 280 μm), and giant *Chuaria circularis* (up to 1200 μm). Of special interest are unusual acanthomorphic acritarchs with fascicles of long piliform processes (vesicles up to 400 μm in diameter; processes 1–2 μm thick and hundreds μm long), which occur at this level only and are attributed to "Unnamed form 1". Small colonies of large *Myxococcoides grandis* Horod. et Donalds. (cells up to 36 μm in size) and fragments of extending thalluses *Ostiana microcystis* Herm. (cells 28–30 μm in diameter) are the other morphotypes of the seventh level. Filamentous forms are represented by *Eomycetopsis robusta* Schopf (2–4 μm), *Leiotrichoides typicus* Herm. (8–20 μm), *Asperatofilum experatus* (Herm.) (40–60 μm), *Polytrichoides oligofilum* Sivertz. corresponding to dense fusiform aggregates of fine sheaths (aggregates and sheaths up 60 and 1–2 μm wide respectively), and by elongated *Brevitrichoides baskiricus* Jank. (50–100 × 400 μm). Among less abundant forms, there are *Caudosphaera expansa* Herm. et Tim. (vesicles 300 μm across with long solitary processes), fragments up to hundreds μm in size of very large segmented cuticular structures, cylindrical sheaths *Enthosphaeroides* sp. with dark inclusions (up to 40 μm) and *Leiotrichoides gracilis* Pjat. lacking the latter (20–30 μm), multiserial *Polytrichoides lineatus* Herm. (aggregates and separate sheaths as wide as 40 and up to 4 μm respectively), smooth-walled *Taenitrichoides jaryshevicus* Asseeva (70–90 μm), and *Plicatidium latum* Jank. with fine transverse striation (130 μm). Single morphotypes of the assemblage correspond to diverse septate *Oscillatoriopsis* spp. (12–18 μm), *Elatera binata* Herm. (up to 300 μm), beaded *Trachytrichoides* sp. (20 × 60–100 μm), small akinete-like *Archaeoellipsoides elongates* Golovenok et Belova. (20 × 80 μm), vesicles with short processes *Germinosphaera tadasii* A. Weiss (80 μm), taeniate ?thalluses (80–100 μm), and asymmetric scarious structures (up to 400 μm).

Levels 8–10 (intervals 2861–2857 m, one sample; 2824–2820 m, one sample; 2799–2792 m, two samples). These levels with microfossils of less significant taxonomic diversity contain in abundance only *Chuaria*

[1] We allude to authors of taxa only when the identified morphotype is mentioned first.

Plate III



circularis up tp 1600 μm in diameter (eights level) and *Polytrichoides lineatus* of common size range (ninth level). The other most remarkable morphotypes are single acanthomorphic acritarchs *Cymatiosphaeroides* sp. with small cylindrical processes in a tunicate frill (vesicles up to 180 μm in diameter and processes up to 12 μm long), which are encountered at the eights level. Besides, all or some of the above levels contain transit acritarchs *Leiosphaeridia crassa, L. tenuissima, L. jacutica* (up to 70, 150 and 300 μm respectively), dividing vesicles *L.* sp. I (340–500 μm), *Simla nerjenica* (up to 380 μm), *Spumosina rubiginosa* (up to 220 μm), sheaths *Leiotrichoides gracilis* (22–28 μm) and *Polytrichoides oligofilum* (aggregates and sheaths 60 and 1–2 μm wide respectively), chains of large dolioform cells *Arctacellularia* sp. (100 × 120 μm), filaments with attached vesicles resembling *Vanavarataenia insolita* Pjat. (thalluses up to 2 mm long and 80–120 μm wide; vesicles more than 150 μm in diameter), and structureless taeniate ? thalluses (up to 150 μm wide).

Level 11 (interval 2779–2772 m, nine samples). Abundant size-variable thin- to thick-walled acritarchs discovered at this level are classed with *Leiosphaeridia crassa, L. tenuissima, L. jacutica* (from 30 up to 300 μm in diameter), *Leiosphaeridia incrassatula*, dividing vesicles *L.* sp. I, clusters of vesicles *L.* sp. II (each up to 160 μm in diameter), *Simia nerjenica* (up to 200 μm), very large sphaeromorphic *Chuaria circularis* (up to 1600 μm), *?Cerebrosphaera globosa* (Ogurtz. et Serg.) of lesser size (up to 600 μm), *Nucellosphaeridium nordium* (up to 500 μm), *Spumosina rubiginosa* (up to 250 μm) and *Navifusa majensis* (240 × 480 μm). The most important acritarch morphotypes are single acanthomorphic *Cymatiosphaeroides* sp. with rare narrow conical processes (envelopes up to 270 μm in diameter; processes up to 24 μm high) and *Cavaspina acuminata* Kol. (270 μm across; processes up to 20 μm high). Acritarchs occur in association with smooth-walled filamentous *Asperatofilum experatus* (up to 50 μm wide), elongated *Brevitrichoides bashkiricus* (80 × 400 μm), *Elatera binata* (up to 400 μm), narrower trichome-like morphotypes (120–140 μm wide), vesicles with long processes *Caudosphaera expansa* (from 60 up to 100 μm in diameter; processes more than 200 μm long), asymmetric *Fabiformis porosus* Pjat. (300 × 800 μm), thin branching thallomes ex gr. *Proterocladus* (up to 50 μm wide), and light-colored structureless ? thalluses (up to 100 μm wide).

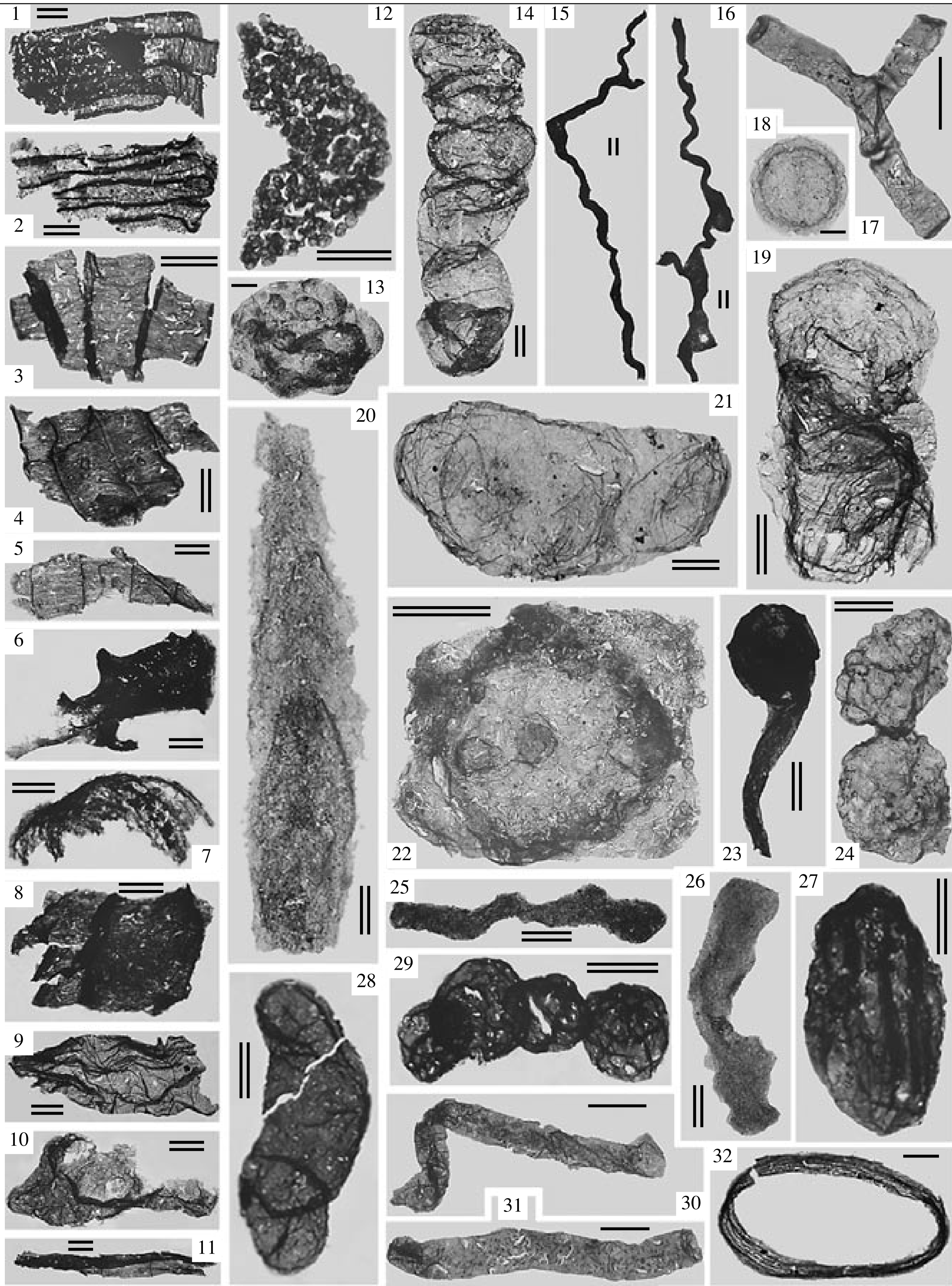
Level 12 (interval 2733–2728 m, two samples) yields an assemblage of microfossils, which is the least diverse in the Vychegda Formation. Microfossils are represented by rare and small thickened acritarchs *Leiosphaeridia crassa* (up to 70 μm), structureless taeniate thalluses (80–100 μm wide), and by "vase-shaped" vesicles with "aperture" (200–270 μm). The latter are similar to largest *Sinianella* forms.

Levels 13 and 15 (interval 2692–2685 m, eight samples; interval 2649–2647 m, two samples; interval 2607–2600 m, seven samples). Acanthomorphic morphotypes of complex structure are important components of microfossil assemblages from these levels. Most abundant among acritarchs are relatively simple medium-sized *Leiosphaeridia crassa, L. atava, L. tenuissima, L. jacutica, L.* sp. I (dividing vesicles), *L.* sp. II (clusters of vesicles), *Simia nerjenica, Spumosina rubiginosa* (all the listed forms are not greater than 300 μm in diameter), larger *Nucellosphaeridium nordium* (up to 380 μm), and *Chuaria circularis* (up to 1400 μm). Ellipsoidal *Navifusa majensis* (200 × 400 μm) and *Navifusa* sp. (500 × 900 μm) are represented by lesser number of specimens. Occasional aggregates or individual vesicles *Cavaspina acuminata* Kol., which have acute narrow-conical empty processes (envelopes up to 160 μm, processes up to 10–12 μm high and up to 4–6 μm) wide near the base), and *Polyhedrosphaeridium echinatum* Zhang et Walter with rare wide-conical processes (up to 250 μm in diameter; processes 30–32 μm high and up to 40 or even 80 μm wide near the base) are most widespread among acanthomorphic acritarchs, being confined to fourteenth level. Somewhat less abundant here are spheroids attributed to "Unnamed form 2," which have rather frequent empty processes (non-branching or bifurcate) freely communicating with inner cavity (up to 280 μm in diameter; processes up to 28 μm high and 20 to 40 μm wide near the base). Rarer microfossils from fourteenth level,

Plate III. Microfossils from the Lower Vendian Vychegda Formation, the Vychegda depression near the Timan Ridge, borehole Kel'tminskaya-1.

(1) *Cymatiosphaeroides kullingii* Knoll emend. Butterfield, vesicle with finest piliform processes set in tunicate frill, specimen no. 2649-47/002. (2) *Cymatiosphaeroides* sp., subspherical vesicle with narrow conical processes set in tunicate frill, specimen no. 2861-57/001, (2a) magnified fragment. (3, 4, 5) "Unnamed form 1," large opaque vesicles with fascicles of long fine piliform processes: (3) specimen no. 2907-00/001, (3a) magnified fragment; (4) specimen no. 2907-00/002; (5) specimen no. 2907-00/003. (6, 7, 8, 9) vesicles with thickened periphery and longitudinal opening – a pylome: (6) specimen no. 2607-2600/1; (7) specimen no. 2607-2600/2; (8) specimen no. 2607-2600/3; (9) specimen no. 2607-2600/4. (10, 11, 12, 13) "Unnamed form 4," ellipsoidal vesicles with large solitary processes at the poles and peculiar central zone (aperture): (10) specimen no. 2692-85/001, (10a) magnified fragment of a process termination; (11) specimen no. 2907-00/002; (12) specimen no. 2692-85/002; (13) specimen no. 2692-85/003. (14) *Caudosphaera expansa* Herm. et Tim., specimen no. 2907-00/004. (1) microphytological level 14, interval 2649–2647, upper Vychegda assemblage of microfossils; (2) microphytological level 8, interval 2861–2857 m, lower Vychegda assemblage of microfossils; (3, 4, 5, 14) microphytological level 7, interval 2907–2900 m; lower Vychegda assemblage of microfossils; (6, 7, 8, 9) microphytological level 15, interval 2607–2600 m, lower Vychegda assemblage of microfossils; (10, 11, 12, 13) microphytological level 13, interval 2692–2685 m, middle Vychegda assemblage of microfossils.

Plate IV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which are provisionally termed as "Unnamed form 3," correspond to polygonal envelopes with large acute empty processes arranged irregularly on the surface (up to 260 μm in diameter; processes 12–25 μm high and 8–30 μm wide in their basal part). At the thirteenth level, we also encountered numerous ellipsoidal envelopes of "Unnamed form 4" with two large polar processes (up to 400 × 800 μm in size; processes up to 100 μm high and 40 μm wide). In addition, levels fourteen and fifteen yield single problematic *Pulvinosphaeridium* aff. *P. antiquum* Paskeviciene, which have broadly rounded empty processes communicating with inner cavity (up to 400 μm in diameter; processes 60 × 120–160 μm in dimensions), and *Asterocapsoides sinensis* Yin et Li. Species *Cymatiosphaeroides kullingii* Knoll with fine piliform processes set in a thin membrane (130 μm in diameter; processes up to 12 μm long and 1–2 μm wide) are detected at the fourteenth level only. At this and fifteenth levels, acanthomorphic morphotypes occur in association with peculiar and abundant small vesicles (diameter 160–200 μm) having thickened spongy periphery and distinct longitudinal opening – a ? pylome.

Besides acritarchs, the levels under consideration contain abundant filamentous sheaths *Asperatefilum experatus* (diameter 40–44 μm), *Polytrichoides lineatus, P. oligofilum* (aggregates up to 40–44 and 60 μm wide respectively; separate sheaths 4 and 1–2 μm wide), vesicles *Caudosphaera expansa* with long processes (up to 500 μm in diameter; processes hundreds μm long), filaments *Vanavarataenia insolita* with attached vesicles (filaments 60–100 μm wide; vesicles100–120 μm in diameter), and asymmetric scarious morphotypes (up to 800 μm across). Less abundant than these are fine filamentous sheaths *Eomycetopsis robusta* (2–4 μm), *Leiotrichoides typicus* (12–18 μm), *Enthosphaeroides* sp. with inner inclusions (up to 80 μm), fine elongated ellipsoidal *Brevitrichoides bashkiricus* (80–100 × 300–400 μm), and structureless taeniate ? thalluses (80–160 μm). Single specimens *Elatera binata, Eosolena anisocyta* Herm. (up to 300 μm wide), cateniform *Arctacellularia* sp. (80 × 100 μm), and spumescent *Fabiformis porosus* (200 × 700 μm) are the rarest components of described microbiota.

Levels 16 and 17 (interval 2559–2556 m, four samples; interval 2509–2502 m, five samples) bear microfossils of a restricted taxonomic diversity. The most remarkable acanthomorphic morphotype *Tanarium* sp. (vesicles up to 140 μm across; processes up to 28 μm high and up to 22 μm wide near the base) was found at the seventeenth level. In addition, both levels contain abundant thin-walled *Leiosphaeridia tenuissima, L. crassa, L. atava, L. jacutica, E. incrassatula*, (vesicles from 70 up to 300 μm in diameter), spongy *Spumosina rubiginosa* (up to 250 μm across), *Chuaria circularis* (1200 μm), broad filamentous sheaths *Leiotrichoides gracilis* (24–28 μm), *Asperatofilum experatus* (40–46 μm), and structureless taeniate ?thalluses (up to 120 μm wide). We also detected here less abundant fusiform aggregates of *Polytrichoides oligofilum* sheaths (up to 50 μm wide), akinete-like *Archaeoellipsoides elongates* (20 × 80 μm), narrow trichomes *Oscillatoriopsis* sp. (12–14 μm), *Elatera binata, Eosolena anisocyta* (up to 160 μm), moniliform *Trachytrichoides* sp. (40 × 120 μm), filamentous *Fabiformis porosus* (300 × 800 μm), and asymmetric scorious morphotypes (up to 600 μm).

Levels 18–20 (interval 2452–2445 m, two samples; interval 2401–2394 m, two samples; interval 2354–2347 m, two samples) contain only single specimens of microfossils. These are small thin-walled and thickened acritarchs *Leiosphaeridia crassa, L. tenuissima, L.* sp. II (all not greater than 150 μm in diameter), small ellipsoidal *Archaeoellipsoides elongates* (20 × 80 μm), and taeniate ? thalluses (60 × 80 μm).

Plate IV. Microfossils from the Lower Vendian Vychegda Formation, the Vychegda depression near the Timan Ridge, borehole Kel'tminskaya-1.

(1, 2, 3, 4, 5, 6, 8, 9, 10, 11) fragments of large cuticular *Parmia*-like structures: (1) specimen no. 2907-00/002; (2) specimen no. 2907-00/003; (3) specimen no. 2907-00/004; (4) specimen no. 2907-00/005; (5) specimen no. 2907-00/006; (6) specimen no. 2647-49/012; (7) specimen no. 2907-00/007; (8) specimen no. no. 2907-00/008; (9) specimen no. no. 2907-00/009; (10) specimen no. 2647-49/013; (11) specimen no. 2907-00/010. (12) *Ostiana microcystis* Herm., specimen no. 2907-00/011. (13) vesicle with large hemispherical processes, specimen no. 2607-00/005. (14) *Eosolena anisocyta* Herm.; specimen no. no. 2861-57/002. (15, 16) branching thalluses ex gr. *Proterocladus*: (15) specimen no.2649-47/014; (16) specimen no. 2649-47/015. (17) *Stiganema*-like branching sheath, specimen no. 2649-47/016. (18) *Simla nerjenica* A. Weiss, specimen no. 2649-47/017. (19) *Elatera binata* Herm., specimen no. 2647-49/018. (20) multiserial sheath, specimen no. 2649-47/019. (21) *Navifusa majensis* (Pjat.), specimen no. 2649-47/020. (22) *Pulvinosphaeridium* aff. *P. antiquum* Paskeviciene, specimen no. 2647-49/021. (23) *Caudosphaera expansa* Herm. et Tim., specimen no. 2907-00/012. (24) two aggregated vesicles with numerous hemispherical processes (tubercles), specimen no. 2779-72/002. (25, 26) *Fabiformis porosus* Pjat.: (25) specimen no. 2649-47/022; (26) specimen no. 2607-00/006. (27) *Cucumiforma vanavaria* Mikh., specimen no. 2907-00/013. (28) *Brevitrichoides baskiricus* Jank., specimen no. 2647-49/023. (29) *Leiosphaeridia* sp. II, clusters of vesicles, specimen no. 2649-47/024. (30, 31) *Leiotrichoides gracilis* Pjat.: (30) specimen no. 2907-00/014; (31) specimen no. 2907-00/015. (32) annular fragment of an organism of unknown morphology, specimen no. 2824-20/001. (1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 23, 27, 30, 31) microphytological level 7, interval 2907–2900 m; lower Vychegda assemblage of microfossils; (6, 10, 15, 16, 17, 18, 19, 20, 21, 22, 25, 28, 29) microphytological level 14, interval 2649–2647 m, upper Vychegda assemblage of microfossils; (13, 26) microphytological level 15, interval 2607–2600 m, upper Vychegda assemblage of microfossils; (14) microphytological level 8, interval 2861–2857 m, lower Vychegda assemblage of microfossils; (24) microphytological level 11, interval 2779–2772 m, lower Vychegda assemblage of microfossils; (32) microphytological level 9, interval 2824–2820 m; lower Vychegda assemblage of microfossils.

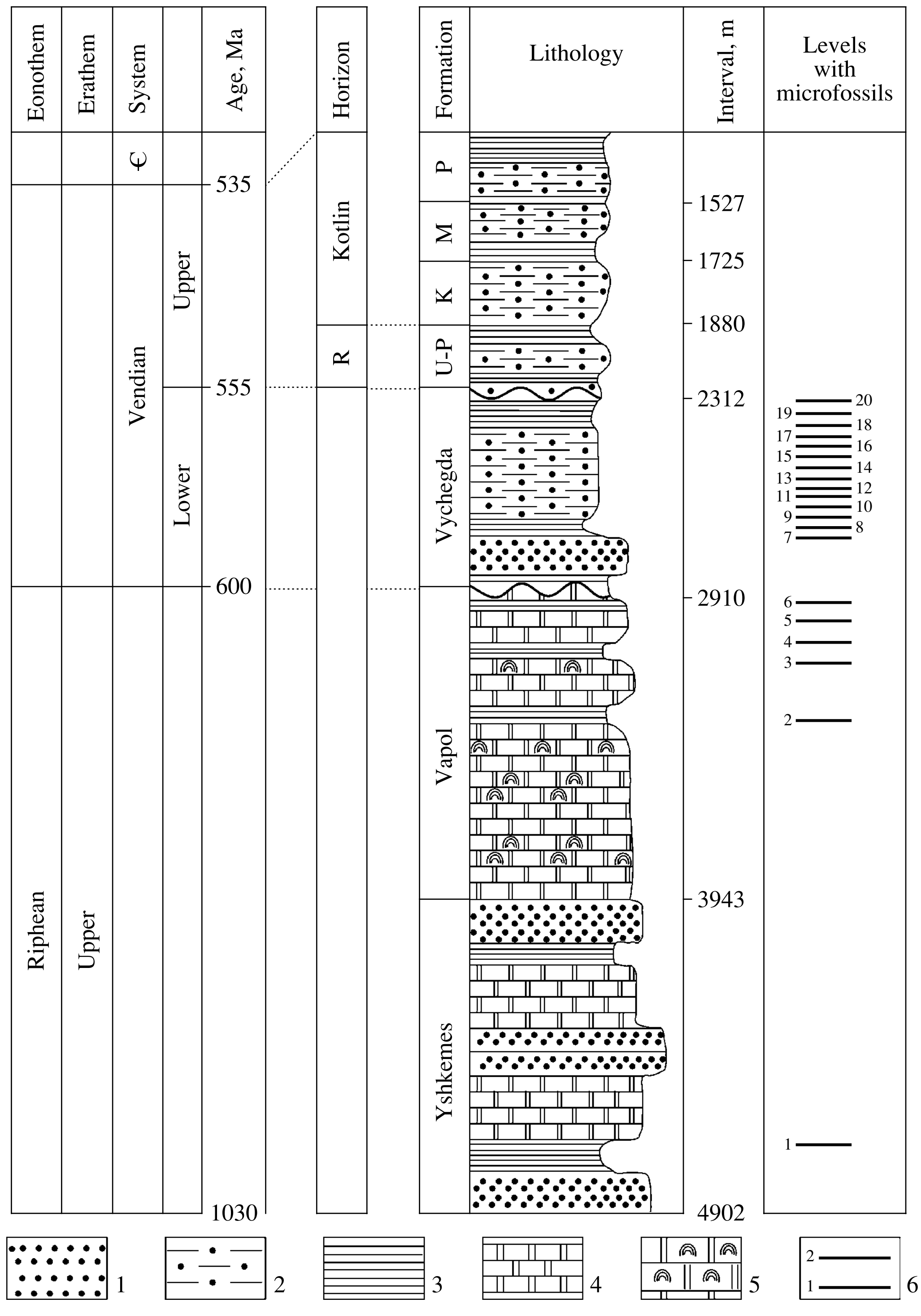


Fig. 2. Lithostratigraphy of Riphean–Vendian deposits in the Vychegda depression, core section Kel'tminskaya-1: (1) sandstone, gravelstone; (2) siltstone; (3) shale; (4) dolostone, limestone; (5) stromatolitic dolostone or limestone; (6) microphytological levels. Abbreviations: (U-P) Ust-Padun; (K) Krasavino; (M) Mezen; (P) Padun; (R) Redkino (age values are quoted from *Addenda to Stratigraphic Code of Russia*, 2000).

DISCUSSION

Biostratigraphic analysis. The results obtained in the course of comprehensive microphytological study of pre-Redkino deposits recovered by the Kel'tminskaya–1 borehole (interval 4902–2312 m; Fig. 2) are as follows.

In the Yshkemes, Vapol and Vychegda formations, microfossils are found at twenty microphytological levels (Fig. 3): one in the Yshkemes Formation (interval 4825–4820 m), five in the Vapol Formation (interval 3495–2961 m), and fourteen in the Vychegda Formation (interval 2907–2347 m). The complete list of taxa identified among microfossils and their distribution in the Kel'tminskaya–1 core section are shown in Fig. 3; most characteristic morphotypes are figured in Plates I–IV. Microfossils devoid of biostratigraphic value, which belong to genera *Leiosphaeridia, Germinosphaera, Spumosina, Konderia, Navifusa, Nucellosphaeridium, Pterospermopsimorpha, Myxococcoides, Eomycetopsis, Leiotrichoides, Enthosphaeroides*, and *Oscillatoriopsis*, are excluded from further consideration.

Less abundant forms of more intricate morphology are distributed through the Kel'tminskaya-1 section in a certain succession. Accordingly, all the microfossils can be divided into four assemblages of different taxonomic composition, which replace one another upward in the section. Microfossils of the Yshkemes and Vapol formations represent one uniform assemblage (levels first to sixth; depth interval 4825–2961 m), while in the Vychegda Formation they are divisible into three different assemblages: the lower (levels seven to twelve; interval 2907–2728 m), middle (level thirteen; interval 2692–2685 m), and upper ones (levels fourteen to twenty; 2649–2347 m). Let us consider principal characteristics of these assemblages.

The Yshkemes–Vapol assemblage consists predominantly of the Upper Precambrian transit microfossils, which do not deserve consideration in this work. A specific feature of this assemblage unobservable higher in the section is joint occurrence of giant *Chuaria circularis* and *Navufusa* sp. (up to 2 mm) in association with characteristic *Konderia elliptica* and *Germinosphaera tadassii.* According to biostratigraphic model of Precambrian microbiota evolution and successions of microfossils in the Riphean reference sections of the southern Urals and Siberia, the lower distribution limit of the above morphotypes' combination is frequently assumed to be corresponding to the Upper Riphean (Karatavian) base. As giant sphaeromorphids of the *Chuaria* type are described, however, from the Lower Riphean and even pre-Riphean deposits, they are interpreted in the aforementioned model as problematic forms, or stratigraphic position of their host deposits is doubted (Veis et al., 1998a, 1998b, 1999, 2000, 2001, 2003; Veis and Vorob'eva, 2002).

Turning now to characterization of three Vychegda assemblages, we should mention first that they are quite similar to each other in taxonomic composition of their dominant morphotypes. All three assemblages include *Chuaria circularis, Spumosina rubiginosa, Asperatofilum experatus, Polytrichoides oligofilum, Brevitrichoides baskiricus, Simia nerjenica, Navifusa majensis, Polytrichoides lineatus, Elatera binata, Eosolena anisocyta, Arctacellularia* sp., *Trachytrichoides* sp., *Fabiformis porosus, Caudosphaera expansa, Vanavarataenia insolita*, and *Parmia*-like cuticular structures. All or nearly all the taxa listed above are components of microbiotas occurring at different levels of the Karatavian (Upper Riphean) succession (*Microfossils of the Precambrian…*, 1989; Butterfield et al., 1994; Butterfield and Rainbird, 1998; Veis et al., 2000, 2003, 2004; Sergeev, 2003), and some of them (*Chuaria, Spumosina, Navifusa, Polytrichoides, Arctacellularia, Trachytrichoides*) transit into the Upper Vendian (Burzin, 1994, 1999). Consequently, the Late Precambrian microbiota from the Kel'tminskaya-1 borehole is largely of successive character in the general taxonomic aspect. That is why the main attention is paid below to those morphotypes, which determine taxonomic individualism of three microfossil assemblages from the Vychegda Formation.

The lower Vychegda assemblage is peculiar owing to abundant large vesicles "Unnamed form 1," which appear at its lower (seventh) level. Other acanthomorphic acritarchs of this assemblage are represented by *Cymatiosphaeroides* sp. with cylindrical processes set in tunicate frill and *Cavaspina acuminata* with narrow conical processes; these forms appear at the eighth and eleventh levels respectively. Besides acanthomorphic morphotypes, only this assemblage includes *Cucumiforma vanavaria, Ostiana microcystis, Myxococcoides grandis, Taenitrichoides jaryshevicus, Plicatidium latum*, which appear at the seventh level, as well as branching thalluses ex gr. *Proterocladus*, and vase-shaped vesicles *?Sinianella* with an "aperture," which are detected at the eleventh and twelfth levels respectively.

In *the middle Vychegda assemblage*, the most remarkable components are abundant elongated vesicles with two large processes at their poles ("Unnamed form 4"), which appear at the thirteenth level. The assemblage lacking the other distinctive morphotypes is mostly represented by *Chuaria, Spumosina, Brevitrichoides, Asperathofilum, Polytrichoides*, and other taxa, which are transit for all the Vychegda assemblages and within the greater interval of the Upper Riphean–Vendian succession.

The upper Vychegda assemblage includes the greatest number of components specific of its composition. These are abundant acanthomorphic acritarchs *Cymatiosphaeroides, Polyhedrosphaeridium echinantum*, "Unnamed form 2" (vesicles with solitary and bifurcate processes), "Unnamed form 3" (polygonal vesicles with empty processes arranged irregularly, level fourteen), *Asterocapsoides sinensis, Pulvinosphaeridium* aff. *P. antuquum* (levels fourteen and fifteen), *Tanarium* sp. (level seventeen), and very peculiar abundant small vesicles with thickened periphery and distinct rimmed opening – a "pylome" that likely appears in these forms at the later stages of their individual development (levels fourteen and fifteen). Similarly remarkable is *Cavaspina acuminata* inherited from the lower Vychegda assemblage (level fourteen).

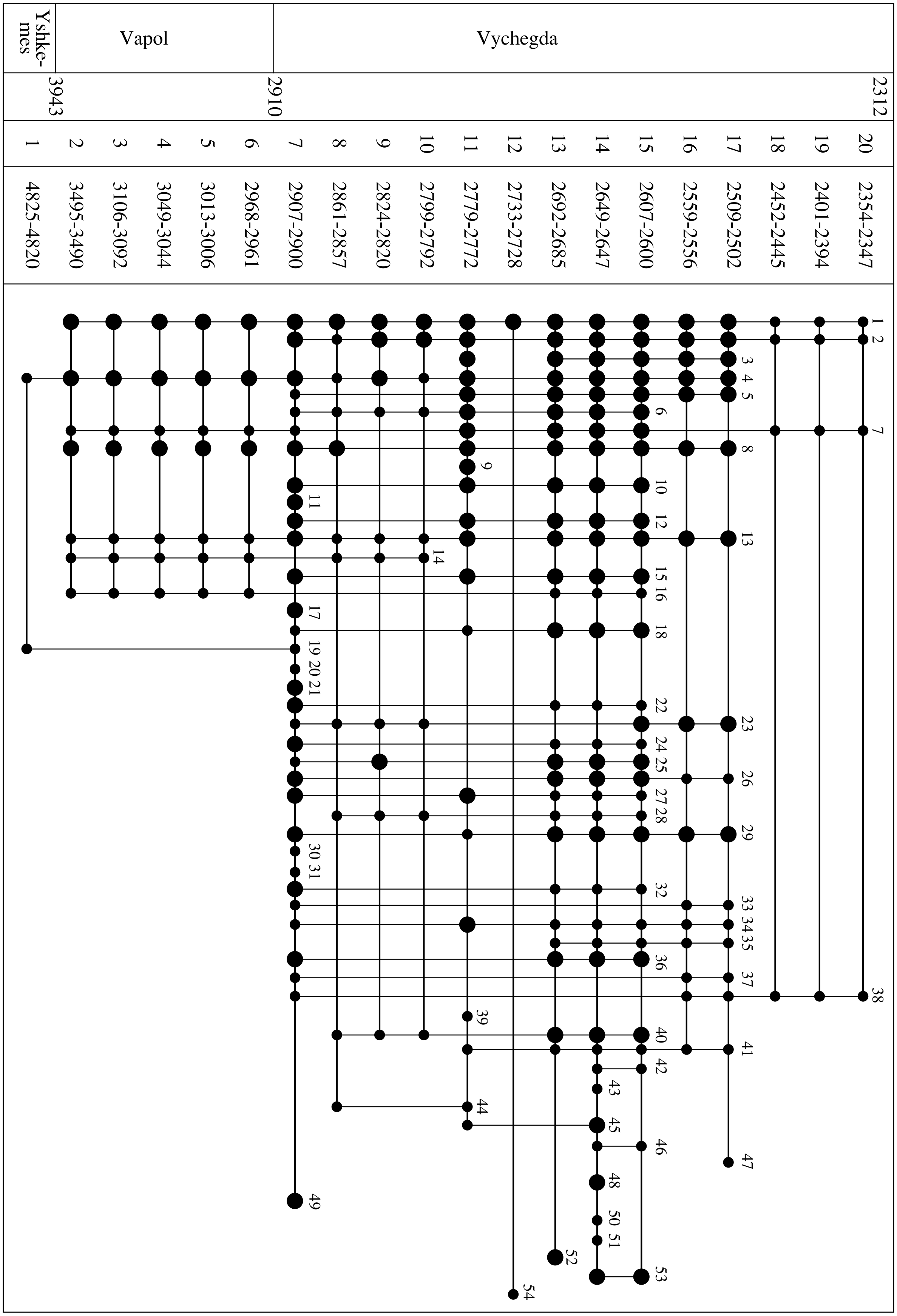
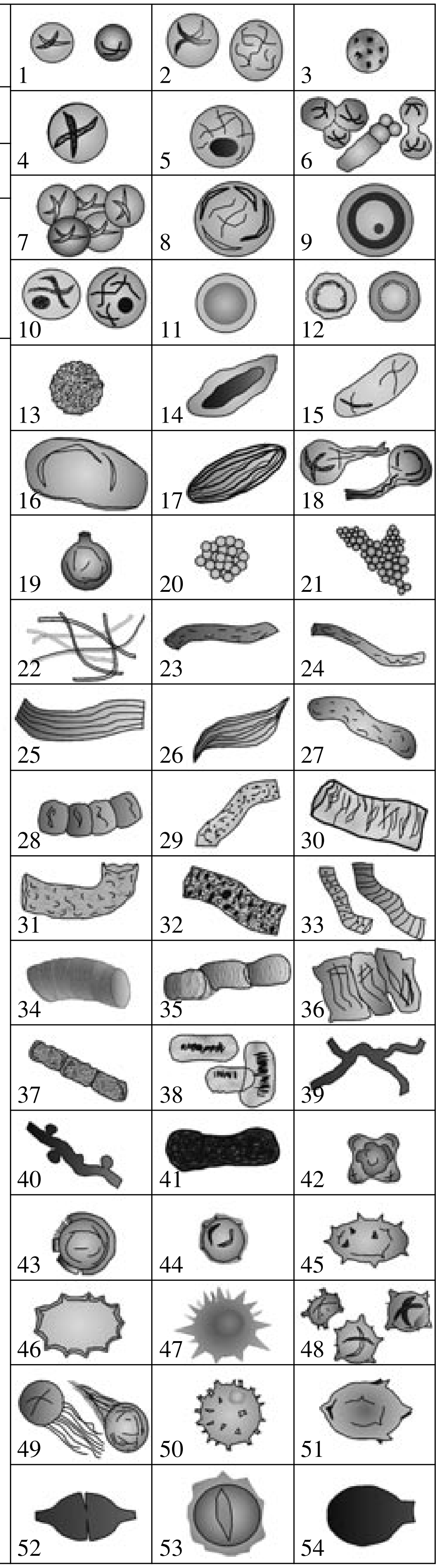


Fig. 3. Distribution of microfossil genera and species in the Riphean–Vendian succession recovered by borehole Kel'tminskaya-1.

Formation
Depth, m
Microphytological level
Sampling interval, m

Microfossils

1. *Leiosphaeridia crassa* (Naum.)
2. *L. tenuissima* Eisenack
3. *L. atava* (Naum.)
4. *L. jacutica* (Tim.)
5. *L. incrassatula* Jank.
6. *L.* sp. I – dividing vesicles
7. *L.* sp. II – clusters of vesicles
8. *Chuaria circularis* Walcott
9. ?*Cerebrosphaera globosa* Butterfield
10. *Nucellosphaeridium nordium* (Tim.)
11. *Pterospermopsimorpha pileiformis* Tim.
12. *Simia nerjenica* A.Weiss
13. *Spumosina rubigin osa* (Andreeva)
14. *Konderia elliptica* A. Weiss
15. *Navifusa majensis* (Pjat.)
16. *N.* sp. – giant forms
17. *Cucumiforma vanavaria* Mikh.
18. *Caudosphaera expansa* Herm. et Tim.
19. *Germinosphaera tadasii* A.Weiss
20. *Myxococcoides grandis* Horod. et Donalds.
21. *Ostiana microcystis* Herm.
22. *Eomycetopsis robusta* Schopf emend. Knoll, Golubic
23. *Leiotrichoides gracilis* Pjat.
24. *L. typicus* Herm. emend. Herm.
25. *Polytrichoides lineatus* Herm. emend. Herm.
26. *P. oligofilum* Sivertz.
27. *Brevitrichoides baskiricus* Jank.
28. *Arctacellularia* sp.
29. *Asperatofilum experatus* (Herm.)
30. *Plicatidium latum* Jank.
31. *Taenitrichoides jaryshevicus* Asseeva
32. *Enthosphaeroides* sp.
33. *Oscillatoriopsis* sp.
34. *Elatera binata* Herm.
35. *Eosolena anisocyta* Herm.
36. *Parmia* – like structures
37. *Trachytrichoides* sp.
38. *Archaeoellipsoides elongatus* (Golovenok et Belova)
39. Branching ex gr. *Proterocladus*
40. *Vanavarataenia insolita* Pjat.
41. *Fabiformis porosus* Pjat.
42. *Pulvinosphaeridium* aff. P. antiquum *Paskeviciene*
43. *Cymatiosphaeroides kullingii* Knoll
44. *Cymatiosphaeroides* sp.
45. *Cavaspina acuminata* (Kolosova)
46. *Asterocapsoides sinensis* Yin et Li
47. *Tanarium* sp.
48. *Polyhedrosphaeridium echinatum* Zang er Walter
49. Unnamed form 1
50. Unnamed form 2
51. Unnamed form 3
52. Unnamed form 4
53. Form with distinct rimmed opening – a “pylome”
54. “*Sinianella*”-like form



Analyzing age significance of the Vychegda microfossil assemblages, we should proceed from the upper level downward in the succession beginning from the Upper Vendian horizons confidently dated by biostratigraphic evidence. In pre-Paleozoic deposits of the upper structural stage penetrated by boreholes 1-Storozhevskaya and 1-Seregovskaya, there are established trace fossils *Palaeopascichnus delicatus, Planolites* aff. *serpens (=P. ballandus)* and impressions of small medusoids *Nimiana* sp. (Olovyanishnikov, 1998, and references therein), which are characteristic of the Redkino and/or Kotlin horizons in the Podol area near the Dniester River and in the Zimnie Gory coastal area of the White Sea and Onega Peninsula (*The Vendian System*, 1985; Fedonkin, 1987). It is remarkable as well that both boreholes penetrated the marker lithostratigraphic member of pink and gray feldspar-quartz sandstones at the base of aforementioned structural stage, which are similar to basal sandstones of the Pletnevka Formation, the lower one in the Redkino Horizon of the Moscow syneclise. The above paleontological and lithostratigraphic data imply that basal horizons of the upper structural stage in the Vychegda depression are correlative with basal beds of the Upper Vendian Redkino Horizon in adjacent areas of the East European platform (Olovyanishnikov, 1998). In addition, M.B. Burzin (oral communication) established in that structural stage penetrated by the Kel'tminskaya-1 borehole a succession of microfossil assemblages characteristic of the Ust-Pinega (Redkino Horizon), Krasavino, Mezen, and Padun (Kotlin Horizon) formations. Thus, we can state surely that the base of the Upper Vendian Redkino Horizon corresponds to the upper distribution limit of the Vychegda microbiota.

The lower distribution limit of this microbiota can be determined less confidently based on regional data. M.E. Raaben who studied stromatolites recovered by the Kel'tminskaya-1 borehole below the Vychegda Formation from the lower and middle Vapol strata classed them with *Inzeria djejimi* and *Poludia polymorpha* respectively. Both taxa are components of stromatolite assemblages known from discrete regional biostratigraphic subdivisions, the beds with particular assemblages of organic remains (Raaben and Oparenkova, 1997). The beds containing these stromatolite form species and associated organic remains are traceable from the southern Urals to the Kanin Peninsula, being confined to the middle part of the Min'yar Formation in the Upper Riphean (Karatavian) type sections of the southern Urals. The Pb–Pb isochron age of this interval in the Karatavian succession corresponds to 780 ± 85 Ma (Ovchinnikova et al., 2000).

The inferable age range of the lower–middle Vapol deposits is consistent with recent data on Riphean microfossils from an area of the Mezen syneclise adjacent to the Vychegda depression (Veis et al., 2004). The borehole Sredne-Nyaftinskaya 21 drilled here recovered a succession of four representative microbiotas: one confined to the Vashka Formation of the Middle Riphean and three others characteristic of the Peza, Leshukonskoe, and Nyafta formations of the Upper Riphean. The last two microbiotas include all the components of the Yshkemes and Vapol assemblages (giant *Chuaria* and *Navifusa* included) and contain as well the acanthomorphic *Trachyhystrichosphaera, Prolatoforma*, and other morphotypes of a complex structure. A comparison of the Leshukonskoe and Nyafta microbiotas with the well-known microbiotas from the Urals and Siberia sowed that they consist of taxa characteristic of the middle Upper Riphean, as is suggested by Veis et al. (2004). In view of taxonomic similarity between the Leshukonskoe–Nyafta and Yshkemes–Vapol microfossil assemblages, the last conclusion appears to be admissible as well for the Vychegda microbiota from the borehole Kel'tminskaya-1.

Consequently, the Vychegda formation that contains microfossils considered in this work rests discordantly on the middle Upper Riphean deposits, being overlain above the eroded top surface by the Upper Vendian strata. Based on taxonomic composition of the Vychegda microbiota, we can determine precisely its stratigraphic position in the post-Karatavian pre-Upper Vendian succession.

Leaving aside microfossils of a simple structure, we should note that remarkable morphotypes of the Vychegda microbiota, such as ex gr. *Chuaria circularis, Navifusa majensis, Ostiana microcystis, Polytrichoides lineatus, Plicatidium latum*, and *Caudosphaera expansa*, are widespread in the Upper Riphean and transit sometimes up to the Upper Vendian (Veis et al., 2000, 2003; Burzin, 1994, 1998, 1999). Besides, *Chuaria, Navifusa (Tawuia)*, and similar forms are known from the Lower Riphean and even pre-Riphean deposits, being therefore of no significance for the precise positioning of this microbiota in the general succession of Late Precambrian microfossils. Much more important in biostratigraphic aspect are acanthomorphic acritarchs *Polychedrosphaeridium, Asterocapsoides, Cavaspina, Tanarium., Cymatiosphaeroides*, and new, still unidentified forms of three Vychergda assemblages, which occur at the microphytological levels 7, 8, 11, 13–15, and 17 (Fig. 3). This assemblage of taxa has been unknown so far from the Upper Riphean sections well-studied in microphytological aspect (Knoll, 2000). This fact and the estimated upper age limit of the Vychegda Formation imply that this formation and its microbiota belong to the Lower Vendian.

Until present, microphytology of the Lower Vendian deposits in the East European platform was known to a limited extent. As it had been concluded (*Microfossils of the Precambrian…*, 1989), microbiota characteristic of these deposits is represented mostly by simple transit taxa occurring throughout the Upper Precambrian (*Leiosphaeridia crassa, Myxococcoides grandis, Eomycetopsis robusta*, and others). A little more representative are the Sergeevka microbiota from the Lower

Vendian Baikibashevo Formation of the Volga–Ural region (Yankauskas, 1980) or the Tolparovo and Suirovo microbiotas from synonymous formations of the southern Urals (Keller and Yankauskas, 1980; Mikhailova and Podkovyrov, 1992). Nevertheless, characteristic "younger" taxa associated with dominant transit forms in the mentioned microbiotas are represented only by small acritarchs of genera *?Baltisphaeridium* and *Retiforma*, and by filamentous sheaths *Pomoria* with rhomboidal ornamentation at their surface.

Three successive assemblages of the Vychegda microbiota are distinguished based on those morphotypes, which are of a limited stratigraphic range and occur at one or several conjugate microphytological levels. These are large acanthomorphic acritarchs *Cavaspina, Polyhedrosphaeridium, Cymatiosphaeroides, Asterocapsoides, Tanarium*, new morphotypes, which have not been described so far, and peculiar vesicles with a rimmed "pylome." The above acritarch genera are characteristic of several microbiotas studied in Europe, Asia, and Australia (Knoll, 2000, and references therein). Most representative among them are microbiotas from the Perthatataka Formation of Central Australia (Zang and Walter, 1992), from the Doushantou Formation of South China (Zhang et al, 1998; Xuinlai and Hofmann, 1998), from the Scotia Group of Spitsbergen (Knoll, 1992), from the Infracrol Formation of the Lesser Himalayas (Tiwari and Knoll, 1994), and from an upper part of the Nepa Horizon in inner areas of the Siberian platform (Pyatiletov and Rudavskaya, 1985; Kolosova, 1991; Moczydlowska et al., 1995). In publications, they are known as microbiotas of the Perthatataka type (Moczydlowska, 2005). Being of a close taxonomic composition, these microbiotas occur at comparable stratigraphic levels in regional successions above tillites (commonly with transgressive overlap) of the Laplandian (Varangerian) Glaciohorizon or correlative deposits and below beds containing the earliest Ediacaran fossils or concurrent strata (Knoll, 2000; Burzin and Kuzmenko, 2000). Because of specific composition and clear stratigraphic position, microbiotas of the Perthatataka type are considered in the composite succession of five Late Riphean–Early Cambrian acritarch zones as typical of the discriminated "Complex Zone III" spanning the age range of 585–570 Ma (Knoll and Walter, 1992; Grey, 1998; Knoll, 2000). Affiliation of the Vychegda microbiota with microbiotas of the Perthatataka type is evident from several common taxa of acanthomorphic microfossils. These are genera *Asterocapsoides* and *Cavaspina (Goniosphaeridium)* known from the Doushantou Formation, *Cavaspina (Goniosphaeridium), Polyhedrosphaeridium* and *Cymatiosphaeridium* from the Perthatataka Formation, *Asterocapsoides* from the Scotia and Infrakrol formations, *Cavaspina* and *Tanarium* (*Goniosphaeridium*) from the Nepa Horizon.

It is impossible at present to analyze comprehensively the facies-ecologic habitat environment of microorganisms and/or conditions of their burial in the Yshkemes–Vychegda basin, because the Kel'tminskaya-1 core section has not been subjected to special sedimentological study. Following the paleoecologic interpretation of Riphean microbiotas from the Urals and Siberia (Veis and Petrov, 1994; Petrov and Veis, 1995), we consider nevertheless the acanthomorphic acritarchs, large morphotypes and/or other microfossils of complex morphology, which belong to representative assemblages from the Vychegda formation, as most characteristic components of the medium-deep facies-ecologic groupings of Riphean microorganisms.

CONCLUSIONS

1. The comprehensive biostratigraphic analysis of microphytological data on the borehole Kel'tminskaya-1 revealed four successive microfossil assemblages: one of the Upper Riphean (contained in the Yshkemes and Vapol formations) and three of the lower Vendian (contained in the Vychegda Formation).

2. The studied microfossils from Upper Precambrian deposits of the Vychegda depression near the Timan elucidate microphytological characterization of Lower Vendian deposits in the East European platform, enhance understanding of Upper Riphean microbiotas occurring in this vast region, and enable chronostratigraphic and chronometric interpretation of distinguishable microfossil assemblages.

3. An important objective in the future is to analyze distribution of microfossils in the other key sections of the study region (boreholes Seregovskaya-1, Storozhevskaya-1, and others planned to be drilled). This is necessary for elaboration of a unified age interpretation of successive microfossil assemblages from Riphean–Vendian deposits of the Mezen syneclise and other areas of the East European platform.

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