

# The Danian and Selandian calcareous benthic foraminiferal assemblages and biostratigraphy of Western Siberia

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## Abstract

Danian and Selandian successions in western Siberia are rich in calcareous benthic foraminifers. The assemblages with a constant systematic composition that have the widest lateral occurrence are distinguished as foraminiferal zones. The *Brotzenella praeacuta* Zone was established in the low-carbonate, clayey beds that form the transition from the Gankinskaya Suite to the Talitskaya Suite. These transitional beds are assigned to the Danian. The calcareous benthic foraminifers in this zone occur mainly together with agglutinated forms. The zone is traced along the areas of the largest subsidence of the Mesozoic-Cenozoic basin, principally in depressions. The transition from the Cretaceous to the Palaeogene is represented by a continuous succession, in which the Danian deposits escaped from erosion and were found to contain the *B. praeacuta* assemblage. In Danian rocks with a shallow-marine facies (near Beryozovo and in the Ust'-Tym depression, Fig. 1), the *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage occurs. It is dominated by primitive forms in addition to more advanced tests (mainly Late Maastrichtian relic species).

The overlying Selandian (Middle Palaeocene) foraminiferal assemblages are assigned to the Talitskaya Suite. The *Ammoscalaria friabilis* assemblage is widely spread and is represented mainly by agglutinated quartz-siliceous forms. Beds with these species are attributed to the *Ammoscalaria friabilis* Zone, which can be correlated with beds in the East containing *Cyclammina coksuvorovae*. The *Cibicoides proprius* assemblage is known from the lower and middle beds of the Talitskaya Suite in Transuralia, the Omsk Depression and more south-eastern areas; the species of this assemblage are characteristic of the Selandian.

**Keywords:** benthic foraminifera, Danian, Selandian, Western Siberia

## 1. Introduction

The West-Siberian Plain is one of the largest low-altitude accumulation plains on Earth. It developed within the Epihercynian West-Siberian plate, the basement of which is composed by intensely deformed Palaeozoic deposits. This basement is covered by unconsolidated, marine and continental Mesozoic-Cenozoic sediments (clay, sandstone, marl and others) of over 2 km thick (within basement troughs up to 3–4 km) (Shatskiy, 1973).

Most of the Paleogene deposits on the West-Siberian plain are buried under a thick cover of the Neogene-Quaternary deposits (Shatskiy, 1973) so that they can be studied only in boreholes, many of which have been drilled in the southern part of the West-Siberian Plain. Their locations are spread evenly over the plain, in Transuralia and, to a lesser extent, the northern areas. Cores from these boreholes have been studied over many years, so that both the general stratigraphy of the Palaeogene of Western Siberia and the detailed lithostratigraphy of the

West-Siberian Plain are to be found in the extensive literature. The present author has also dealt with several stratigraphic aspects (e.g. Podobina, 1998, 2003, 2009).


The Palaeocene foraminiferal assemblages of western Siberia have already been studied more than half a century, among many others by Freiman (1960), Lipman et al. (1960), Dain (1961), Subbotina & Kiselman (1961) and Subbotina (1964). The most complete material on the Palaeocene and the Palaeogene was reported by Podobina (1998). The present contribution deals with the Danian and Selandian assemblages and zones that belong, as already found earlier, to the uppermost Gankinskaya Suite (Gankinskian Horizon) and the Talitskaya Suite (Talitskian Horizon) (local and regional stratigraphic subunits; see Table 1). A section of borehole 1-r, drilled in the Novo-Loginovo area, provides the best record for tracing the marginal foraminiferal assemblages and their zones that occur principally in the central district of Western Siberia (*sensu* Podobina & Kseneva, 2005). The marine sedimentary conditions were fairly stable there, so that the transitional Danian-Selandian strata could be dis-

tinguished on the basis of foraminifers within numerous sections of boreholes in Western Siberia (Fig. 1). The 1-r borehole section was therefore chosen as the object of the present study (Table 1).


## 2. Materials and biostratigraphy

The Danian marine deposits of Western Siberia are known from Transuralia (in Russian 'Zauralye'), which is the geographical name of the part of the West-Siberian Plain adjacent to the eastern slope of the Ural mountains; it covers the basins of the Ob' and Tobol rivers (Fig. 1) and the Omsk Depression in the South-West. They are rare in the central district of the West-Siberian Plain (the Ob-Irtysh interfluvium near Novyi Vasyugan) and are considered to represent the regions of the deepest subsidence of the Mesozoic-Cenozoic sediments (Aleskerova et al., 1957). They have also been found in the East within the almost continuous Cretaceous-Palaeogene sections of the Ust'-Tym Depression and in some sections of the Ob' Basin (in Russian: Priobyie) (Podobina, 1998). In the


series	subseries	stage	horizon	suite	depth [m]	lithological log	lithological characteristics	foraminiferal zones	foraminiferal assemblages
Palaeocene	Lower	Middle	Selandian	Talitskian	602.55		dark-grey plastic clay	<i>Ammoscalaria friabilis</i>	<b><i>Cibicoides proprius</i> assemblage:</b> <i>Nonionellina ovata</i> (Brotzen), <i>Cibicides simplex</i> Brotzen, <i>C. mammilatus</i> Brotzen, <i>Cibicoides proprius</i> Brotzen, <i>Anomalinoidea nobilis</i> Brotzen, <i>Bulimina paleocenica</i> Brotzen, <i>Subbotina varianta</i> (Subbotina), <i>S. triculinoidea</i> (Plummer)
					603				
	604								
	605								
	605.55								
Lower	Middle	Danian	Gankinskian	Gankinskaya	606	v v v v	grey siliceous clay	<i>Brotzenella praeacuta</i>	<b><i>Brotzenella praeacuta</i> assemblage:</b> <i>Bathysiphon nodosariiformis</i> Subbotina, <i>Glomospira charoides</i> Parker et Jones, <i>Trochammina completa</i> Lipman, <i>Allomorphina halli</i> Jennings, <i>Parella lens</i> Brotzen, <i>Brotzenella praeacuta</i> (Vassilenko), <i>Subbotina varianta</i> (Subbotina)
					607		grey calcareous siltstone		
					607.55				



clays



siliceous clays



siltstones

**Table 1.** Lithological and foraminiferal characteristics of the part of the section (borehole 1-r) under study.

above regions, the uppermost Gankinskaya Suite of the Gankinskian Horizon is usually attributed to the Danian Stage; the sediments of the suite become here arenaceous, less calcareous, but sometimes slightly siliceous, and they seem to develop gradually from the overlying deposits of the Talitskaya Suite of the Talitskian Horizon (Table 1) (Podobina, 1998).

In 1937 Dain originally distinguished (without publishing) the *Clavulina parisiensis* - *Anomalina ammonoides* var. *acuta* assemblage from this part of the section near settlement Shumikha on the eastern slope of the Ural Mountains (and described it in Dain, 1961). The zone

of the same name was also established by Dain (1961) in the sedimentary body composed of the somewhat siliceous light-grey clays. It was initially assigned by her to the Danian. Subbotina and Kiselman (1961) later designated this zone as *Anomalina praeacuta* and dated it also as Danian. Podobina (1975) assigned this species to the genus *Brotzenella*, that is *Brotzenella praeacuta*.

The Danian assemblage distinguished by Dain (1961) is similar in its taxonomy to those found in several sections of Transuralia and the central district of the West-Siberian Plain (in the Omsk Depression, including Novo-Loginovo,

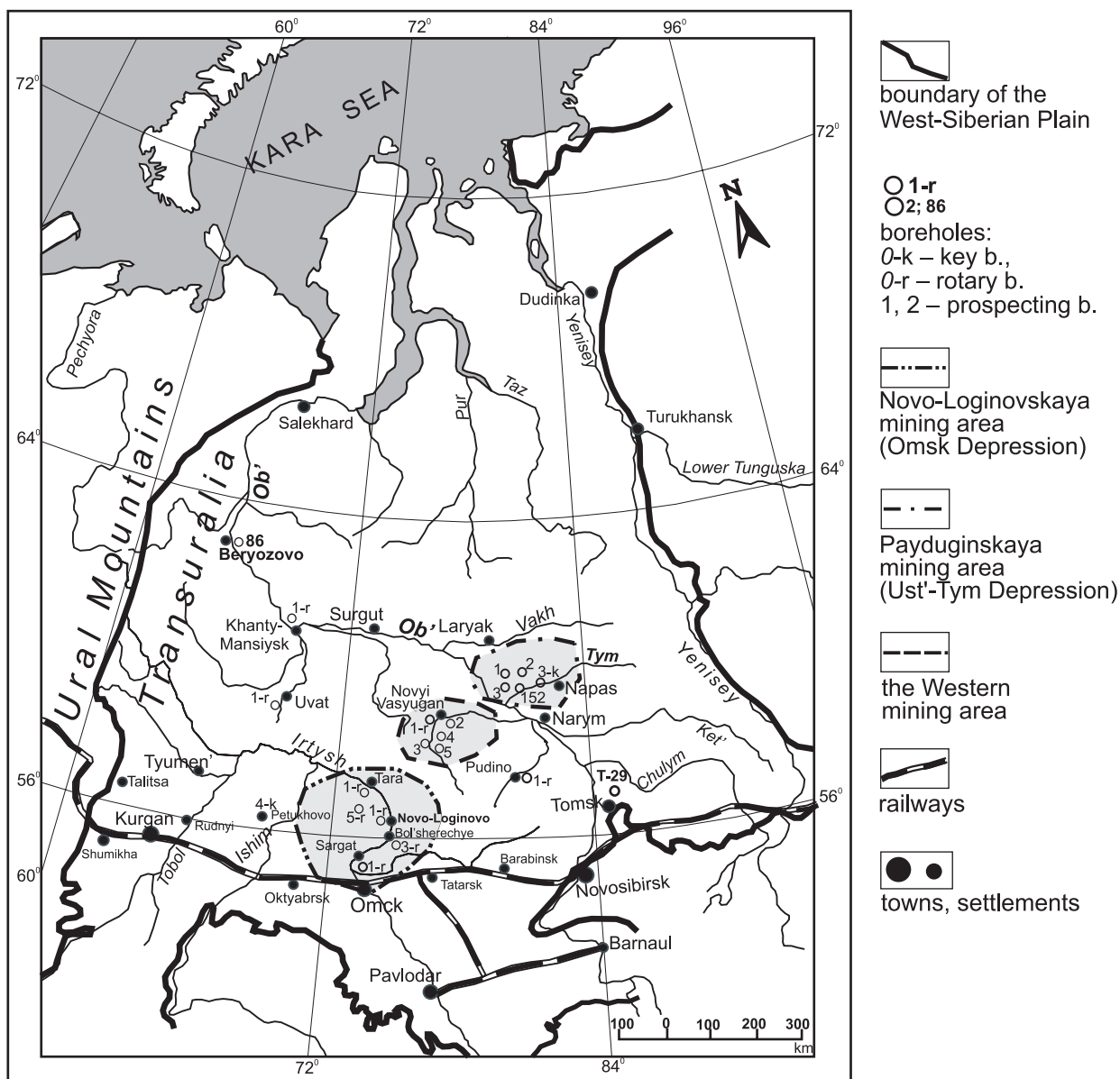
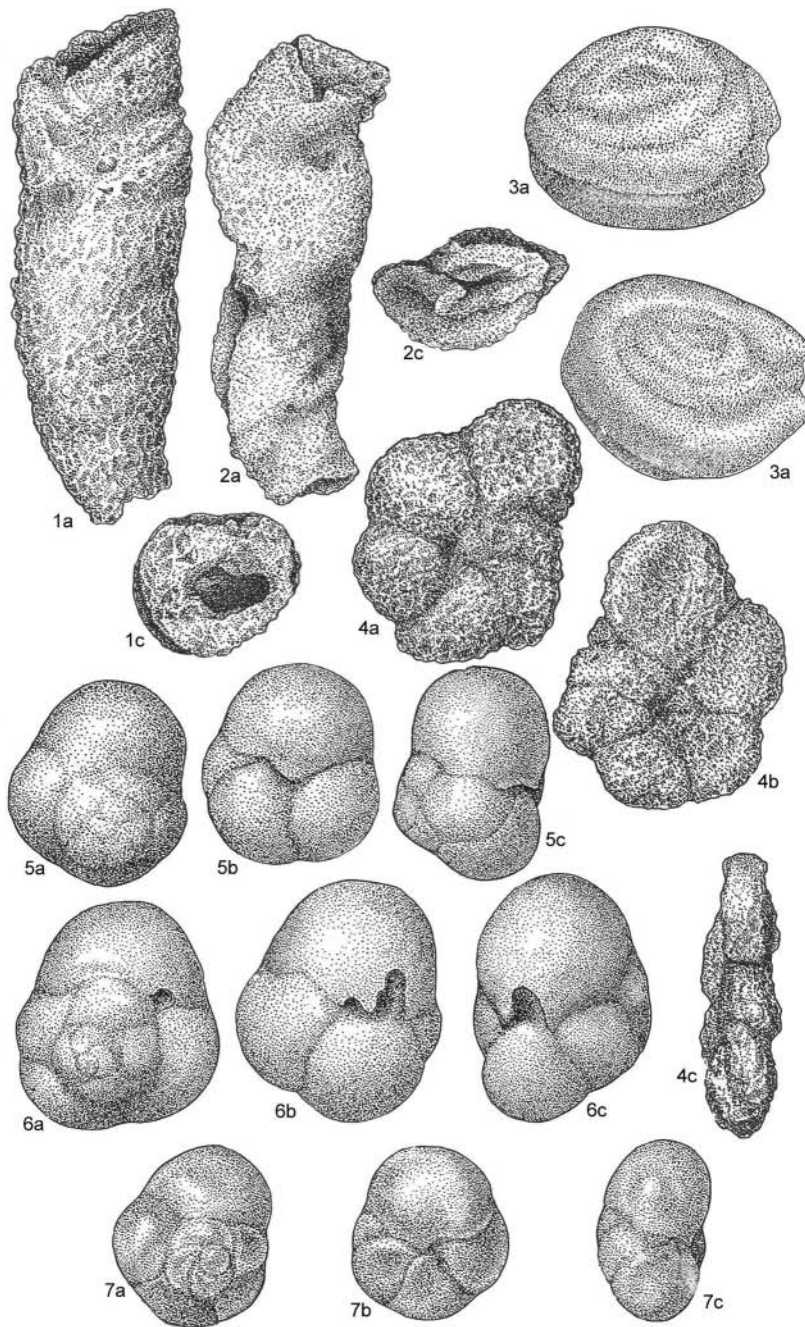


Fig. 1. Locations of the boreholes with sections under study.



**Plate I.** Foraminifers from the upper beds of the Gankinskian Horizon and transitional beds to the Talitskian Horizon (Danian, West-Siberian Plain); borehole 1-r (near Novo-Loginovo), depth 607.55–602.55 m (2 m from the end of the core). All specimens are stored in the Micropaleontological Department of the Paleontological Museum of Tomsk State University.

Figs. 1–2: *Bathysiphon nodosarieformis* Subbotina; specimens 3115, 3116; magnification x100; a – lateral view; c – apertural view.

Fig. 3: *Glomospira charoides* Parker et Jones, specimen 3117, x100; a – lateral view.

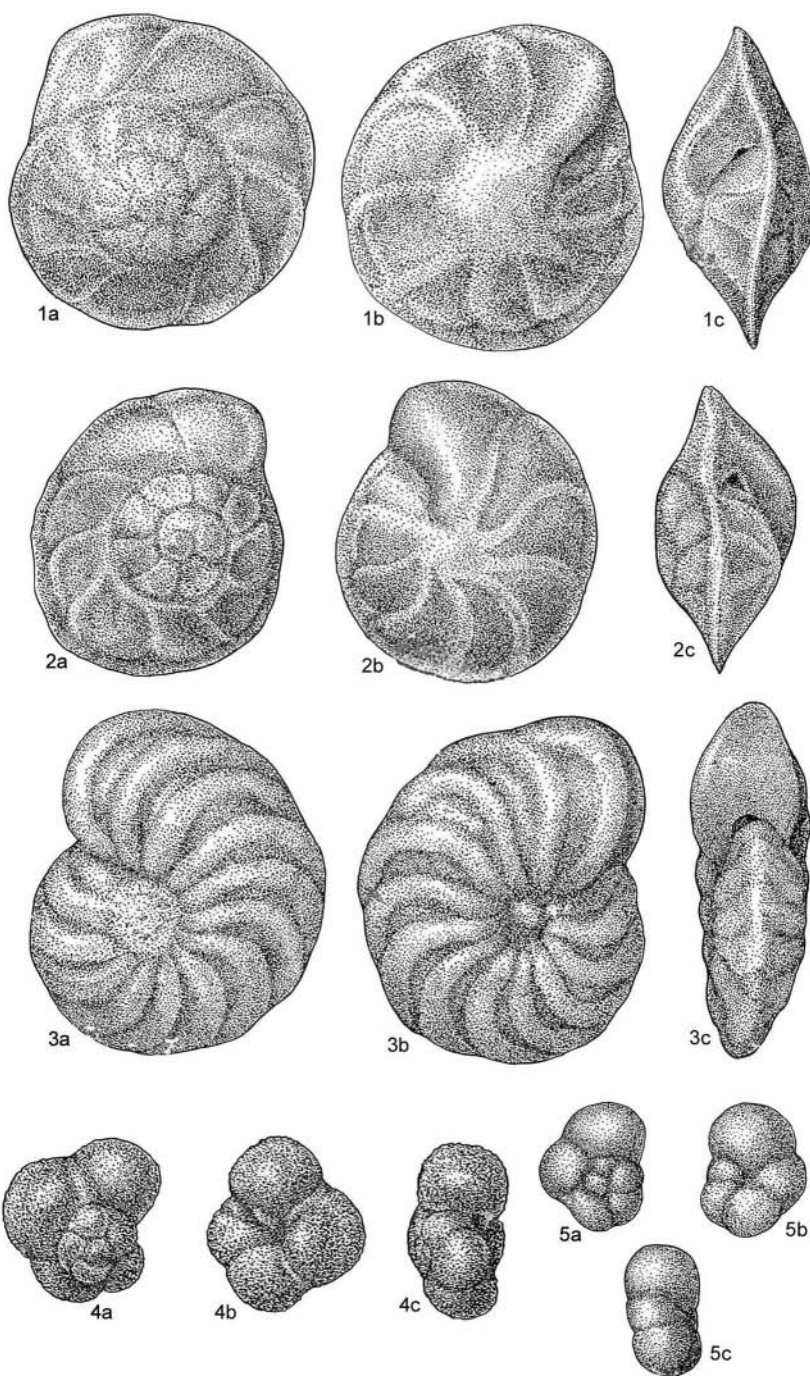
Fig. 4: *Trochammina completa* Lipman, specimen 3118, x60; a – dorsal view; b – ventral view; c – apertural view.

Figs. 5–7: *Allomorphina halli* Jennings, specimens 3118a, 3119, 3120, x100; a – dorsal view; b – ventral view; c – apertural view.

Sargat, Bolsherechye, Tara), as mentioned by Podobina (1998). In the East, Danian beds with the *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage were found in similar deposits of continuous Cretaceous-Palaeogene sections (Podobina, 1990, 2009) (Fig. 1).

In addition, Selandian foraminiferal assemblages and the associated zonal subunits have been studied. The *Ammoscalaria incultus* var. *friabilis* Zone has been described from

the overlying Talitskaya Suite (Lipman et al., 1960; Subbotina, 1964); it was renamed by the present author as the *Ammoscalaria friabilis* Zone (Podobina, 1975). This zone is correlatable in the East (the Ust-Tym Depression) with beds containing the *Cyclammina coksuorovae* assemblage, and in the South-East with beds containing the *Cibicidoides proprius* assemblage, which is also known from numerous sections in the western and central districts of the West-



**Plate II.** Foraminifers from the upper beds of the Gankinskian Horizon and transitional beds to the Talitskian Horizon (Danian, West-Siberian Plain): borehole 1-r (near Novo-Loginovo), depth 607.55–602.55 m (2 m from the end of the core); Magnification x100. All specimens are stored in the Micropaleontological Department of the Paleontological Museum of Tomsk State University.

Figs. 1–2: *Parella lens* Brotzen, specimens 3121, 3122; a – dorsal view; b – ventral view; c – apertural view.

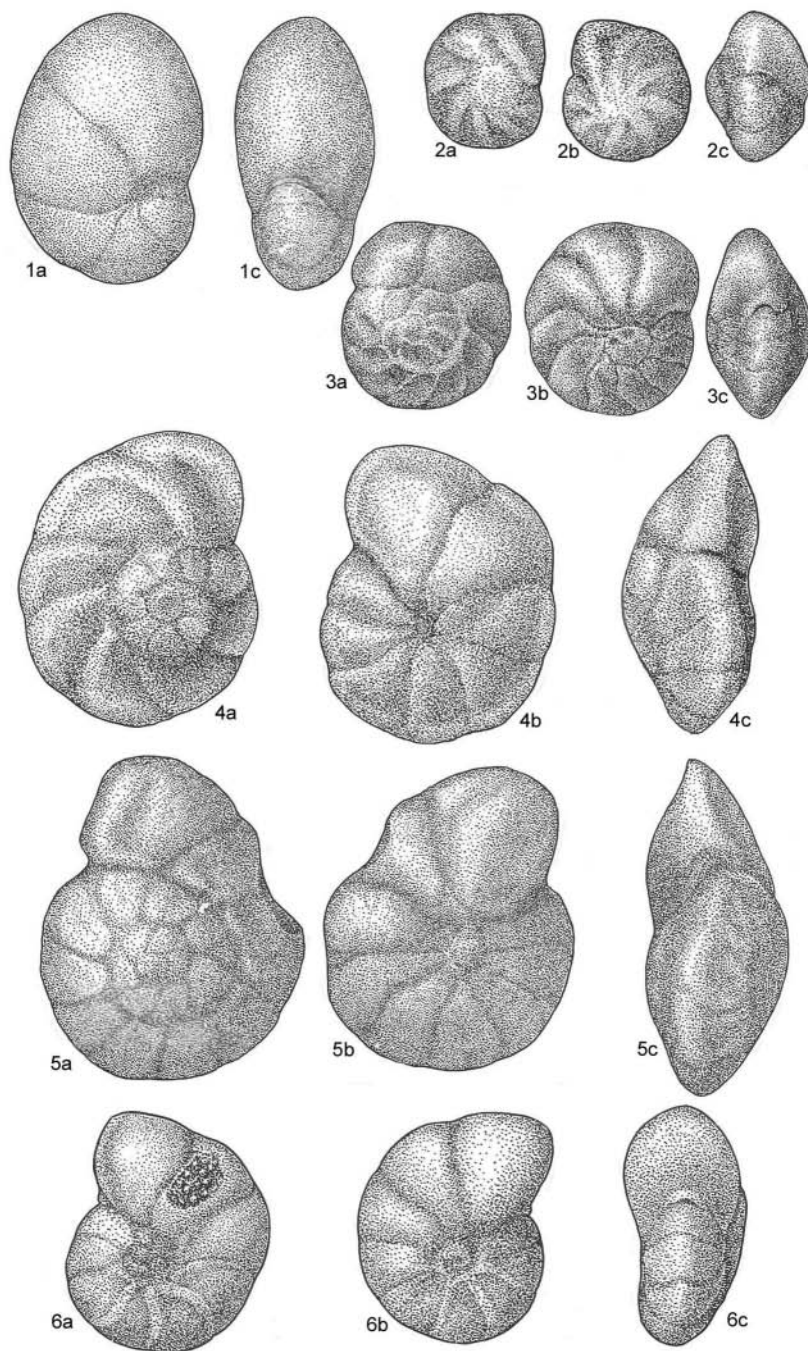
Fig. 3: *Brotzenella praeacuta* (Vassilenko), specimen 3123; a – dorsal view; b – ventral view; c – apertural view.

Figs 4–5: *Subbotina varianta* (Subbotina), specimens 3124, 3125; a – dorsal view; b – ventral view; c – apertural view.

Siberian Plain. All Palaeocene foraminiferal assemblages studied by the present author are depicted in a monograph and some less extensive works (Podobina, 1998, figs 5–14, chapter III; 2003, plates I–VIII; 2008, plates I–III).

The Danian and Selandian zones and the beds with index-species have been revised by the present author. In addition to the Danian-Selandian foraminiferal collections that have been revised by the present author earlier, new

data on foraminiferal occurrences have later become available from the south-eastern area of Western Siberia (borehole T-29 in the surroundings of Tomsk) (Podobina, 2009). The previously studied deposits have been analysed again as regards the transitional Cretaceous – Palaeogene strata from the section of borehole 1-r; this borehole yielded for the first time samples from a depth of 607.55–602.55 m, where two assemblages (the *Brotzenella prae-*



**Plate III.** Foraminifera from the Talitskian Horizon (Selandian, West-Siberian Plain): borehole 1-r (near Novo-Loginovo), depth 607.55–602.55 m (1 m from the beginning of the core); Magnification x100. All specimens are stored in the Micropaleontological Department of the Paleontological Museum of Tomsk State University.

Fig. 1: *Nonionellina ovata* (Brotzen), specimen 3100; a – lateral view, c – apertural view.

Fig. 2: *Cibicides simplex* Brotzen, specimen 3101; a – dorsal view; b – ventral view; c – apertural view.

Fig. 3: *Cibicides mammilatus* Brotzen, specimen 3102; a – dorsal view; b – ventral view; c – apertural view.

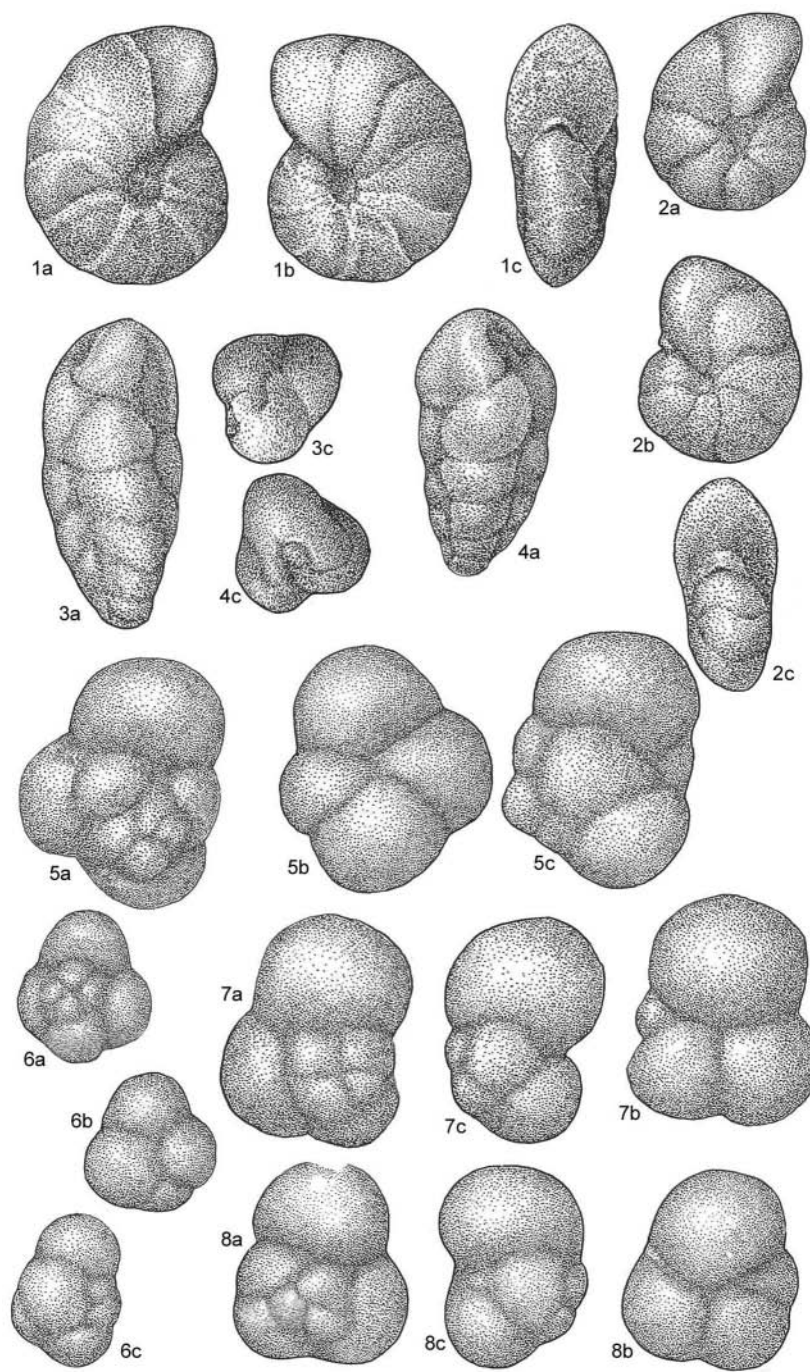
Figs. 4–5: *Cibicidoides proprius* Brotzen, specimens 3103, 3104; a – dorsal view; b – ventral view; c – apertural view.

Fig. 6: *Anomalinooides nobilis* Brotzen, specimen 3105; a – dorsal view; b – ventral view; c – apertural view.

*cuta* and the *Cibicidoides proprius* assemblages) could be distinguished instead of the single Danian-Palaeocene assemblage that had no established index species and that was described by Freiman (1960). Both newly distinguished assemblages are composed mainly of calcareous benthic and planktonic forms (Plates I–IV).

### 3. Results

The “West-Siberian common Danian – Palaeocene” assemblage of foraminifera, originally established by Freiman (1960) from borehole 1-r (deep-water facies of the Novo-Loginovo area), has not been carefully studied, nor have index species been distinguished or described. Podobina (1990, 1998, 2009) has identified this assemblage elsewhere in Western Siberia, how-



**Plate IV.** Foraminifers from the Talitskian Horizon (Selandian, West-Siberian Plain): borehole 1-r (near Novo-Loginovo), depth 607.55–602.55 m (1 m from the beginning of the core).; Magnification  $\times 100$ . All specimens are stored in the Micropaleontological Department of the Paleontological Museum of Tomsk State University.  
 Figs. 1–2: *Anomalinoidea nobilis* Brotzen, specimens 3106, 3107; a – dorsal view; b – ventral view; c – apertural view.  
 Figs. 3–4: *Bulimina paleocenica* Brotzen, specimens 3108, 3109; a – lateral view; c – apertural view.  
 Figs. 5–6: *Subbotina varianta* (Subbotina), specimens 3110, 3111; a – dorsal view; b – ventral view; c – apertural view.  
 Figs. 7–8: *Subbotina triloculinoides* (Plummer), specimens 3112, 3113; a – dorsal view; b – ventral view; c – apertural view.

ever, describing its species composition and establishing *Brotzenella praeacuta* as its index-species, so that the *Brotzenella praeacuta* Zone could be established. This Danian *Brotzenella praeacuta* assemblage was studied by the present author from numerous sections in Western Siberia. The Danian foraminiferal species from borehole 1-r are illustrated in Plates I and II. Among the most characteristic species composing the Danian assemblage from this section

are *Gaudryina gigantea* (Subbotina), *Clavulina parisiensis* d’Orbigny, *Parella lens* Brotzen, *Cibicides spiropunctatus* Gallowey et Morrey, *Anomalina danica* (Brotzen), *Brotzenella praeacuta* (Vassilenko), and *Lenticula inusitata* Kisselman (Podobina, 2009).

In the eastern part of Western Siberia, within the Ust’Tym sections (the Payduginskaya mining area) with the assumed Danian shallow facies, the following species have been re-

corded: *Bathysiphon nodosarieformis* Subbotina, *Glomospira gordialiformis* Podobina, *G. charoides* Parker et Jones, *Trochamminoides lamentabilis* Podobina, *Labrospira granulosa* (Lipman), *Adercotryma horrida* (Grzybowski), *Spiroplectammina* sp. (aff. *S. kazanzevi* Dain) and *Trochammina completa* Lipman. These species jointly form the *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage (Podobina, 1998, 2003, 2008) (Table 2).

Among the calcareous benthic forms of the *Brotzenella praeacuta* assemblage, sparse planktonic species are encountered, which form the basis for the zonal subdivision in the column 'Unified Stratigraphic Scheme, 2001' of Table 2. These Palaeocene zones (including the Danian) of the Boreal Realm have been correlated with the coeval zones of Berggren and Pearson (2005) that contain some common species from the Tethyan Realm.

In the International Stratigraphic Guide (ISG) there are no analogues to the Russian 'beds with fauna (flora)' (in our case 'beds with foraminifers'), which are subsidiary biostratigraphic units. According to the Stratigraphic Code of Russia (2006), chapter VII, Article VII.10, "Beds with fauna (flora) represent deposits containing remains of organisms or com-

posed of them but not conforming the requirements imposed upon a biostratigraphic zone. Such beds are established in deposits where either no remains of organisms are encountered in the underlying and overlapping formations or they are rare in occurrence in them."

The beds with the *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage were primarily established by the present author in borehole 1 (depth 470 m) of the Ust'-Tym Depression (Fig. 1). The assemblage is dominated by primitive forms along with the more advanced species *Trochamminoides lamentabilis* Podobina, *Labrospira granulosa* (Lipman), *Haplophragmoides fastosus* Podobina, and *Adercotryma horrida* (Grzybowski). The *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage was also distinguished in boreholes 2, 3, 152 of the Ust'-Tym Depression (Fig. 1). A foraminiferal assemblage of a somewhat different taxonomical composition was traced in a borehole in the surroundings of Novyi Vasyugan; it was distinguished from the transitional deposits of the Gankinskaya Suite to the Talitskaya Suite, that are composed of the dark-grey compact silty clay. A small number of the species *Ammodiscus glabratus* Cushman et Jarvis, *Glomospira charoides* Parker et Jones, *G. gordialiformis*

series	subseries	stage	zones of planktonic foraminiferas		zones and beds of benthic foraminiferas of western Siberia					
			Tethyan belt	boreal belt	foraminiferal zones (Podobina, 2009)	beds with foraminiferas (Podobina, 2009)				
			Berggren & Pearson (2005)	Unified Regional Stratigraphic Scheme (2001)						
PALAEOCENE	upper	Thanetian	<i>M. velascoensis</i>	<i>Acarinina acarinata</i>	<i>Glomospira gordialiformis</i> , <i>Cibicidoides favorabilis</i>	<i>Glomospira gordialiformis</i> , <i>Cyclammina coksuvorovae</i>				
			<i>Ac. soldadoensis</i> – <i>Gl. pseudomenardii</i>							
			<i>Acarinina subsphaerica</i>							
		middle	Selandian	<i>Gl. pseudomenardii</i> – <i>P. variolaria</i>			<i>Igorina djanensis</i>	<i>Ammoscalaria friabilis</i>	<i>Cibicidoides proprius</i> – <i>Cyclammina coksuvorovae</i>	
				<i>Igorina albeari</i>						<i>Morozovella conicotruncata</i>
				<i>Igorina pusilla</i>						<i>Morozovella angulata</i>
	lower	Danian	<i>P. uncinata</i>	<i>Acarinina inconstans</i>	<i>Brotzenella pralacuta</i>	<i>Bathysiphon nodosarieformis</i> , <i>Glomospira charoides</i>				
			<i>Gl. compressa</i> – <i>Praemurica inconstans</i>							
			<i>Subbotina triloculinoides</i>				<i>Globoconusa daubjergensis</i>			
			<i>P. pseudobulloides</i>				<i>Euglobigerina taurica</i>			
			<i>P. eugubina</i> & <i>G. cretacea</i>							

Table 2. Correlations between planktonic and benthic foraminiferal zones and beds.



Podobina and *Brotzenella* cf. *praeacuta* (Vassilenko) were recorded from these sediments in borehole 4 (depth 415 m; Novyi Vasyugan area, Fig. 1).

In another section of the Novyi Vasyugan area (borehole 5, depth 443 m; Fig. 1), rare occurrences of the *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage, in which primitively arranged species were prevailing, were found in dark-grey silty clays with light-grey sand inclusions: *Bathysiphon nodosarieformis* Subbotina, *Glomospira charoides* Parker et Jones, and *G. gordialiformis* Podobina. In addition, the more advanced forms *Heterostomella* aff. *foveolata* (Marsson) and *Nodosaria aspera* (Reuss) are present.

An assemblage of similarly impoverished composition dominated by sugar-white, primitive forms was recorded from borehole 86 (depth 273–268 m) in northern Transuralia (near Beryozovo) (Fig. 1). Foraminifers of the *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage, including *Bathysiphon nodosarieformis* Subbotina, *Hyperammina inferbulbata* Bulatova, *Ammodiscus glabratus* Cushman et Jarvis, *Glomospira charoides* Parker et Jones, *Cribrostomoides paleogenicus* Podobina, *Recurvoidella lamella* (Grzybowski), *Spiroplectammina kasanzevi* Dain, and *Clavulina parisiensis* d'Orbigny were found in greenish-grey fragmented micaceous clays admixed with grey fine-grained sand. Specimens of the genera *Bathysiphon* and *Spiroplectammina* dominated (up to ten specimens in all five samples; depth 273–268 m); the other species were less common (up to five specimens).

It should be noted that the amounts of species in all studied samples usually do not exceed five specimens. In addition to the index species, *Spiroplectammina kasanzevi* Dain and *Clavulina parisiensis* d'Orbigny were the most characteristic of this part of the borehole section. The presence of relic Late Cretaceous (Late Maastrichtian) species is, obviously, the most characteristic of this assemblage, along with the dominance of the fairly primitive genera *Bathysiphon*, *Hyperammina*, *Ammodiscus*, and *Glomospira*.

The species indicate that the foraminifers lived in a limnic basin under a hydrological re-

gime that was unfavourable for benthic calcareous forms, as opposed to the more deep-water facies of the Omsk Depression and southern Transuralia.

## 4. The Early Palaeocene (Danian)

### 4.1. The *Brotzenella praeacuta* Zone

(Plate I, Figs 1–7; Plate II, Fig. 1–5)

Dain (1961) originally established the *Clavulina parisiensis* – *Anomalina ammonoides* var. *acuta* Zone; Subbotina and Kiselman (1961) later distinguished the *Anomalina praeacuta* Zone. Podobina (1992) re-designated this zone to *Brotzenella praeacuta*.

#### 4.1.1 Lectostratotype

Omsk Depression, near the village of Sargat, borehole 1-r, depth interval 558.83–552.18 m. Clays grey, silty, slightly siliceous. Thickness 6 m.

Zonal assemblage of characteristic foraminifers in the lectostratotype: *Gaudryina gigantica* (Subbotina), *Clavulina parisiensis* d'Orbigny, *Lenticula inusitata* Kisselman, *Parrella lens* Brotzen, *Anomalina danica* (Brotzen), *Cibicides spiropunctatus* Galloway et Morrey, *Brotzenella praeacuta* (Vassilenko).

Along with these benthic foraminifers, other sections of the zone contain sparse planktonic forms, among others *Subbotina varianta* (Subbotina), *S. trivialis* (Subbotina), *S. trilocolinoides* (Plummer). The base of the zone is established by the appearance of the zonal species and by the diagnostic assemblage. Calcareous foraminifers dominate throughout, with Rotaliidae prevailing. The zone is traceable in the uppermost beds of the Gankinskian Horizon and in the transitional beds to the Talitskian Horizon.

#### 4.1.2 Occurrence

The West-Siberian Plain. In the eastern part of Western Siberia (the Ust'-Tym Depression) beds encompassing the *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage correspond to those with the *Brotzenella praeacuta* Zone.

As Subbotina & Kiselman (1961) indicated, the presence of numerous relic Late Maastrichtian forms is characteristic of the foraminiferal assemblages of the Danian of Western Siberia and also for other regions. They reported the presence of two types of the Danian foraminiferal assemblages in Western Siberia. One is characterized by the presence of the above-listed species of planktonic foraminifers. In some sections, they are joined by primitive agglutinated forms. The planktonic forms seem to be absent in the Tym sections, but primitive agglutinated foraminifers are present.

The second Danian assemblage has a more varied composition and includes mostly genera and species of Rotaliidae, Anomaliniidae and other families. The planktonic forms are already present as Danian-Selandian taxa, such as *Subbotina varianta* (Subbotina), *S. trivialis* (Subbotina), and *S. triloculinoides* (Plummer).

#### 4.1.3 Stratigraphic position

The Danian Stage in the lectostratotype of the *Brotzenella praeacuta* Zone. In the East (the Tym Basin), it can be correlated with beds containing *Bathysiphon nodosarieformis* – *Glomospira charoides* assemblage.

The *Brotzenella praeacuta* Zone seems to be correlatable with the Danian zones of planktonic foraminifers of the Tethyan Realm (Interdepartmental Stratigraphic Committee, 2001; Berggren & Pearson, 2005) (Table 2).

## 5. The Middle Palaeocene (Selandian) Talitskaya Suite and Talitskian Horizon

The overlying marine deposits of the Middle Palaeocene are mainly represented by the Talitskaya Suite of the Talitskian Horizon.

The Talitskaya Suite was established in 1955 by Aleskerova and Osyko (Aleskerova et al., 1957). It is composed of dark-grey, sometimes almost black, silty, compact clays. The *in situ* conditions of the suite, its thickness and contacts with the under- and overlying deposits indicate that this suite is not retained in full measure in the eastern part of the Ob-Irtysh in-

terfluve. The thickness of the suite ranges here commonly from 10 to 15 m (the thickness is up to 320 m in the stratotype near the village of Talitsa in the Sverdlovsk Region). The bottom beds of the suite are often completely water-worn, and only its top can be traced in the section.

### 5.1 The central district

In the central district of Western Siberia, the present author studied the Talitskaya Suite in boreholes 1, 4 and 5 of the Novyi Vasyugan area (Fig. 1). The *Ammoscalaria friabilis* assemblage was identified in borehole 1 (depth 600 m). As demonstrated before (Podobina, 1975), the Middle Palaeocene deposits contain the index-species *Ammoscalaria friabilis* (Ehremeeva).

The assemblage from borehole 1 (Novyi Vasyugan area) includes the following species: *Bathysiphon nodosarieformis* Subbotina, *Psammosphaera laevigata* White, *Glomospira gordialiformis* Podobina, *Ammodiscus glabratus* Cushman et Jarvis, *Labrospira granulosa* (Lipman), *Quinqueloculina* aff. *moremani* Cushman et Jarvis, *Q. pulchra* Putrja, *Robulus discus* Brotzen, *Donsissonia laxata* Podobina, *Eponidus lunatus* Brotzen, *Cibicoides proprius* Brotzen, *Evolutononion sibiricus* (Lipman), *Nonionellina ovata* (Brotzen), *Subbotina varianta* (Subbotina), *S. triloculinoides* (Plummer), *Protoglobobulimina ovata* (Brotzen) and others. In addition to agglutinated tests, this assemblage contains calcareous forms (the 11 just-mentioned species, starting with *Quinqueloculina*) of the Selandian *Cibicoides proprius* assemblage, which is widespread in Transuralia.

A large number of species composing this assemblage are known from the Selandian stratotype (island Sjælland or Seeland, Denmark); they were described by Brotzen (1948) from this stratigraphic level in southern Sweden. The West-Siberian taxa were compared with Selandian forms from Denmark by Podobina (1998, 2003, 2008, 2009).

The Selandian foraminiferal species from the borehole 1-r (Novo-Loginovo) are illustrated in Plates III and IV.

### 5.1.1. The Uvat borehole

The most complete section of the Talitskaya Suite (and the Middle Palaeocene) has been studied in the Uvat key borehole, where this suite is 125 m thick, and where it can be divided on the basis of its lithology into an upper and a lower subsuite. The thickness of the lower subsuite approximates 80 m, that of the upper subsuite is 45 m.

The foraminiferal zones established in these subsuites have also different thicknesses. For example, the thickness of the lower beds in the Uvat borehole (the Selandian *Ammoscalaria friabilis* Zone) is 105 m, and that of the upper beds (Thanetian *Glomospira gordialiformis*-*Cibicidoides favorabilis* Zone) is 20 m. Consequently, the upper Thanetian zone of the central district comprises only the uppermost beds of the Talitskaya Suite and the lowermost beds of the Lyulinvorskaya Suite (Podobina, 1998, 2003, 2008).

### 5.1.2. The *Ammoscalaria friabilis* Zone

(Plate III, Figs 1–6; Plate IV, figs 1–8)

The *Ammoscalaria incultus* var. *friabilis* Zone has been established by Lipman (Lipman et al., 1960); then, the *Ammoscalaria incultus* – *Cibicides incognitus* Zone was established by Freiman (1960), afterwards the *Ammoscalaria incultus* Zone was established by Subbotina and Ushakova (Subbotina, 1964), and finally the *Ammoscalaria friabilis* Zone was established by Podobina (1975).

### 5.1.3. Lectostratotype

The Novyi Vasyugan key borehole 1-r, depth interval 584.65–543.44 m. Clays dark-grey, with a greasy feel, slightly siliceous. Thickness 41 m.

The assemblage of characteristic foraminifers in the lectostratotype includes: *Labrospira granulosa* (Lipman), *Haplophragmoides fastosus* Podobina, *Asanospira grzybowski* (Mjatiuk), *Cyclammina coksuvorovae* Ushakova, *Ammoscalaria friabilis* (Ehremeeva), *Ammomarginulina brevis* (Lipman), *Verneuilinoides paleogenicus* (Lipman), *Trochammina pentacamerata* Lipman, and *T. completa* (Lipman) (Podobina, 1998).

The foraminiferal assemblages vary over the numerous sections. In some places, the num-

bers of species are limited and the specimens are poorly preserved; tests are of intermediate or small size. The agglutinated quartz-siliceous benthos amounts to almost 90%. Haplophragmiidae and Trochamminidae dominate.

The base of the zone is established by the appearance of the index species and characteristic species of the assemblage. At the upper boundary, the zone-specific and other species disappear.

## 5.2. Northern Transuralia

In northern Transuralia, the *Ammoscalaria friabilis* assemblage was recorded from a depth of 258–203 m in borehole 86 (near town Beryozovo), where the sediments consist of dark-grey, almost black, compact clay that is fragmented and contains local admixtures of glauconite. Agglutinated foraminifers are dominant in all samples, except those from the depths of 213 m, 208 m and 203 m, where they are sparse. Numerous calcareous forms of the *Cibicidoides proprius* assemblage were found from a depth of 233 m, along with agglutinated foraminifers of the *Ammoscalaria friabilis* assemblage. This species was also found in the bottom and middle parts of the depth range 258–203 m, whereas some calcareous species were traced together with agglutinated forms throughout the whole section of the Talitskaya Suite.

Podobina (2003, 2006, 2008) studied the taxonomy of this assemblage, which resembles, as mentioned, that of the Selandian assemblages from Denmark and Sweden.

### 5.2.1. Borehole 86

In borehole 86, the *Cibicidoides proprius* assemblage of planktonic foraminifers from the lowermost beds of the Talitskaya Suite is the most diverse. A principally similar composition is known from the Omsk Depression (among others the section of borehole 1-r; Fig. 1; Table 1). The deposits with this assemblage are, together with the overlying beds assigned to the *Ammoscalaria friabilis* Zone (Podobina, 1975, 2003).

### 5.3 The Ust-Tym Depression

In the Ust-Tym Depression (boreholes 2, 3, 152; Figure), at this stratigraphic level the beds are traced with a depauperated assemblage of agglutinated foraminifera and large cyclamminas designated by the present author (Podobina, 1990, 1998, 2003) as the *Cyclammina coksuvorovae* assemblage. Beds with this assemblage are correlatable with the Middle Paleocene *Ammoscalaria friabilis* Zone. Farther eastwardly and south-eastwardly, in the vicinity of town Tomsk (borehole T-29) the *Cibicidoides proprius* assemblage was distinguished. This assemblage contains the Selandian characteristic planktonic species *Morozovella angulata* White (Podobina, 2006, 2009).

The Selandian foraminiferal species from the section of borehole 1-r of the Novo-Loginovo area are illustrated by paleontological Plates III and IV.

### 5.4. Occurrence and stratigraphic position

#### 5.4.1. Occurrence

Throughout western Siberia, most of the Talitskaya Suite, including the above zone, is assigned to the Selandian. Beds with the *Cibicidoides proprius* assemblage of the *Brotzenella praeacuta* Zone, established originally by Freiman (1960) from the Novo-Loginovo sections without specification of the index-species, are conventionally assigned to this suite. The present author has demonstrated that numerous species of benthic foraminifera from these beds are also distributed higher up in the Talitskaya Suite section. She re-designated the assemblage of benthic forms to the *Cibicidoides proprius* assemblage, which is also encountered in the Selandian lowermost part of the Talitskaya Suite. The *Cibicidoides proprius* assemblage is composed of the species *Bolivinosia scanica* Brotzen, *Spiroloculina alabamensis* Cushman, *Quinqueloculina pulchra* Putrja, *Discorbinella limbata* (Brotzen), *Donsissonia laxata* Podobina, *D. ornata* Podobina, *Eponides toulmini* Brotzen, *E. lunatus* Brotzen, *Gavelinella umbilicata* (Brotzen), *Cibicides simplex* Brotzen, *Cibicidoides proprius* Brotzen, *Evolutononion sibiricus*

(Lipman), *Nonionellina ovata* (Brotzen), *Protoglobobulimina risilla* (Subbotina), and *Bulimina ovata* (d'Orbigny) (Podobina, 1998, 2009).

Planktonic species have been encountered together with the above benthic forms in the assemblage found in borehole 1-r (Novo-Loginovo) at a depth of 607.55 and 602.55 m; Fig. 1); the species *Subbotina varianta* (Subbotina), *S. trivialis* (Subbotina), *Acarinina* aff. *inconstans* Subbotina have been identified. A study on the *Cibicidoides proprius* assemblage, which is very similar to a Swedish assemblage (Brotzen, 1948), demonstrated that the nearest analogue of the latter had been encountered in borehole 86 (Fig. 1). Beds with the *Cibicidoides proprius* assemblage in this borehole are confined to the lower and middle strata of the Talitskaya Suite.

#### 5.4.2. Stratigraphic position

The Selandian stage in the lectostratotype of the *Ammoscalaria friabilis* Zone correlates with most of the Talitskaya Suite of the Talitskian Horizon.

Along with large Cyclamminae and other agglutinated forms, Podobina (1998, 2003, 2008) has distinguished calcareous benthic foraminifera in the Middle Palaeocene assemblage of the Tym Basin (borehole 3-k); they are the same species as in the *Cibicidoides proprius* assemblage found in the lower beds of the Talitskaya Suite that are widespread over the western part of the West-Siberian Plain. In the eastern part of Western Siberia (the Ust'-Tym Depression), the present author has recognised the beds with *Cyclammina coksuvorovae* confined to the *Ammoscalaria friabilis* Zone.

The *Ammoscalaria friabilis* Zone, which is assigned to the Selandian, seems to correlate with the planktonic foraminiferal zones (Interdepartmental Stratigraphic Committee, 2001; Berggren & Pearson, 2005) (Table 2).

## 6. Conclusions

The study was aimed at Danian-Selandian benthic foraminiferal assemblages and the zonal subunits based on them. Whereas the present author's previous publications have

reported data on the Palaeocene assemblages of agglutinated foraminifers, the present contribution deals with calcareous forms. These tests, collected from borehole 1-r near Novo-Loginovo, are illustrated in Plates I–IV (see also Table 1).

Freiman (1960) has previously established one Danian–Palaeocene (principally Selandian) foraminiferal assemblage from this borehole (from a depth of 607.55–602.55 m) without specifying the index species. The present author has subdivided the sediments of this interval into two zones: a first one (607.55–602.55 m; 2 m from the end of the core) containing the Danian *Brotzenella praeacuta* assemblage (Plates I–II), and a second one (607.55–602.55 m; 1 m from the top of the core of this interval) with the *Cibicidoides proprius* assemblage (Plates III–IV). This sedimentary succession encloses the transition from the Danian to the Selandian and is traced mainly in the central part of western Siberia.

Thus, foraminiferal assemblages and zones of the Danian (Lower Palaeocene) and Selandian (Middle Palaeocene) were established from the complete section of the Novo-Loginovo borehole 1-r.

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