

The Santonian/Campanian boundary foraminiferal zones of Western Siberia

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Abstract

In the recent regional stratigraphic scheme (ISCRF, 2005) with regard to the Upper Cretaceous of Western Siberia, the Slavgorodskian Horizon is in its entirety assigned to the Campanian stage. For many decades the author of this paper has objected to this particular definition. On the basis of foraminifera, a Santonian to early Campanian age is assigned for this regional stratigraphic subdivision. It is interesting to note that only the uppermost layers of the Slavgorodskian Horizon can be attributed to the lower Campanian (Podobina, 1975, 1989, 2000, 2009). A similar conclusion relating to the age is based not only on palaeontological data, principally foraminifera, but the geological development of the region as well. In this respect, Western Siberia and Canada together with Northern Alaska as separate provinces (West Siberian and Canadian) are included in the Arctic Palaeobiogeographical Realm of the same circumpolar belt.

KEY WORDS: Foraminifera, Slavgorodskian Horizon, Santonian – Lower Campanian, Western Siberia.

INTRODUCTION

In the latest regional stratigraphic scheme (ISCRF, 2005) with regard to the upper Cretaceous of Western Siberia, the Slavgorodskian Horizon is entirely assigned to the Campanian stage. For many decades the author of the paper has objected to this particular definition and has proved the Santonian – early Campanian age of this regional stratigraphic subdivision. As this takes place, it is interesting to note that only the uppermost layers of the Slavgorodskian Horizon can be attributed to the early Campanian (Podobina, 1975, 1989, 2000, 2009). The analogous conclusion relating to the age is based not only on the palaeontological data, principally foraminifera, but the geological development of the region. In this respect, Western Siberia makes an inseparable, integral part with the Arctic and Canadian territories as separate province constituting the Arctic palaeobiogeographical realm of the same circumpolar belt. In the northwest of northern America tectonic movements of the late (Nevadian) stage of the Cimmerian orogeny took place in the most intensive way. In the author's opinion, the territory being studied, especially the area adjacent to the Rocky Mountains, had already been drained since the Campanian stage. Continental sedimental accumulation in this region had been observed there since then and up to the end of the Cretaceous (Podobina, 2009; Tappan, 1962). The results of the orogeny were reflected in the absence of the greater part of Campanian sediments in the territory of Western Siberia (Podobina, 2009). That was the reason why only the lowest

layers of the Campanian stage were discovered in the lower part of the Slavgorodskian Horizon. But unlike western Canada and northern Alaska where the continental regime of sedimentary accumulation occurred from the Campanian up to the Late Cretaceous, in Western Siberia especially in its southern part, subsidence of the territory and the beginning of the late Campanian–Maastrichtian transgression connected with the southern seas across the Turgay Strait had been observed since this time. For this reason the upper Campanian–Maastrichtian sediments including foraminiferal zones are found in sections of Western Siberia up to the end of the Cretaceous (Podobina, 2000, 2009).

RESULTS

Agglutinated quartz-siliceous foraminifera are abundant in the section of the Slavgorodskian Horizon in the vast area of the region where relatively deep-water facies were formed. With regard to the assemblages, the author has established three microfaunistic zones (from down – up): 1 – *Ammobaculites dignus*, *Pseudoclavulina admota* (lower Santonian); 2 – *Cribrostomoides exploratus*, *Ammomarginulina crispera* (upper Santonian); 3 – *Bathysiphon vitta*, *Recurvoides magnificus* (lower Campanian) (Podobina, 1975, 1989, 2000, 2009). The first and the second zones constitute previously unified *Spiroplectammina lata*, *S. senonana pocurica* Zone, the latter represents the upper part of the *Spiroplectammina optata* Zone (Tables 1, 2, 3; pls I, II, III).

Table 1. Zones and foraminiferal assemblages of the Santonian-Campanian of Western Siberia

Stage	Substage	Horizon	Zones	Foraminiferal assemblages
Campanian	upper	Gankinsky	<i>Cibicidoides primus</i>	<i>Valvulineria procera</i> Podobina, <i>Dorothia pupoides</i> (d'Orb.) <i>ovata</i> Podobina, <i>Ataxophragmium crassus</i> (d'Orb.) <i>caspium</i> Vassilenko, <i>Ceratobulimina cretacea</i> Cushman & Harris, <i>Cibicidoides primus</i> Podobina, <i>Cibicidoides aktulagayensis</i> (Vassilenko), <i>Nonionellina taylorensis</i> (Hofker)
	lower		<i>Bathysiphon vitta</i> , <i>Recurvoides magnificus</i>	<i>Bathysiphon nodosarieformis</i> Subbotina, <i>Bathysiphon vitta</i> Nauss, <i>Glomospira corona</i> Cushman & Jarvis, <i>Recurvoides magnificus</i> Podobina, <i>Adercotryma glomeratoformis</i> (Zaspelova), <i>Spiroplectammina optata</i> Kisselman, <i>Spiroplectammina variabilis</i> Neckaja
Santonian	upper	Slavgorodsky	<i>Cribrostomoides exploratus</i> <i>Ammomarginulina crispera</i>	<i>Haplophragmoides tumidus</i> Podobina, <i>Cribrostomoides exploratus</i> Podobina, <i>Adercotryma glomeratoformis</i> (Zaspelova), <i>Ammobaculites agglutiniformis</i> Podobina, <i>Ammomarginulina crispera</i> (Kyprianova), <i>Spiroplectammina lata</i> Zaspelova, <i>Spiroplectammina ancestralis</i> Kisselman
	lower		<i>Ammobaculites dignus</i> , <i>Pseudoclavulina admota</i>	<i>Labrospira collyra</i> (Nauss), <i>Haplophragmoides eggeri</i> Cushman, <i>Recurvoides optivus</i> Podobina, <i>Cyclammina flexuosa</i> Podobina, <i>Ammobaculites dignus</i> Podobina, <i>Ammobaculites uvaticus</i> (Bulatova), <i>Haplophragmium obesus</i> (Bulatova), <i>Ammoscalaria incultus</i> (Ehremeeva), <i>Spiroplectammina senonana</i> Laliker <i>pocurica</i> Balakhmatova, <i>Trochammina priva</i> Podobina, <i>Pseudoclavulina admota</i> Podobina

In the section of borehole UK-2591 of the Nether-Polar Urals (int. 125.3 – 93.0 m), drilled by the Vorkuta Geological Survey expedition of “Polyaruralgeologiya” a distinctive early Santonian macrofauna – *Inoceramus* cf. *pachti* Arkh., *I. cardissoides* Gold etc. as well as the foraminifera *Ammobaculites dignus*, *Pseudoclavulina admota* was established, as had been previously done within the boundaries of the Ust-Yenisey depression. Radiolarians of the *Prunobrachium crassum* assemblage (Amon, 1994) are abundant here. In the Russian Plate this part of the section corresponds to the *Gavelinella infrasantonica* Zone based on the benthic foraminifera. The upper Santonian *Cribrostomoides exploratus*, *Ammomarginulina crispera* Zone of the West Siberian Plain in the area of the Nether-Polar Urals is not observed. Instead, Amon (1994) points out layers with *Praebulimina gracilis* at this stratigraphic level, which are accompanied by the finds of molluscs of the late Santonian *Inoceramus patootensis* Lor. etc. The layers with *Praebulimina gracilis*

correspond to the Western Siberian *Cribrostomoides exploratus*, *Ammomarginulina crispera* Zone, which is similar to the upper Santonian *Gavelinella stelligera* Zone of the Russian Plate.

Within the boundaries of the northern Transuralia the section of borehole 24 (Berezovo settlement) is of great interest. Along with agglutinated forms (depth interval 209.3–208.8 m) calcareous shells characteristic of the Santonian sediments of the Russian plate and Western Europe: *Valvulineria laevis* Brotzen, *Reinholdella brotzeni* Olsson, *Eponides concinnus* (Brotzen) *plana* Vassilenko are found.

Just the same mixed foraminifera which have distinctive Santonian species: *Cibicidoides eriksdalensis* (Brotzen), *Eponides concinnus* (Brotzen) *plana* Vassilenko et al. along with agglutinated forms of the Slavgorodskian Horizon (the foraminifera of two identified Santonian zones) were discovered in a section in the east of Western Siberia (Northern

Table 2. Foraminiferal assemblages of Santonian – lower Campanian of Western Siberia

Stage	Substage	Horizon	Foraminiferal Zones of Western Siberia	Layers with foraminiferal assemblages in borehole sections of the southeast of Western Siberia	
				borehole ZN-1	borehole N-15
Campanian	Lower	Slavgorodskiy	Bathysiphon vitta, Recurvoides magnificus	No samples have been found	<i>Recurvoides magnificus</i> (samples from a depth of 297.0 m) <i>Ataxophragmium orbignynaeformis</i> Mjatliuk, <i>Heterostomella</i> cf. <i>praefoveolata</i> (Marsson), <i>Cibicides</i> aff. <i>temirensis</i> Vassilenko, <i>Gavelinella</i> aff. <i>clementiana</i> (d'Orb.)
			Cribrostomoides exploratus, Ammomarginulina crispa	Distinctive agglutinated and secreted calcareous species: <i>Gaudryina rugosa</i> (d'Orb.), <i>G. laevigata</i> Franke, <i>Heterostomella stephensoni</i> Cushman, <i>Orbignyna variabilis</i> (d'Orb.), <i>Globorotalites micheliniana</i> (d'Orb.), <i>Gavelinella clementiana</i> (d'Orb.), <i>G. aff. stelligera</i> (Marie)	<i>Gavelinella stelligera</i> (samples from a depth of 340.0 m) Distinctive agglutinated and secreted calcareous shells of the species <i>Orbignyna variabilis</i> (d'Orb.), <i>Gaudryina</i> cf. <i>rugosa</i> (d'Orb.), <i>Gavelinella</i> cf. <i>stelligera</i> (Marie), <i>G. santonica</i> (Akimez), <i>Osangularia whitei</i> (Brotzen) <i>praeceps</i> (Brotzen)
Santonian	Upper		Ammobaculites dignus, Pseudoclavulina admota	Distinctive agglutinated and secreted calcareous species: <i>Stensioina</i> cf. <i>exsculpta</i> Reuss <i>gracilis</i> Brotzen, <i>Osangularia whitei</i> (Brotzen), <i>Gavelinella</i> cf. <i>infrasantonica</i> (Balakhm.), <i>Gaudryina laevigata</i> Franke	No samples have been found

area, boreholes 201, 202 etc.) (Podobina, 1975, 1989).

The finds in the southeast (the suburbs of Tomsk, Seversk) of distinctive Santonian calcareous foraminifera which are abundant in the Kazakhstan and Eastern European provinces along with the agglutinated quartz-siliceous foraminifera confirm the Santonian age of the Slavgorodskaya Horizon (lower and middle layers) of Western Siberia (Podobina, 2000, 2009; Podobina & Kseneva, 2007).

Consequently, the author believes that on the basis of the finds of peculiar foraminifera and mollusks, the lower and middle layers of the Slavgorodskian Suite of the same horizon are related to the Santonian stage.

The upper part of the Slavgorodskian Horizon and the lower

part of the Gankinsky Horizon including the transitional layers, which are abundant in the east are attributed to the Campanian stage. The transitional layers of greenish-grey aleurolities having a thickness of 20–30 m can be regarded as an independent lithological package (Kargasokskaya package or layers in the author's view), which often relate to the upper parts of the Slavgorodskian Horizon. In the eastern area the Kolpashevsky iron ore Horizon corresponds to these layers.

In the lower Campanian, the *Bathysiphon vitta*, *Recurvoides magnificus* foraminiferal zone from the upper part of the Slavgorodskian Horizon are abundant: foraminifera, ostracoda, radiolarian. Echinoderm spines and remains of mollusk shells are rarely found. The foraminiferal assemblage consists of approximately 45 species, three-fourths of which

Table 3. Scheme of the zonal subdivision and correlation by means of benthic foraminifera of the Santonian – Campanian of Western Siberia and the Russian Plate.

Stage	Substage	Russian plate (Practical Manual, 1991)	Western Siberia (Podobina, 2000, 2009)	Horizon
Campanian	upper	<i>Globorotalites emdiensis</i> (upper)	<i>Cibicidoides primus</i>	Gankiskian
		<i>Brotzenella monterelensis</i>		
	lower	<i>Cibicidoides temirensis</i>		Slavgorodskian
		<i>Gavelinella clementiana</i>	<i>Bathysiphon vitta</i> , <i>Recurvoides magnificus</i>	
Santonian	upper	<i>Gavelinella stelligera</i>	<i>Cribrostomoides exploratus</i> , <i>Ammomarginulina crispera</i>	
	lower	<i>Gavelinella infrasantonica</i>	<i>Ammobaculites dignus</i> , <i>Pseudoclavulina admota</i>	

are agglutinated while the other ones are calcareous. The latter species are widely distributed in the central region of Western Siberia (*Eponides*, *Gavelinella*, *Anomalinoidea*, *Cibicides*, *Cibicidoides*, *Praebulimina*, *Bulimina*, among others). In the assemblage one can observe various representatives of *Haplophragmoides*, which are widespread in the low-lying sediments of the Slavgorodskian Horizon. In addition, other agglutinated quartz-siliceous forms – *Gaudryinopsis vulgaris* (Kyprianova), *Arenogaudryina granosa* Podobina, *Trochammina wetteri* Stelck & Wall senonica Belousova and a number of other species known since the Early Santonian continue to exist in the Early Campanian. In the east (the sections of the boreholes of the Tym and Vach rivers), the Early Campanian assemblage mainly consists of comparatively primitive *Rhizammina*, *Bathysiphon*, *Psammospaera*, *Saccammina*, *Hyperammina*, etc. which suggests a significant shallowing of the basin here, as seen by the predominance of grey aleurolites and millstone grits in the upper part of the Slavgorodskian Horizon including the Kargasokskaya package. Most of the indicated genera have fine-grained white shells.

In the northwest of the plain in the basin of the Northern Sosjva and Synya rivers, gaize rocks relating to the upper part of the Slavgorodskian Horizon include *Scaphites cuvieri* Mort., *Baculites obtusus* Meek (the definition given by N. M. Mikhailova and A. E. Glazunova). Judging by these molluscs, we can speak about an early Campanian age of the enclosing rocks (Aleskerova *et al.*, 1957; Galerkina, 1959).

Most of the average part of the Campanian sediments in Western Siberia fall out from the section of the Upper Cretaceous. When compared to the Campanian stratigraphic scheme of the Russian plate (Table 3), part of the sediments distinguished from the section of Western Siberia corresponds to the *Cibicidoides temirensis* Zone (the lower Campanian), *Brotzenella monterelensis*, the biggest lower part of the *Globorotalites emdyensis* Zone (the upper Campanian).

The *Bathysiphon vitta*, *Recurvoides magnificus* Zone from the upper part of the Slavgorodskian Horizon in Western Siberia correspond to the lower Campanian *Gavelinella clementiana* Zone on the Russian Plate. The *Gibicidoides primus* Zone of the Gankinskaya Suite of the same Horizon complies with the uppermost layers of the *Globorotalites emdiensis* Zone of late Campanian age (Table 3).

The time has come to reconsider the regional stratigraphy of the Upper Cretaceous sediments – the Slavgorodskian Horizon of Western Siberia in particular, the age of which according to all the indicators is Santonian to Early Campanian.

CONCLUSIONS

According to the study of agglutinated foraminifera, the biggest middle part of the Campanian deposits in Western Siberia has been investigated from the section of the Upper Cretaceous. When compared with the stratigraphic scheme of the Campanian of the Russian Plate, these layers corre-

spond to those of: *Cibicidoides temirensis* (Lower Campanian), *Brotzenella monterelensis*, the largest lower part of the *Globorotalites emdyensis* Zone (Upper Campanian) (Table 3).

In the lower layers of the Campanian (the Slavgorodskaya Suite) the *Bathysiphon vitta*, *Recurvoides magnificus* Zone established by the author corresponds to the *Gavelinella clementiana* Zone on the Russian plate.

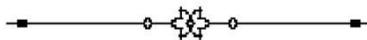
The highest layers of the upper Campanian (the lower layers of the Gankinskaya Suite) identified by the author as the *Cibicidoides primus* Zone correlates with the upper layers of the *Globorotalites emdiensis* Zone on the Russian Plate (Podobina, 2009).

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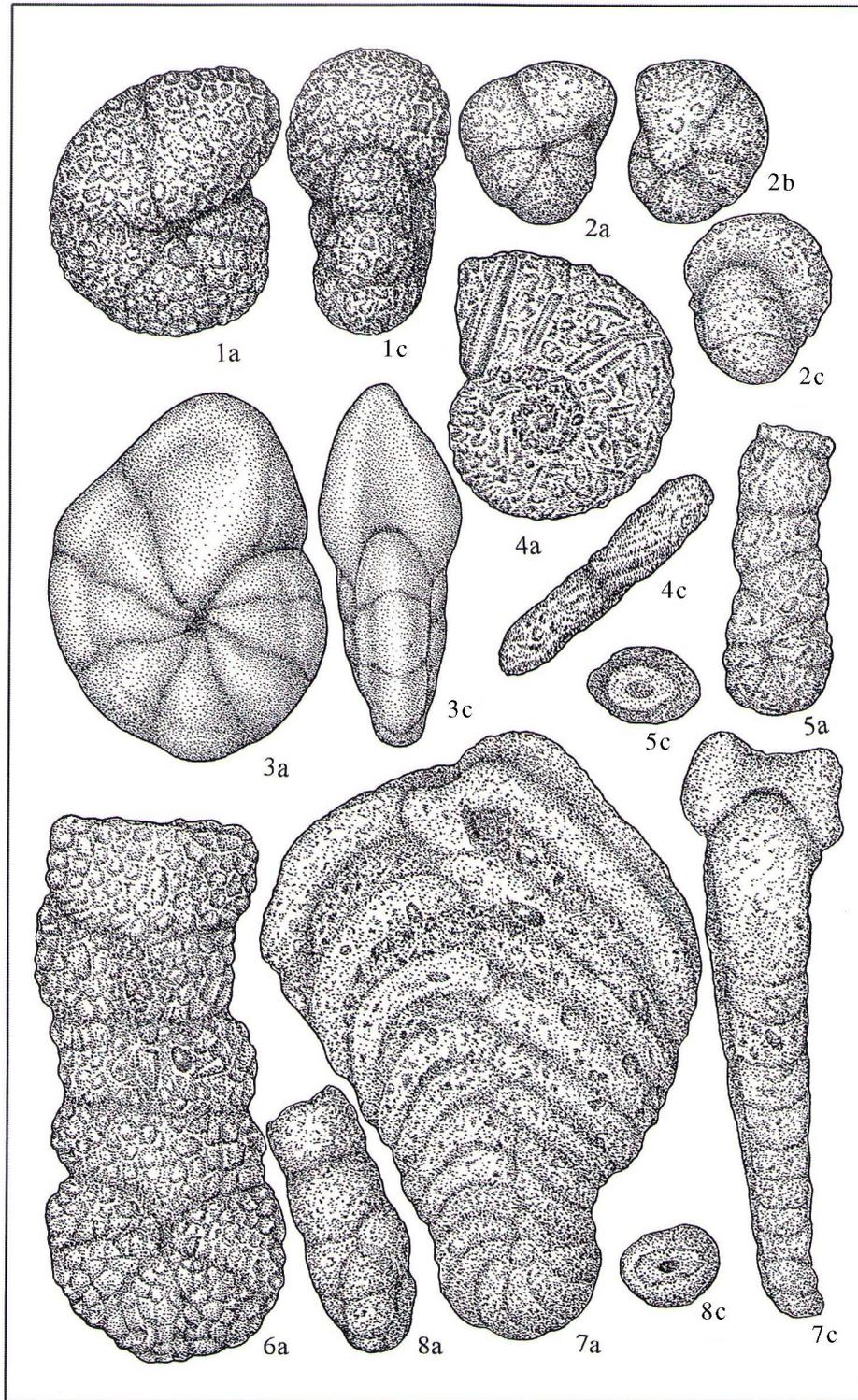


Plate 1. Lower Santonian Ammobaculites dignus, Pseudoclavulina admota Zone. All specimens are stored in the Micropalaeontological Department of the Palaeontological Museum of Tomsk State University. a – lateral or dorsal view; b – ventral view; c – apertural view. **1.** *Cribrostomoides astrictus* Podobina, Specimen No 190. Omsk region, Tara key hole 1-r, depth 727.8 m; x80. **2.** *Recurvoides optivus* Podobina, Specimen No 104. Tomsk region, Vasyuganian profile, borehole 3-k, depth interval 462.08-449.2 m; x80. **3.** *Cyclammina flexuosa* Podobina, Specimen No 196. Tomsk region, Middle-Parabel area, borehole 16-k, depth 270.0 m; x80. **4.** *Ammoscalaria incultus* (Ehremeeva), Specimen No 805. Tomsk region, Ob profile, borehole 26, depth interval 393.3-375.3 m; x80. **5.** *Ammobaculites dignus* Podobina, Specimen No 779. Tomsk region, Tym profile, borehole 1-k, depth interval 455.6-449.6 m; x80. **6.** *Ammobaculites uvaticus* (Bulatova), Specimen No 784. Tomsk region, Tym profile, borehole 1-k, depth interval 392.5-382.5 m; x80. **7.** *Spiroplectammina lata* Zaspelova, Specimen No 1282. Tomsk region, Kenga river basin (Parbig party), borehole 83, depth 277.0 m; x80. **8.** *Pseudoclavulina admota* Podobina, Specimen No 284. Tomsk region, Tym profile, key borehole 1-r, depth interval 423.0-413.0 m; x80.

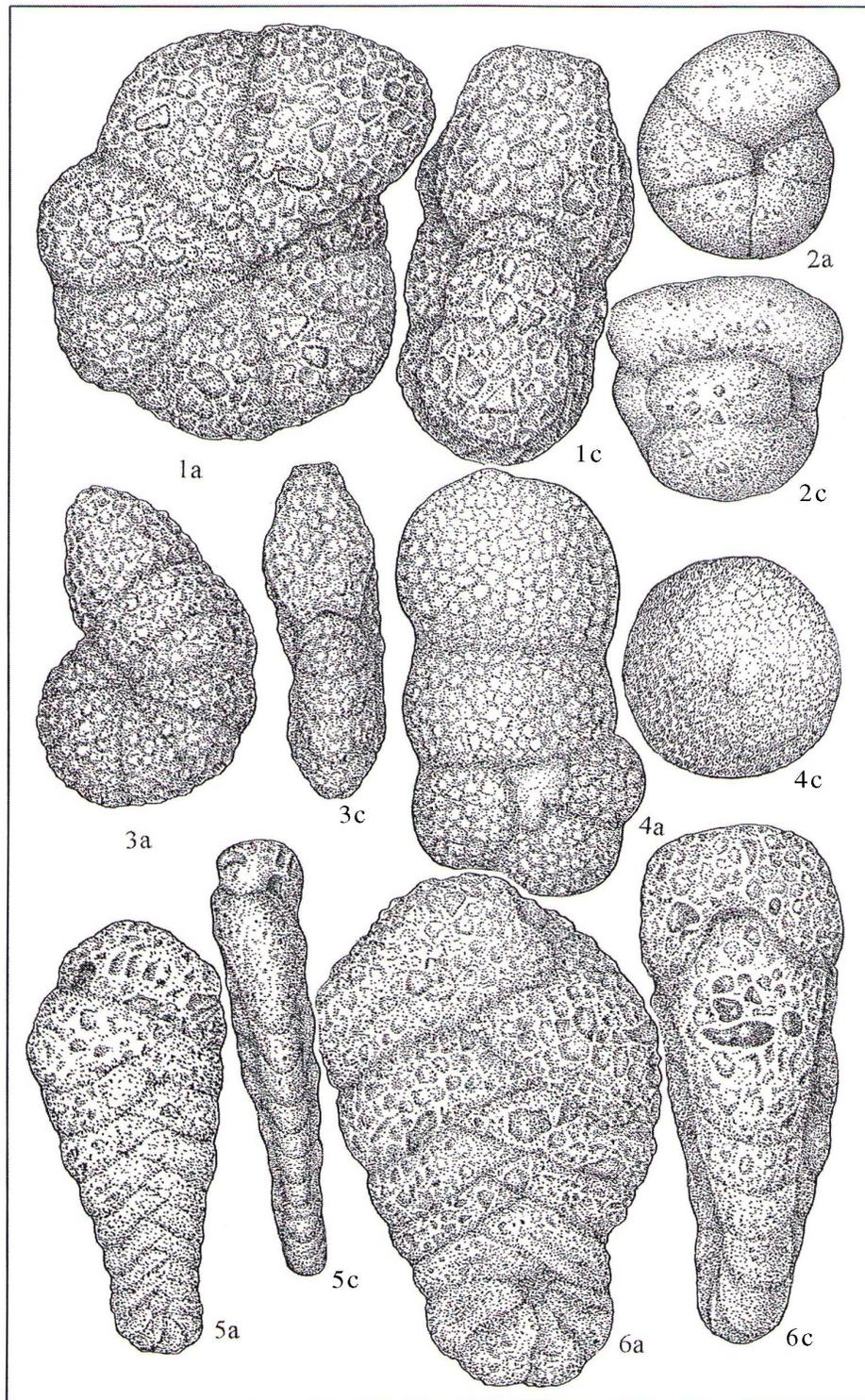


Plate 2. Upper Santonian *Cribrostomoides exploratus*, *Ammomarginulina crispera* Zone. a – lateral view; c – apertural view. **1.** *Haplophragmoides tumidus* Podobina. Specimen No 178. Tomsk region, Middle-Parabelskaya area, borehole 8-k, depth interval 273.75-264.85 m; x80. **2.** *Cribrostomoides exploratus* Podobina, Specimen No 112. Tomsk region, Parabel-Chuzic profile, borehole 3-k, depth interval 408.95-397.15 m; x80. **3.** *Ammomarginulina crispera* (Kyprianova), Specimen No 791. Tomsk region, Ambarskaya area, borehole 1-r, depth interval 718.36-712.26 m; x80. **4.** *Haplophragmium obesum* (Bulatova), Specimen No 426. Tomsk region, Ambarskaya area, borehole 14-k, depth interval 235.5-231.0 m; x80. **5.** *Spiroplectammina ancestralis* Kisselman, Specimen No 1286. Tomsk region, Chuzic river basin (Parbig party), borehole 25, depth 234.0 m; x80. **6.** *Spiroplectammina senonana* Lalicker subsp. *pocurica* Balakhmatova, Specimen No 1283. Tomsk region, Chuzic river basin (Parbig party), borehole 25, depth 226.0 m; x80.

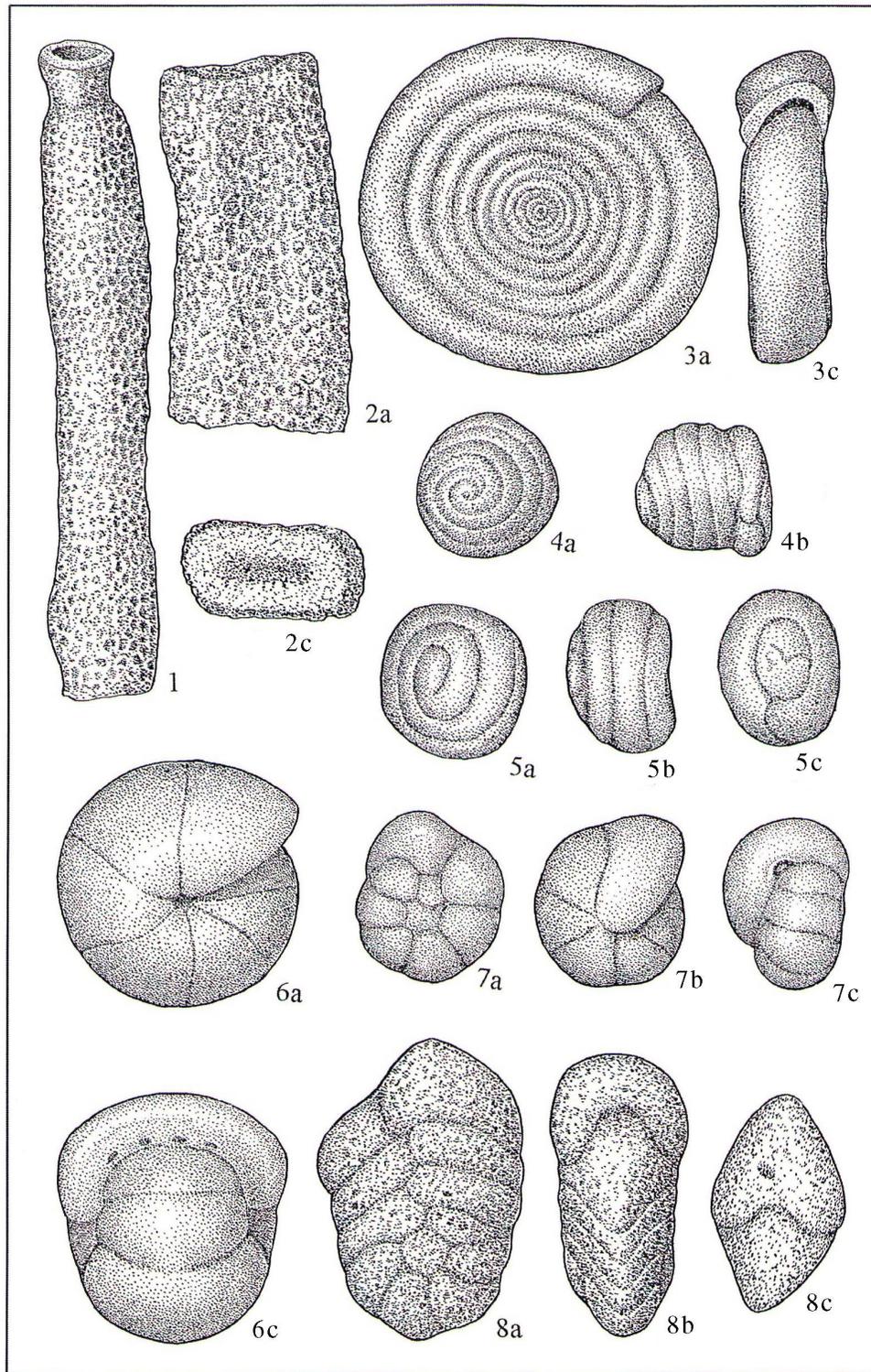


Plate 3. Lower Campanian *Bathysiphon vitta*, *Recurvoides magnificus* zone. a – lateral or dorsal view; b – lateral or ventral view; c – apertural view. **1.** *Bathysiphon nodosarieformis* Subbotina, Specimen No 539/7. Sverdlovsk region, Kuznetsovo-Kerchel profile, borehole 4-kp, depth 273.35 m; x50. **2.** *Bathysiphon vitta* Nauss, Specimen No 851. Tomsk region, Chizhapka river basin (Chizhapkian party), borehole 10-k, depth 320.0 m; x80. **3.** *Ammodiscus cretaceus* (Reuss), Specimen No 854. Tomsk region, the river Chizhapka basin (Chizhapkian party), borehole 10-k, depth 322.0 m; x80. **4-5.** *Glomospira corona* Cushman et Jarvis, 4. Specimen No 297a. Tomsk region, Senkinsky area, borehole 28, depth 294.3 m; x80. 5. Specimen No 300. Omsk region, Uyskian profile, borehole 20-k, depth 696.0 m; x80. **6.** *Cribrostomoides trinitatensis* Cushman subsp. *sibiricus* Podobina, Specimen No 108a. Tomsk region, Ambarskaya area, borehole 1-r, depth interval 718.37-712.27 m; x80. **7.** *Recurvoides magnificus* Podobina, Specimen No 110. Tomsk region, Ambarskaya area, borehole 1-r, depth interval 718.37-712.27 m; x80. **8.** *Spiroplectammina optata* Kisselman, Specimen No 1287a. Tomsk region, Ambarskaya area, borehole 1-r, depth interval 718.37-712.27 m; x80.