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New Species of Schwagerinids (Foraminifera, Schwagerinida) from the Carboniferous-Permian of the Fore-Urals (Perm Region)

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Abstract—Four new species of schwagerinids are described from the Carboniferous-Permian of the Fore-Urals (Perm Region): *Rugosofusulina larga, R. gubakhica* (Rugosofusulinidae), *Sphaeroschwagerina visherensis* (Pseudoschwagerinidae), and *Anderssonites ognevae* (Pseudofusulinidae).

INTRODUCTION

This paper continues the author's study of the taxonomic diversity of fusulinids in the Upper Carboniferous–Lower Permian beds of the Fore-Urals (Perm Region) (Vilesov, 1997; 1998). The description of new species is based on collections of oriented thin sections of schwagerinids from four Fore-Urals sections, i.e., the Kholodny Log, Ostanets, Akchim, and Kamen Stolby sections. The Kholodny Log Section is on the right bank of the Kosva River 5 km upstream from the Gubakha train station. The section includes carbonate rocks from the Kasimovian of the Upper Carboniferous to the upper Asselian of the Lower Permian. Bluffs composed of Asselian limestones are as high as 100 m. The bed-by-bed description of the Permian part of the section was performed by Echlakov and Zolotova (1986). The latter paper describes, in addition, the Carboniferous-Permian beds in the Kamen Stolby Section (on the right bank of the Beryozovaya River 9 km upstream from the small town of Vizhai). The Ostanets Section lies on the left bank of the Kosva River against the Kholodny Log Section and represents a sequence of small bedrock outcrops composed of upper Gzhelian and lower Asselian limestones. A thorough description of this section was carried out by Shcherbakova (1986). The Akchim Section lies on the Vishera River upstream of the small town Akchim and includes limestone and dolomite bluffs on both banks of the river. The section includes outcrops of rocks from the Viséan of the Lower Carboniferous to upper Asselian of the Lower Permian. The overall length of the section is about 4 km. The description of the Lower Permian part of the section is given in Rakshin *et al.* (1974). Sampling localities of type material for new schwagerinid species are numbered according to these descriptions.

MATERIAL

The entire type material is in the repository of the Polenov Museum of Paleontology and Historical Geology of the Department of Regional Geology, Perm State University (PGU).

SYSTEMATIC PALEONTOLOGY

Order Schwagerinida Solovieva, 1985

Family Rugosofusulinidae Davydov, 1980

Genus *Rugosofusulina* Rauser, 1937

***Rugosofusulina larga* Vilesov, sp. nov.**

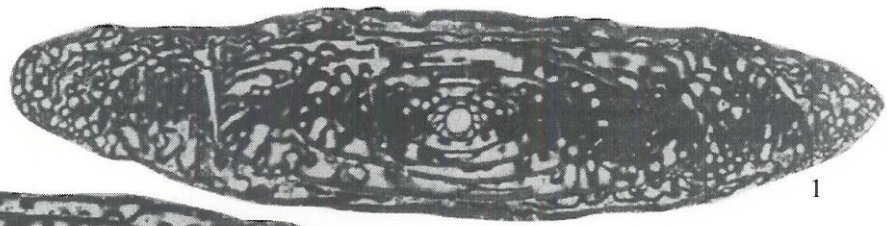
Plate 3, figs. 1 and 2

Etymology. From Latin *largus* (large).

Holotype. PGU, Kholodny Log collection, no. 3182; Perm Region, Kosva River, Kholodny Log Section (outcrop 22, bed 5); Lower Permian, Asselian, *Sphaeroschwagerina vulgaris–S. fusiformis* Zone.

Description. The test is elongated, subcylindrical with blunted and widely-rounded axial ends. The proloculus is spherical and large. The test elongation increases with volutions: the first volution is short-fusiform, the second is fusiform, the subsequent are subcylindrical. The last volution shows a maximum increase in elongation: the test is elongated-subcylindrical. The test coiling is regular and relatively free; the coiling index ranges from 1.0 to 1.6. The wall tectum is rugose. The wall of the last volutions is wavy. The wall thickness uniformly increases with volutions and attains its maximum (120 μm) in the last volution. Except for the axial ends, where the wall thickness appreciably decreases, the thickness remains virtually unchanged. Septa are thinner than the wall. The septal fluting is irregular. Within the first five volutions, the fluting is faint to moderate and usually covers the lateral and axial parts of the test; within the medial part of the test, the septal fluting is very poor. Plicae are usually swollen at the top and vary in height and shape: broad circular, trapezoidal, or mushroom-shaped. In the first five volutions, the axial meshworks are large-meshed. In axial ends of the last volution, the well-defined septal fluting forms broad fine-meshed axial meshworks.

Plate 3



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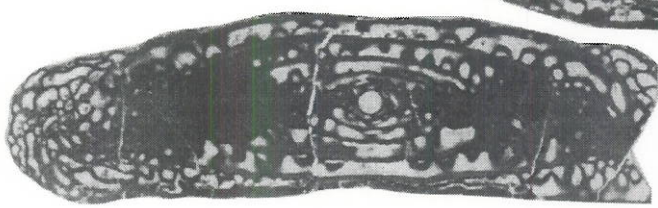

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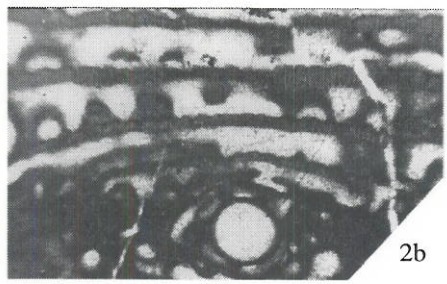

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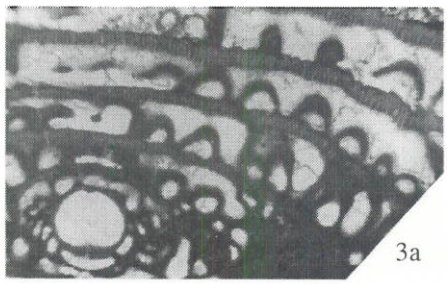

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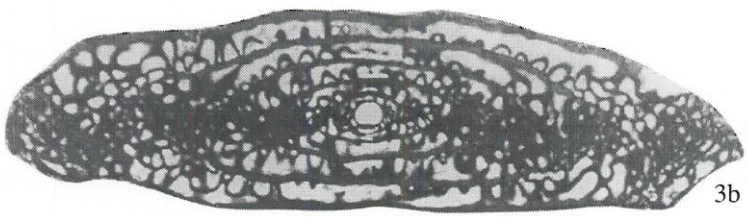

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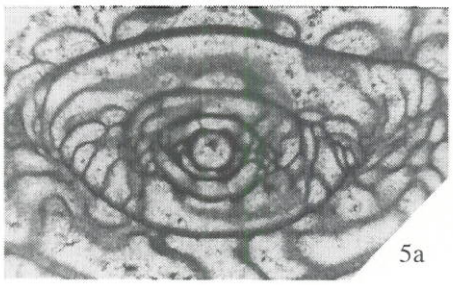

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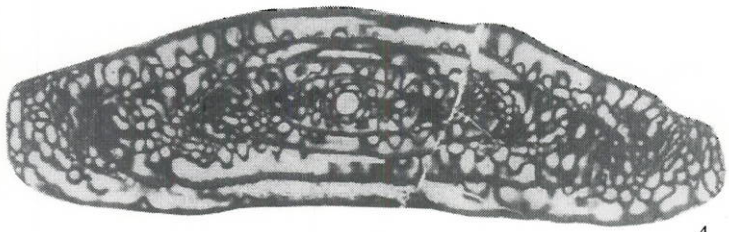

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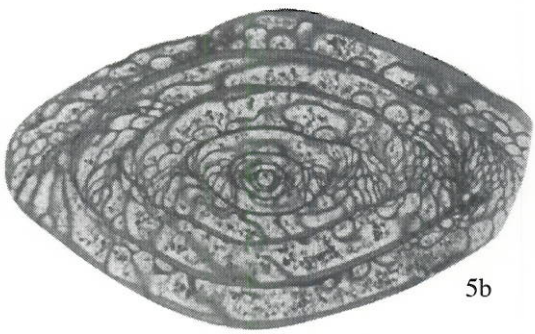

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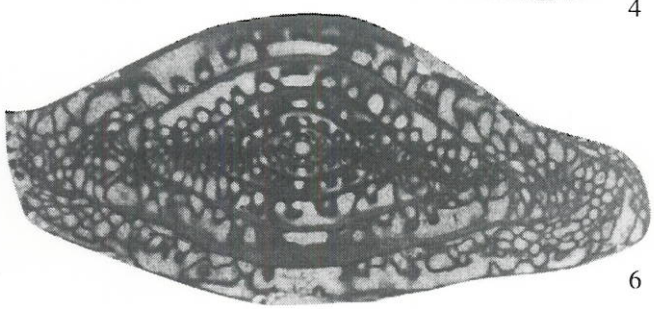

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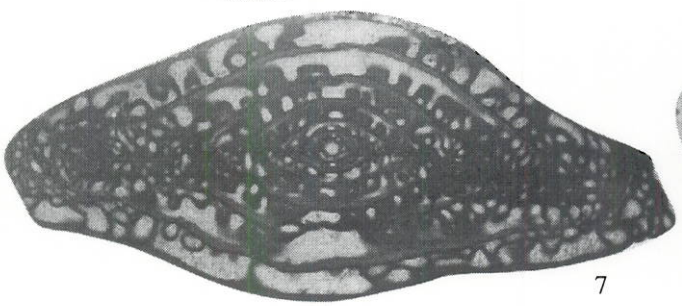

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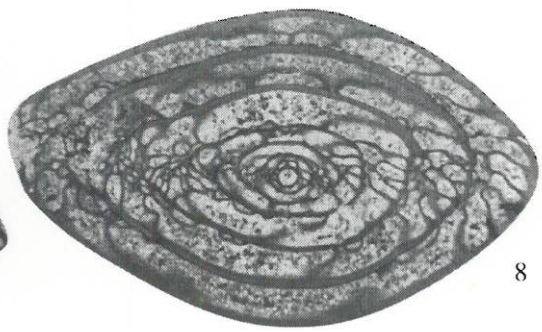

8

Axial meshworks are broad (usually cover all the volutions except for the last), discontinuous to massive. The aperture is slit-like, of medium height (half as high as the corresponding volution), broad, and gradually widens with volutions. The proloculus forms small chomata. The first through to the third or fourth volutions contain small hooked-shaped pseudochomata.

Measurements. L = 6.19–8.04 mm; D = 1.65–1.87 mm; L/D = 3.8–4.3; the volution number is 5.5–6; the diameter of proloculus is 216–264 μm; diameters of volutions in mm: I = 0.36–0.40, II = 0.55-0.65; III = 0.83–0.92; IV = 1.15–1.27; V = 1.49–1.63; VI = 1.70–1.87. Measurements of the holotype and type specimen are listed in the following tables.

Length of volutions in mm (L)

Specimen no.		1	2	3	4	5	5.5	6
1	3182	0.60	1.27	2.04	3.70	5.30	6.86	–
2	3196	0.67	1.46	2.40	3.55	4.85	–	8.04

Diameters of volutions in mm (D)

	proloculus	1	2	3	4	5	5.5	6
1	0.264	0.38	0.55	0.83	1.18	1.63	1.68	–
2	0.264	0.40	0.65	0.92	1.27	1.51	–	1.87

L/D

	1	2	3	4	5	5.5	6
1	1.6	2.3	2.5	3.1	3.3	4.1	–
2	1.7	2.3	2.6	2.8	3.2	–	4.3

Coiling index (P) of holotype

1.3	1.0	1.6	1.5	1.2	Proloculus	1.3	1.6	1.3	1.0

Wall thickness in mm

	1	2	3	4	5	6
1	0.032	0.032	0.036	0.046	0.070	0.072
2	0.022	0.036	0.042	0.048	0.068	0.096

Width of aperture in mm

	1	2	3	4	5	6
1	0.063	0.130	0.264	0.401	–	–
2	0.070	0.165	0.260	0.430	–	–

Comparison. *Rugosofusulina larga* sp. nov. is similar to species *R. restricta* Sjomina, 1971 and *R. subundulat* Sjomina, 1971 (Kireeva *et al.*, 1971) from the group *Rugosofusulina stabilis* Rauser. From *R. restricta* Sjomina, the new species differs in having considerably less developed septal fluting; from *R. subundulata* Sjomina, in having more massive axial deposits. From both reference species, *Rugosofusulina larga* sp. nov. differs in having an unusual elongated-subcylindrical test (the shape index of the test of species *R. restricta* Sjomina and *R. subundulata* Sjomina is 2.7–3.3, whereas the shape index of the new species ranges from 3.8 to 4.3).

Stratigraphic range. Lower Permian, Asselian, *Sphaeroschwagerina vulgaris–S. fusiformis* Zone.

Material. Four axial and one paraaxial sections from the Kholodny Log Section (outcrop 24, bed 5; outcrop 22, bed 5).

***Rugosofusulina gubakhica* Echlakov and Vilesov, sp. nov.**

Plate 3, figs. 3 and 4

Etymology. From the town of Gubakha.

Holotype. PGU, Kholodny Log collection, no. 24-5-9/17; Perm Region, Kosva River, Kholodny Log Section (outcrop 24, bed 5); Lower Permian, Asselian, *Sphaeroschwagerina vulgaris–S. fusiformis* Zone.

Description. The test with rounded axial ends is elongated-subcylindrical. The proloculus is large and spherical. The test elongation gradually increases with volutions: the first volution is short-fusiform; the second, short-cylindrical; and the third and fourth, subcylindrical. The spiral height gradually increases with volutions. From the second volution, the tectum is rugose. The wall thickness uniformly increases with volutions and attains its maximum (110 μm) in the last volution. Except for axial areas, where the wall thickness appreciably decreases, the thickness remains virtually

Explanation of Plate 3

Magnification ×15 in all cases except for (2b), (3b), and (5b).

Figs. 1 and 2. *Rugosofusulina larga* Vilesov, sp. nov.: (1) no. 3196 (from the collection of Yu.A. Echlakov), axial section; (2a) holotype, no. 3182 (from the collection of Yu.A. Echlakov), axial section; (2b) wall and fragment of early volutions of the holotype, ×35; Kholodny Log Section, outcrop 22, bed 5.

Figs. 3 and 4. *Rugosofusulina gubakhica* Echlakov and Vilesov, sp. nov.: (3a) holotype, no. 24-5-9/17, axial section, Kholodny Log Section, outcrop 24, bed 5; (3b) wall and fragment of early volutions of the holotype, ×35; (4) no. 3183 (from the collection of Yu.A. Echlakov), axial section, Kholodny Log Section, outcrop 22, bed 5.

Figs. 5 and 8. *Sphaeroschwagerina visherensis* Vilesov, sp. nov.: (5a) holotype, no. 4014-1/5, axial section; (5b) early volutions of the holotype, ×35; (8) no. 4014-1/2, axial section, Akchim Section, the base of outcrop 4014.

Figs. 6 and 7. *Anderssonites ognevae* Vilesov, sp. nov.: (6) no. 3-4/1, axial section; (7) holotype, no. 3-1/5, axial section, Ostanets Section, bed 3.

unchanging. Septa are thin and show well developed septal fluting along their entire length. In the last volution, the septal fluting commonly spreads over the aperture area (in this case, the aperture is indistinct). The septal fluting is irregular to regular; in the last volution, occasionally wavy. Plicae are arcuate and vary in height and width. Axial meshworks of medium width are fine- and medium-meshed. The slit-like aperture is broad even in the second volution. In subsequent volutions, the aperture widens further and attains a width of 670 μm in the fourth volution. Chomata are absent. The second and later volutions contain slender, hook-shaped pseudochomata. Axial deposits are only slightly developed and discontinuous.

Measurements. L = 6.34–6.65 mm; D = 1.78–1.90 mm; L/D = 3.4–3.7; the volution number is 5; the diameter of the proloculus is 214–265 μm; diameters of volutions in mm: I = 0.35–0.40, II = 0.54–0.60; III = 0.86–0.94; IV = 1.27–1.37; V = 1.78–1.90. Measurements of the holotype and typical specimen are listed in the following tables.

Length of volutions in mm (L)

Specimen no.		1	2	3	4	5
1	24–5–9/17	0.60	1.46	2.74	4.44	6.65
2	3183	0.62	1.41	2.88	4.84	6.55

Diameters of volutions in mm (D)

	proloculus	1	2	3	4	5
1	0.265	0.40	0.60	0.94	1.37	1.85
2	0.248	0.38	0.58	0.88	1.30	1.78

L/D

	1	2	3	4	5
1	1.5	2.4	2.9	3.2	3.6
2	1.6	2.4	3.3	3.7	3.7

Coiling index (P) of holotype

1.1	1.5	1.8	1.3	Proloculus	1.5	1.4	1.3	1.0

Wall thickness in mm

	1	2	3	4	5
1	0.010	0.025	0.050	0.097	0.105
2	0.016	0.024	0.049	0.070	0.090

Width of aperture in mm

	1	2	3	4	5
1	0.048	0.168	0.288	0.504	–
2	0.070	0.144	0.300	0.672	–

Comparison. *Rugosofusulina gubakhica* sp. nov. differs from *Rugosofusulina larga* sp. nov. in the absence of massive axial deposits and in having more developed septal fluting and a wider aperture. In addition, the first three or four volutions of *Rugosofusulina gubakhica* show the rate of elongation which is markedly higher than that of the reference species.

From a similar species *Rugosofusulina latioralis* Rauser, 1937, the new species differs in having smaller measurements (in *Rugosofusulina latioralis* Rauser L ranges from 7.00 to 11.8 mm; D, from 2.15 to 3.10 mm), lesser regularity in septal fluting, and a considerably smaller stratigraphic range (*R. latioralis* Rauser is characteristic of the Shikhanskii Horizon of the Asselian and lower zone of the Tastubskii Horizon of the Sakmarian).

Stratigraphic range. Lower Permian, Asselian, the upper part of the *Sphaeroschwagerina vulgaris–S. fusiformis* Zone.

Material. Three axial and several subaxial sections from the Kholodny Log Section (outcrop 24, bed 5; outcrop 22, bed 5).

Family Pseudoschwagerinidae Chang, 1963

Genus *Sphaeroschwagerina* A. Miklukho-Maclay, 1956, sensu Davydov, 1984

***Sphaeroschwagerina visherensis* Vilesov, sp. nov.**

Plate 3, figs. 5 and 8

Etymology. From the Vishera River.

Holotype. PGU, Akchim collection, no. 4014-1/2; Perm Region, Vishera River, Akchim Section (the base of outcrop 4014); Lower Permian, Asselian, *Sphaeroschwagerina vulgaris–S. fusiformis* Zone.

Description. The test with rounded axial ends and convex lateral slopes is of medium size and short-fusiform. The proloculus is spherical and rather large relative to the outer diameter of the test. Their ratio (D/D proloculus) ranges from 14 to 18. The first volution is spherical; the second, ovoid; further volutions perceptibly extend along the axis to become short-fusiform. First 2–2.5 volutions are coiled tightly; in volutions 3 and 4, the spiral height markedly increases (the coiling index increases up to 2.2–2.5); in further volutions, the spiral height attains a maximum and remains relatively unchanged. The coiling axis remains the same for all volutions. Within the first two or three volutions, the wall is thin; in the first volution, the tectum and keriotheca of the wall usually remain undifferentiated. In volutions 3 and 4, the wall thickness markedly increases and then attains a maximum in the sixth volution (up to 100 μm). Septa are slender; the septal fluting is poorly developed and irregular. The septal fluting is wavy and forms low circular arcs with a wide base. The degree of fluting varies with specimens. In the axial ends, septa form narrow fine- and medium-meshed meshworks. The aperture is broad, slit-like, and low; in the last volution, occasionally indistinct. Small and round chomata are developed on the proloc-

ulus and the first 2–2.5 volutions. The subsequent volutions contain only small hook-shaped pseudochomata.

Measurements. L = 4.32–5.28 mm (commonly about 5.00 mm); D = 2.5–3.24 mm; L/D = 1.7–1.8; the volution number is 5.5–6.5; the diameter of the proloculus is 156–216 μm; diameters of volutions in mm: I = 0.26–0.34, II = 0.43–0.54; III = 0.74–0.89; IV = 1.25–1.51; V = 1.94–2.30; VI = 2.78–3.02, VII (incomplete) = 3.12. Measurements of the holotype and typical specimen are listed in the following tables.

Specimen no.		Length of volutions in mm (L)						
		1	2	3	4	5	6	6.5
1	4014–1/2	0.38	0.69	1.58	2.95	4.03	5.16	–
2	4014–1/5	0.34	0.70	1.39	2.64	3.60	5.18	5.28

Diameters of volutions in mm (D)

	proloculus	1	2	3	4	5	6	6.5
1	0.160	0.26	0.43	0.82	1.49	2.21	2.98	–
2	0.216	0.34	0.54	0.74	1.25	1.94	2.78	3.12

L/D

	1	2	3	4	5	6	6.5
1	1.5	1.6	2.1	2.0	1.8	1.7	–
2	1.0	1.3	1.9	2.1	1.9	1.9	1.7

Coiling index (P) of holotype

1	1.0	0.9	1.6	2.5	1.6	Proloculus	1.8	1.8	2.2	1.3	1.0
2	1.1	1.2	2.2	1.3	1.6	Proloculus	1.5	1.6	1.4	2.1	1.1

Wall thickness in mm

	1	2	3	4	5	6	6.5
1	0.014	0.020	0.026	0.048	0.072	0.096	–
2	0.012	0.024	0.046	0.046	0.064	0.076	0.072

Width of aperture in mm

	1	2	3	4	5	6	6.5
1	0.056	0.098	0.216	0.400	0.624	–	–
2	0.048	0.074	0.144	0.312	0.401	0.600	0.336

Comparison. The new species differs from a similar species *Sphaeroschwagerina poljarica* (Grozdilova, 1966) in having an axially elongated test: the shape index (L/D) of *S. visherensis* sp. nov. lies within a range of 1.7–1.8; whereas that of *S. poljarica* (Grozdilova), of 1.3–1.4.

Remarks. *Sphaeroschwagerina visherensis* sp. nov. is similar to representatives of the genus *Eozellia* Rosovskaya 1975 in the pattern of septal fluting and in having a poorly separated juvenarium. At the same time, the described species differs distinctly from representatives of the genus *Eozellia* in having a thin wall in early volutions, the wall of the first volution undifferentiated into a tectum and keriotheca, an abrupt increase in the wall thickness in volutions 3 and 4, and a smaller proloculus. In representatives of the genus *Eozellia*, the wall is rather thick even in the first volution, where it distinctly differentiates into the tectum and keriotheca; the increase in wall thickness with volutions is uniform.

From representatives of the genus *Zellia, Sphaeroschwagerina visherensis* sp. nov. differs in the above-mentioned characters of the test wall, as well as in having a thin-walled proloculus and fusiform test.

Stratigraphic range. Lower Permian, Asselian, the lower part of the *Sphaeroschwagerina vulgaris–S. fusiformis* Zone, Fore-Urals (Perm Region).

Material. In addition to the holotype, four axial sections from the Akchim Section (the base of outcrop 4014) and two axial sections from the Kamen Stolby Section (bed 12).

Family Pseudofusulinidae Dutkevich, 1934

Genus *Anderssonites* Sjomina, Solovieva, and Bensh, 1987

***Anderssonites ognevae* Vilesov, sp. nov.**

Plate 3, figs. 6 and 7

Etymology. In honor of I.I. Ogneva, the micropaleontologist.

Holotype. PGU, Ostanets collection, no. 3-1/5; Perm Region, Kosva River, Ostanets Section (the base of outcrop 3); Upper Carboniferous, Gzhelian, *Ultradaixina bosbytauensis–Daixina robusta* Zone.

Description. The fusiform test has concave lateral slopes and blunted axial ends. The proloculus is small and spherical. In the early two or three volutions, the test is short-fusiform. From the third or fourth volution on, the test gradually elongates. The spiral coiling in early volutions is tighter than that of later volutions; however, the height of volutions increases rather uniformly except for the third volution where the increase in spiral height accelerates: the coiling index (P) attains here its maximum and fluctuates between 1.7 and 1.8. In early volutions, the wall is thin, then gradually increases with volutions and attains a maximum in the fifth or sixth volutions (up to 0.100–0.110 mm). The increase in wall thickness can be due to the development of discontinuous deposits of the external tectorium. Septa are only slightly thinner than the wall. In the two early volutions, the septal fluting is poor or absent; in further volutions, well-developed, high, and regular. Plicae are usually rectangular and trapezoidal, commonly considerably swollen at the top. In the last volution, the septal fluting becomes irregular (gerontic stage). Axial meshworks are medium-meshed and narrow; they can appreciably extend only in the last volution. Axial deposits are discontinuous. The oval aperture, the position of which is independent of volutions,

is of medium height (half as high as the corresponding volution) and uniformly extends with volutions. The early two volutions contain small rounded chomata; further volutions contain pseudochomata of diverse shapes: pillar-, hook-, and mushroom-shaped.

Measurements. L = 5.81–6.34 mm; D = 2.64–2.85 mm; L/D = 2.0–2.4; the volution number is 6–6.5, occasionally 7; the diameter of the proloculus is 160–170 μm; diameters of volutions in mm: I = 0.22–0.31, II = 0.36–0.54; III = 0.59–0.84; IV = 0.80–1.30; V = 1.44–1.91; VI = 2.14–2.64, VII = 2.86. Measurements of the holotype and typical specimens are listed in the following tables.

Specimen no.		Length of volutions in mm (L)						
		1	2	3	4	5	6	6.5
1	3–1/5	0.58	1.01	1.63	2.54	4.08	5.52	6.24
2	3–4/1	0.50	0.92	1.70	2.81	4.42	6.34	–

Diameters of volutions in mm (D)

	proloculus	1	2	3	4	5	6	6.5
1	0.168	0.31	0.54	0.84	1.27	1.80	2.45	2.69
2	0.166	0.30	0.49	0.82	1.30	1.91	2.64	–

L/D

	1	2	3	4	5	6	6.5
1	1.9	1.9	1.9	2.0	2.3	2.3	2.3
2	1.7	1.9	2.1	2.2	2.3	2.4	–

Coiling index (P) of holotype

1.1	1.3	1.5	1.7	1.4	Proloculus	1.3	1.8	1.2	1.4	1.0

Wall thickness in mm

	1	2	3	4	5	6
1	0.016	0.030	0.050	0.070	0.100	0.064
2	0.024	0.036	0.040	0.060	0.108	0.048

Width of aperture in mm

	1	2	3	4	5	6
1	0.035	0.070	0.100	0.192	0.360	0.600
2	0.036	0.072	0.140	0.224	0.336	0.720

Comparison. *Anderssonites ognevae* sp. nov. resembles the species *Anderssonites confertus* (Vilesov, 1997), but differs from the latter in the test shape (concave lateral slopes), in more developed and regular septal fluting, and in considerably thinner tectorium deposits.

Anderssonites ognevae sp. nov. is very similar to the form that was described by Mikhailova from the Chernyshev Range and determined by her as *Anderssonites anderssoni* (Schellwien) (Fore-Urals, Pechora Region) (Mikhailova, 1966, p. 21, pl. 1, figs. 5 and 6). As noted in Zolotova *et al.* (1977), the forms depicted in Mikhailova's paper cannot be attributed to the species *A. anderssoni* (Schellwien) by characters such as a more tightly coiled spiral and the presence of pseudochomata in later volutions. These characters, as well as a number of others (the shape and size of the test, character of septal fluting and axial deposits, shape of aperture, and others), liken *Anderssonites ognevae* sp. nov. to *A. anderssoni* (Schellwien, sensu Mikhailova, 1966). Therefore, they can with good reason be recognized to be a single species.

Material. Four axial sections from the Ostanets Section (bed 3).

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