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Article *in* Paleontologicheskii Zhurnal · January 2001

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Paleontological Journal, Vol. 35, No. 1, 2001, pp. 10–15. Translated from Paleontologicheskii Zhurnal, No. 1, 2001, pp. 13–18.

New Species of the Genus *Praepseudofusulina* Ketat et Solotukhina, 1984 (Foraminifera, Schwagerinida) from the Upper Carboniferous of the Middle Urals

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Received March 23, 1999

Abstract—Three new schwagerinid species of the genus *Praepseudofusulina*, i.e., *P. gemma, P. bullula*, and *P. arsenii*, are described from the Upper Carboniferous (Gzhelian Stage, *Daixina bosbytauensis–Globifusulina robusta* Zone) of the Middle Urals.

INTRODUCTION

The genus *Praepseudofusulina* Ketat et Solotukhina 1984 includes morphologically distinctive small-sized schwagerinids with inflated-fusiform and ovoid tests, a small number of volutions, large proloculus, and poorly developed septal fluting that is concentrated predominantly in the axial ends and on the slopes of the test. The interval of the stratigraphic occurrence of the *Praepseudofusulina* includes three fusulinid zones of the standard scale: *Daixina bosbytauensis–Globifusulina robusta* Zone of the Gzhelian Stage of the Upper Carboniferous and *Schwagerina vulgaris–S. fusiformis* and *Schwagerina moelleri–Globifusulina fecunda* zones of the Asselian Stage of the Lower Permian. The geographical range of the genus includes the Fore-Urals, South Urals, Dnieper–Donets, Caspian Sea, Darvaz–Trans-Alai, and Fergana provinces of the Mediterranean paleobiogeographic region and Timan-Pechora province of the Europe–Canadian region; paleobiogeography after Grunt (1995).

The majority of species of the genus *Praepseudofusulina* were described from the Volga and South Uralian sections (Kireeva *et al.*, 1971). In the Carboniferous–Permian boundary beds of the Middle Urals, *Praepseudofusulina* is also fairly abundant and diverse (*Pogranichnye otlozheniya*, 1986; Shcherbakova and Shcherbakov, 1994; Vilesov, 1997). In the middle Urals, this genus is common in the *Daixina bosbytauensis–Globifusulina robusta* Zone and uncommon in the overlying Kholodnyi Log Horizon.

My study of the Gzhelian and Asselian schwagerinids from the Nizhnyaya Gubakha and Belaya Gora sections on the Kos'va River (Perm Region, Russia) resulted in the erection of three new *Praepseudofusulina* species described below.

The Nizhnyaya Gubakha section is located on the left bank of the Kos'va River 1.5 km downstream of the railroad station Nizhnyaya Gubakha. This section is represented by rock-cut terraces and rock exposures with an overall length of about 1 km and includes rocks aging from the Viséan of the Lower Carboniferous to the Asselian of the Lower Permian. The Carboniferous–Permian boundary beds crop out in rock exposures and on the railroad cutting near the railroad bridge across the Kos'va River. This part of the section was thoroughly described (Vilesov, 1997); in this paper, beds are numbered as in this description.

The Belaya Gora section runs along the right bank of the Kos'va River, across and slightly downstream of the Nizhnyaya Gubakha section. This section is represented by continuous rock-cut terraces and separate rock exposures with an overall length of more than 1 km. Most of the section length is composed of Lower Permian rocks (from the Asselian to the Artinskian); separate rock exposures in the vicinity of the railroad bridge are composed of Upper Carboniferous carbonate rocks of the Gzhelian Stage. The Belaya Gora section was first thoroughly described by Pnev with coworkers (1971). More recently, Zolotova and Provorov (1974) described the same section under the name Most. My description of new *Praepseudofusulina* species refers to the beds numbered after Zolotova and Provorov.

All of the new species described in the paper are from the *Daixina bosbytauensis–Globifusulina robusta* Zone of the Gzhelian stage of the Upper Carboniferous. As in previous papers (e.g., Vilesov, 1998), I use the standardized nomenclature proposed by Kalmykova (1982).

MATERIAL

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

SYSTEMATIC PALEONTOLOGY

Family Pseudofusulinidae Dutkevich, 1934

Subfamily Pseudofusulininae Dutkevich, 1934

Genus *Praepseudofusulina* Ketat et Solotukhina, 1984

***Praepseudofusulina gemma* Vilesov, sp. nov.**

Etymology. From Latin *gemma* (bud).

Holotype. PGU, no. F-2-10; Perm Oblast, Kos'va River, Nizhnyaya Gubakha section (layer 9); Upper Carboniferous, Gzhelian Stage, *Daixina bosbytauensis–Globifusulina robusta* Zone.

Description (Figs. 1a, 1a', and 1b). The test is small and fusiform with rounded or slightly tapered axial ends and flat or slightly convex lateral slopes. The proloculus is large and spherical. In the first volution, the test is slightly fusiform, in the second and later volutions, the test is fusiform. The coiling of the test is fairly uniform and the variations in the height of the spiral are small.

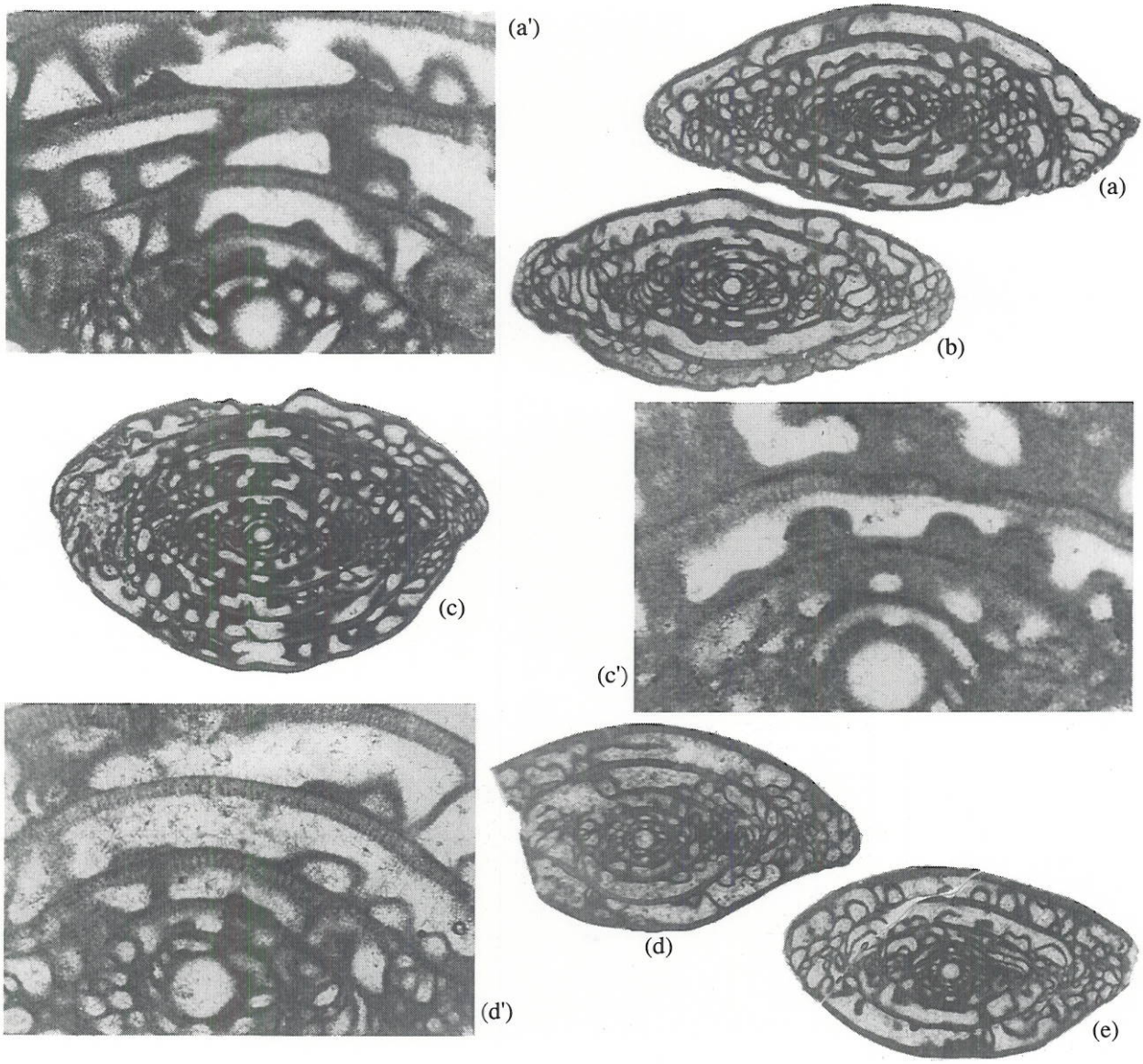

Fig. 1. New species of the genus *Praepseudofusulina* from the Gzhelian stage of the Upper Carboniferous of the Middle Urals: (a), (a'), and (b) *Praepseudofusulina gemma* sp.nov.: (a) holotype LGU, no. F-2-10, axial section, ×15, Nizhnyaya Gubakha section, layer 9; (a') median area of the holotype, ×50, well-defined external tectorium may be clearly seen on the wall between the third and fourth volutions; (b) specimen no. 3301, axial section, ×15, Nizhnyaya Gubakha section, layer 9; (c) and (c') *Praepseudofusulina arsenii*, sp. nov.: (c) holotype PGU, no. C-4-1, axial section, Nizhnyaya Gubakha section, layer 9, ×15; (c') earlier volutions of the holotype, ×75, well-defined external tectorium may be clearly seen on the wall between the second and third volutions; (d), (d'), and (e) *Praepseudofusulina bullula* sp. nov.: (d) specimen no. 6A-6e/3, axial section, ×15, Belaya Gora section, layer 6; (c') median area of the same specimen, ×50; (e) holotype PGU, no. F-2-4, axial section, ×15, Nizhnyaya Gubakha section, layer 9.

Table 1. Measurements of tests of (1) the holotype and (2) the paratype of *Praepseudofusulina gemma* sp. nov. (in mm)

Specimen no.	Diameter of volutions (*D*)					
	proloculus	1	2	3	4	5
1 F-2-10	0.210	0.36	0.59	0.94	1.40	1.92
2 F-2-13	0.216	0.35	0.53	0.82	1.27	1.73
	Length of volutions (*L*)					
	1	2	3	4	5	
1	0.53	1.15	1.90	3.29	4.40	
2	0.53	1.01	1.73	3.02	3.65	
	L/D					
	1	2	3	4	5	
1	1.5	2.0	2.0	2.4	2.3	
2	1.5	1.9	2.1	2.4	2.1	
	Thickness of walls					
	1	2	3	4	5	
1	0.032	0.045	0.054	0.084	0.048	
2	0.035	0.040	0.050	0.065	0.084	
	Width of apertures					
	1	2	3	4	5	
1	0.036	0.048	0.156	0.288	0.696	
2	0.025	0.064	0.108	0.280	0.456	

The coiling index (P)[1] of the holotype

5	4	3	2		2	3	4	5
1.1	1.4	1.4	1.5	proloculus	1.9	1.5	1.3	1.2

The wall of the test is fairly thick even in the first volution. In the fourth and fifth volutions, the wall is usually thickened by the external tectorium (Fig. 1a'). Up to the axial ends of the test, the thickness of the walls varies little. The last volution shows gerontic thinning of the walls. The pillars of the keriotheca are slender. Septa are thin and slightly folded. The septal fluting is well-defined, predominantly on the axial ends and slopes of the test; in the median area, the septal fluting is poorly defined or virtually absent. Septal plicae vary in shape and height, with wide and low plicae predominating. Axial meshworks are medium- to large-meshed. The aperture is of medium height, in the first two volutions, it remains narrow and oval-shaped, in the third and later volutions, it markedly widens to become slit-shaped. The proloculus and the first two volutions have chomata of medium height, rounded, and triangular with the vertical surface facing the aperture. The later volutions contain hook-shaped pseudochomata.

Measurements: L = 3.65–4.40 mm; D = 1.73–1.92 mm; L/D = 2.1–2.3; the number of volutions is 4.5–5; the diameter of proloculus is 204–240 μm; diameters of volutions (mm): I = 0.34–0.38, II = 0.53–0.62, III = 0.82–0.96, IV = 1.27–1.46, V = 1.73–1.92. Measurements are listed in Table 1.

Comparison. From the similar *P. orenburgensis orenburgensis* (Dobrokhotova, 1971) from the Carboniferous–Permian boundary beds of Orenburg Oblast (Kireeva *et al.*, 1971) *P. gemma*, sp. nov. differs in having a shorter test, more uniform stretching along the axis, and thicker walls in earlier volutions. From the *Praepseudofusulina antropovi* (Malkovsky, 1971), described from the coeval beds of the middle Volga River region (ibid.), the new species differs in having convex lateral slopes, earlier stretching of the test along the axis, and smaller values of *L/D* (2.8).

Material. In addition to the holotype, two axial and three oblique sections from the Nizhnyaya Gubakha section.

[1] "Coiling index," which characterizes the coiling of tests in fusulinids), was proposed by Moeller (1878) as early as the last century. This index may be computed for each volution of the test (except for the first) from the formula: $P = H_{(a+1)}/H_a$, where H is the height of volution and a is the volution number. The coiling index is a simple and informative numerical character complementary to verbal descriptions of the coiling of tests.

Table 2. Measurements of tests of (1) the holotype and (2) the paratype of *Praepseudofusulina bullula* sp. nov. (in mm)

Specimen no.	Diameter of volutions (*D*)					
	proloculus	1	2	3	4	5
1 F-2-4	0.216	0.32	0.50	0.80	1.20	1.75
2 6a-6f/3	0.220	0.35	0.58	0.91	1.39	1.99
	Length of volutions (*L*)					
	1	2	3	4	5	
1	0.43	0.82	1.46	2.14	3.22	
2	0.53	1.04	1.66	2.64	4.21	
	L/D					
	1	2	3	4	5	
1	1.3	1.6	1.8	1.8	1.8	
2	1.5	1.8	1.8	1.9	2.1	
	Thickness of walls					
	1	2	3	4	5	
1	0.022	0.032	0.045	0.060	0.098	
2	0.034	0.045	0.048	0.072	0.104	
	Width of apertures					
	1	2	3	4	5	
1	0.020	0.052	0.072	0.264	0.480	
2	0.035	0.060	0.144	0.270	0.576	

***Praepseudofusulina bullula* Vilesov, sp. nov.**

Etymology. From Latin *bullula* (bubble).

Holotype. PGU, no. F-2-4; Perm Oblast, Kos'va River, Nizhnyaya Gubakha section (layer 9); Upper Carboniferous, Gzhelian Stage, *Daixina bosbytauensis–Globifusulina robusta* Zone.

Description (Figs. 1d, 1d', and 1e). The test is fusiform with widely rounded axial ends and convex lateral slopes. The proloculus is spherical and thick-walled. The first volution is almost spherical; in the second and later volutions, the test uniformly lengthens to become slightly fusiform in the second volution and fusiform in the later volutions. In the first three or three and a half volutions, the height of volutions gradually increases, in the last one and a half or two volutions, the rate of the height increase gradually declines.

Coiling index (*P*) of the holotype

5	4	3	2		2	3	4	5
1.3	1.4	1.7	1.5	proloculus	1.5	1.4	1.7	1.0

The external surface of the test is smooth. The thickness of walls increases uniformly with the volutions. In the first volutions, the wall seems massive because of the additional deposits. Pillars of the keriotheca are of medium thickness (in the outer volutions, a 0.1-mm length contain 5–6 pillars). Septa are thin, with plicae along the entire length and height of septa, but the septal fluting is poorly defined, widely spaced, and irregular. In the axial section, septal plicae appear as arc-shaped and sagging undulating lines. Axial meshworks are narrow and medium-meshed. In the first two or three volutions, the aperture is oval, of medium height, in the outer volutions, the aperture rapidly extend to become slit-shaped. The proloculus has small rounded chomata. The first two or three volutions have pillar- or hook-shaped massive pseudochomata. In the later volutions, pseudochomata are poorly developed or absent.

Measurements: L = 3.22–4.21 mm; D = 1.72–1.99 mm; L/D = 1.8–2.1; the number of volutions is 5; the diameter of proloculus is 212–220 μm; diameters of volutions (mm): I = 0.32–0.35, II = 0.50–0.58, III = 0.79–0.91, IV = 1.20–1.39, V = 1.75–1.99. Measurements are listed in Table 2.

Comparison. From the similar species *P. cara* (Dobrokhotova, 1971), described from the Carboniferous/Permian boundary beds of Orenburg Oblast (Kireeva *et al.*, 1971), *P. bullula* sp. nov. distinctly differs in having a thick-walled proloculus, thicker walls of earlier volutions, and fusiform shape of the test as early as the second volution (the test of the *P. cara* remains subspherical up to the penultimate volution).

Table 3. Measurements of the test of the holotype of *Praepseudofusulina arsenii* sp. nov. (in mm)

Measurements	Volutions						
	1	2	3	4	5	6	7
L	0.44	0.96	1.56	2.23	2.57	3.33	3.91
D	0.33	0.53	0.84	1.25	1.70	2.16	2.64
L/D	1.3	1.8	1.9	1.8	1.5	1.5	1.5
Width of apertures	0.028	0.050	0.096	0.168	0.264	0.312	0.402
Thickness of walls	0.020	0.044	0.044	0.054	0.070	0.086	0.072

Material. In addition to the holotype, one axial section from the Belaya Gora section and an oblique section from the Nizhnyaya Gubakha section.

***Praepseudofusulina arsenii* Vilesov, sp. nov.**

Etymology. In memory of my son Arsenii (September 15, 1994–August 23, 1997).

Holotype. PGU, no. C-4-1; Perm Oblast, Kos'va River, Nizhnyaya Gubakha section (layer 9); Upper Carboniferous, Gzhelian Stage, *Daixina bosbytauensis–Globifusulina robusta* Zone.

Description (Figs. 1c and 1c'). The test is ovoid with rounded axial ends and convex lateral slopes. The proloculus is spherical, thick-walled and with a diameter of 0.192 mm. The first volution is almost spherical, from the second to fourth volutions, the test is fusiform; in the fifth and later volutions, the test is ovoid. The coiling of the test is uniform; in the first four volutions, the height of spiral increases gradually and slightly, while in volutions 5–7 volutions, it remains almost invariable. The values of the coiling index adequately depict the character of the test coiling.

Coiling index (*P*) of the holotype

7	6	5	4	3	2		2	3	4	5	6	7
1.0	1.1	1.2	1.5	1.5	1.4	proloculus	1.5	1.5	1.4	1.1	1.0	1.0

The external surface of the test is rough, with distinct septal furrows. In the first volution, the wall of the test is very thin, in the second volution, the thickness of the wall increases more than twofold and subsequently increases uniformly. In the sixth volution, the wall attains a maximum thickness. The wall has a well-defined external tectorium (Fig. 1 c'). The seventh volution shows a gerontic thinning of the walls. Pillars of the keriotheca are thin (from the fifth to sixth volutions, a 0.1-mm length contains 7–8 pillars). Septa are thick, only slightly thinner than the wall. The septal fluting is very irregular and occurs throughout the length of the septa. The septal plicae form few arches. Axial meshworks are narrow with meshes varying in size. The aperture is wide, slit-shaped, of medium height (usually 1/2 of the corresponding volution), the position of the aperture with respect to the median plane of the test may markedly vary with the volutions. The proloculus forms rounded chomata. All of the volutions have massive pseudochomata; in the first three volutions, pseudochomata are pillar-shaped; in the subsequent volutions, hook-shaped. The axial ends of the fourth volution have small axial compactions.

Measurements. Measurements are listed in Table 3.

Comparison. From all known *Praepseudofusulina* species distinctly differs both in habit and in a number of particular morphological characters. These particular characters include: (1) transformation of fusiform neanic tests into ovoid ephebic and gerontic tests, (2) thick septa, and (3) a high and irregular septal fluting that forms few arches.

Remarks. The species *Praepseudofusulina arsenii*, sp. nov. was described using a single axial section; this is quite justified by the test morphology of the new species. It is worth noting that this species is apparently rather uncommon. Analysis of several hundred of oriented sections of schwagerinids prepared from a large collection of specimens gathered from the Nizhnyaya Gubakha section within the interval corresponding to the *Daixina bosbytauensis–Globifusulina robusta* Zone (13 m) failed to identify even a single specimen of this species. Close examination of the specimens associated with the holotype of the new species was unproductive.

Material. Holotype.

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