

Cenomanian-Turonian Foraminiferal Zones of West Siberian Province and Their Correlation with Canadian Province

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Abstract

Data on Late Cenomanian and Early Turonian foraminiferal assemblages in the northern palaeo biogeographical district of the West Siberian province are summarized in the paper. In addition, the section of borehole 1016 of the Parusovaya area located in the far north of the province is considered. New information on the foraminiferal zones of this stratigraphic level along with the previously known sections of the Tazovskaya, Purpeiskaya, Van-Eganskaya areas provided an opportunity to carry out a correlation of these zones between the West Siberian and the Canadian provinces (Western Canada, Northern Alaska). The West Siberian Late Cenomanian *Trochammina wetteri tumida*, *Verneulinoides kansasensis* and the Early Turonian *Gaudryinopsis angustus* foraminiferal zones have their analogues as similar zones in the Canadian province. Due to the provided correlation of the micropalaeontological (foraminiferal) zones, their age in the West Siberian province has been clarified. Besides, similarity of the conditions of dwelling within the boundaries of the entire Arctic palaeobiogeographical realm has been observed.

Keywords

Foraminifera, Upper Cenomanian, Lower Turonian Zones, Correlation, West Siberian, Canadian Provinces

1. Introduction

A comparative characteristic of Late Cretaceous West Siberian foraminiferal assemblages and other provinces of the Northern hemisphere has shown that the Cenomanian-Turonian assemblages are significantly distinctive in their systematic composition but correspond to those of the Canadian province (Western

Canada, Northern Alaska) within the boundaries of the Arctic palaeobiogeographical realm [1] [2] [3] [4].

The layers of Cenomanian-Turonian assemblages of Western Siberia had been earlier attributed to the microfaunistic zones (upper Uvatskian, Kuznetsovskian Horizons) by the author of the paper. The assemblages of interest are similar in their systematic composition with time-equivalent assemblages of the analogous zones of Western Canada and Northern Alaska formations attributed to the Canadian province. One should observe a similarity not only at the generic but at specific levels in the Cenomanian and Turonian assemblages. Apparently, it is due to the existence of unimpeded associations between the basins of Western Siberia and Northern America and a similarity of the conditions of existence. In the compared assemblages one can observe almost a general generic composition and a high percent (up to 60%) of similar species, vicariants (geographical substitutes of a related taxon) and geographical subspecies. In all the compared assemblages with the exception of those from the far away areas, agglutinated quartz-siliceous shells are predominant. A similar, specific composition of plankton (pelagic) forms assigned to the lower Turonian stratigraphic level is of great interest. However, a comparison of the Cenomanian-Turonian assemblages of Western Siberia with those of Arctic Canada and the Canadian Arctic Archipelago [5] [6] revealed a considerable impoverishment of the latter, and among the assemblages of Arctic Canada there are no even general generic taxa except primitive forms. It is probably accounted for by a considerable shallowing of the area concerned which brought about unfavourable conditions for the existence of more highly organized foraminifera [1] [2] [3] [4].

The paper concerned presents results of researching Late Cenomanian and Early Turonian foraminifera from this stratigraphical level of northern palaeobiogeographical district of West Siberian province. This is one of the five districts named according to the cardinal points [1] [7] [8]. Late Cenomanian assemblages had been previously studied in the upper parts of the Uvatskian Horizon from the sections of a number of boreholes of the Tazovskaya, Purpeiskaya, Van-Eganskaya areas located southwards just in the same palaeobiogeographical district (**Figure 1**). Continuation of the research of Late Cenomanian and Early Turonian foraminifera in the basin of the northern district is due to the identification of this biota (the Parusovaya area located eastwards Yamal). The present paper describes results of the section studies of this area providing new data on the Cenomanian-Turonian. The correlation of the Cenomanian-Turonian foraminiferal zones of West Siberian and the Canadian provinces within the boundaries of the Arctic realm is provided (see **Table 1**).

2. Previous Research

Research of Cenomanian foraminifera from the Uvatskian Horizon in Western Siberia has been carried out since the 50-s of the last century. Only a fragmentary amount of information on isolated foraminifera in this part of the section has

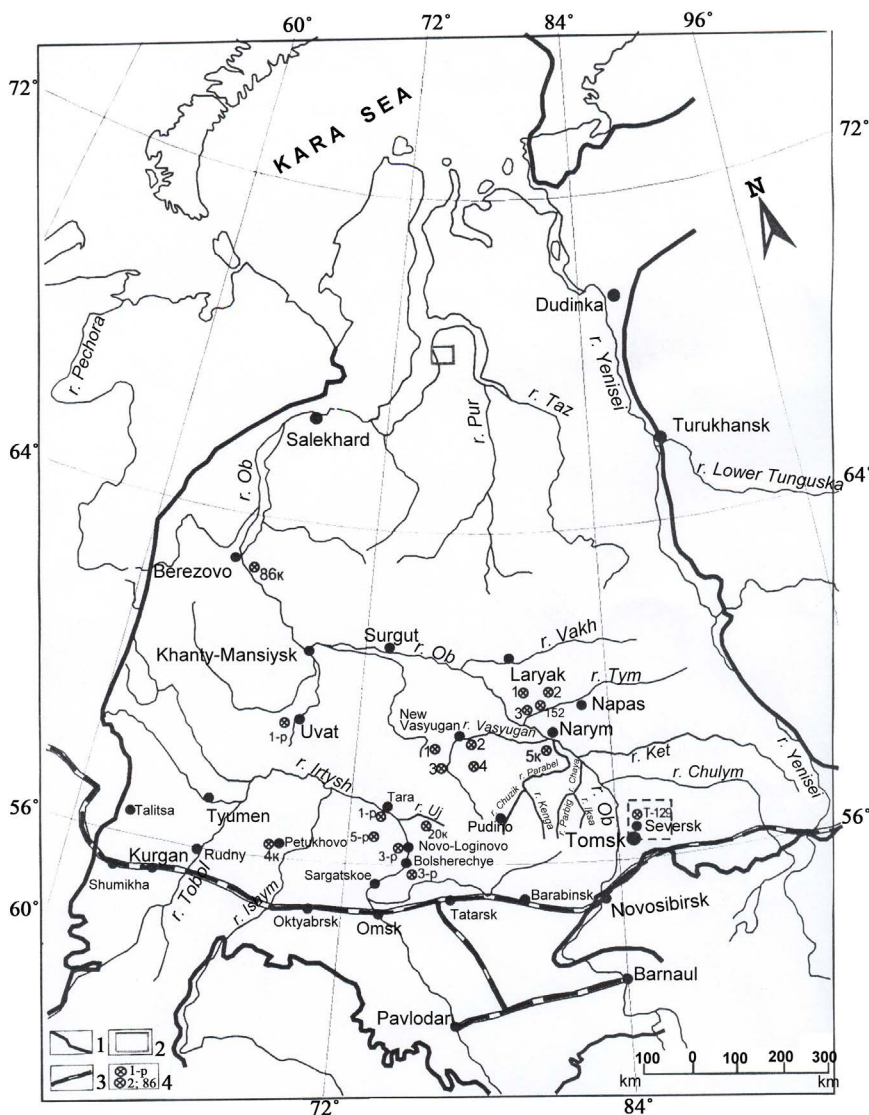


Figure 1. Research district (Parusovaya area). 1: boundary of West-Siberian plain; 2: Parusovaya area; 3: railways; 4: boreholes of various depths.

been provided in the works published by [9] [10] [11] [12]. Findings of Cenomanian foraminifera from the Uvatskian Horizon of Transuralia are mainly well-known. In the northern district they were first discovered by V. M. Podobina in marine deposits of the Uvatskian Horizon [13].

The Uvatskian Horizon in the northern district consists of grey aleurolites and light-grey millstone grit of the marine genesis. The rocks comprise coarse-grained agglutinated quartz-siliceous foraminifera which are practically the only basis for establishing the Cenomanian age of this Horizon.

The foraminifera of Early Cenomanian of seven sections of Van-Egansky area's boreholes have been studied in detail, so in the shallow water facies of the Uvatskian Horizon two foraminiferal zones: *Saccammina micra*, *Ammomarginulina sibirica* (lower zone), *Trochammina wetteri tumida*, *Verneuilinoides kansasensis* (upper zone) with the layers of *Gaudryinopsis nanushukensis* at the

Table 1. Scheme of Cenomanian-Turonian foraminiferal zone correlation of West Siberian and Canadian provinces in Arctic realm.

		Western Siberia		Western Canada		Northern Alaska	
		Podobina (2000, 2009)	Peace River Alberta (Stelck and Wall, 1954, 1955)	Central Alberta (Wall, 1967)	Vermilion Area, Alberta (Nauss, 1947)	Northern regions (Tappan, 1960, 1962)	
Stage	Substage	Formations and members		Formations and members		Formations and members	
	Horizon	Micropaleontological zones	Micropaleontological zones	Micropaleontological zones	Micropaleontological zones	Micropaleontological zones	Micropaleontological zones
Turonian	upper	<i>Pseudoclavulina hastata</i>	Cardium	Cardium	unknown	unknown	Ayiyak member <i>Pseudoclavulina hastata</i> , <i>Arenobulimina (?) torula</i>
	kusnetsovskian		unknown	Opabium member	<i>Pseudoclavulina sp. (P. hastata)</i>		
Cenomanian	lower	<i>Gaudryinopsis angustus</i>	Kaskapau	Haven member	Lloydminster	<i>Rugoglobigerina, Haplophragmoides (?) collyra</i>	Lower member
	uvatskian		Pelagic, <i>Haplophragmoides spiritensis</i>	Blackstone	Vimy member		
	upper	<i>Trochammina wetteri tumida, Verneuilinoides kansasensis</i>	Danvegan	Sunkay member	unknown	<i>Haplophragmoides gigas</i>	Ninuluk
			<i>Ammobaculites pacalis</i>		<i>Verneuilinoides kansasensis</i>		<i>Gaudryina (?) irenensis, Trochammina rutherfordi</i>
			Shaftesbury				

base of the upper zone [7] [8] [14] had been established earlier by the author. In all other areas except the northern area and Transuralia Uvatskian Horizon is represented by continental facies containing plant remains and spore and pollen complexes.

Data on two Turonian foraminifera zones are known in many works of V.M. Podobina [2] [3] [4]. These foraminifera are abundant in the Kuznetsovskian Horizon of a marine genesis throughout the area of Western Siberia.

The determination of the age of the Uvatskian and Kuznetsovskian Horizons is of great practical value because industrial hydrocarbon reserves are assigned to the Uvatskian Horizon and the Kuznetsovskian Horizon is a cap rock which has kept these hydrocarbons from destruction.

3. Material and Methods

Biostratigraphy of upper Cenomanian - lower Turonian deposits of the northern district of Western Siberia has been the object of much experimentation. Twenty core samples selected in the section of borehole 1016 of the Parusovaya area located eastwards of Yamal (**Figure 1**) served as the additional material to study. Foraminifera of various systematic composition represented by agglutinated quartz-siliceous shells were discovered as a result of the microfaunistic analysis.

Systematic composition of Late Cenomanian and Early Turonian foraminifera assemblages in the section of borehole 1016 was distinguished and their stratigraphic significance was established, too. The micrographs (**Figures 2-4**) illustrate several species including index-species of late Cenomanian and two Early Turonian foraminifera assemblages. In **Figure 5** one can see the intervals of depths of core selection in the section of borehole 1016 from the samples of which foraminifera have been extracted.

The boundary between the Uvatskian and Kuznetsovskian Horizons is drawn arbitrarily mainly according to the geological data. The lithological and microfaunistic characteristic of the section being studied is made coincident with the biostratigraphic data of both Horizons as well as the identification of index species of the determined assemblages and the corresponding foraminifera zones (**Figure 5**).

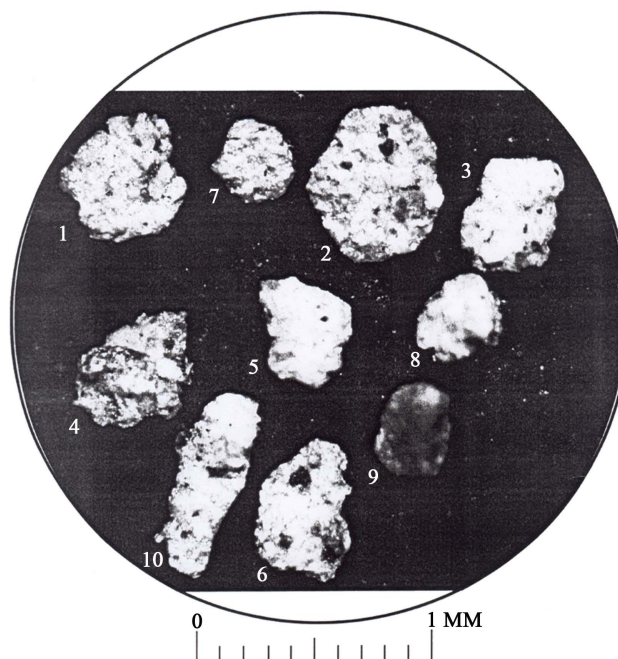


Figure 2. Foraminifera assemblage with *Gaudryinopsis nanushukensis elongatus*. Western Siberia, Parusovaya borehole 1016, interval 1040.5 - 1048.8 m, 1.45 m beginning of core, depth 1041.95 m; Cretaceous system (K), upper part (K₂), Cenomanian stage (K₂cm), upper substage (K₂cm₂), Uvatskian Horizon. 1 - 2: *Haplophragmoides* cf. *variabilis* Podobina; 3 - 6: *Ammomarginulina* cf. *sibirica* Podobina; 7 - 9: *Trochammina* aff. *wetteri* Stelck et Wall *tumida* Podobina; 10: *Gaudryinopsis* aff. *nanushukensis* (Tappan) *elongatus* Podobina.

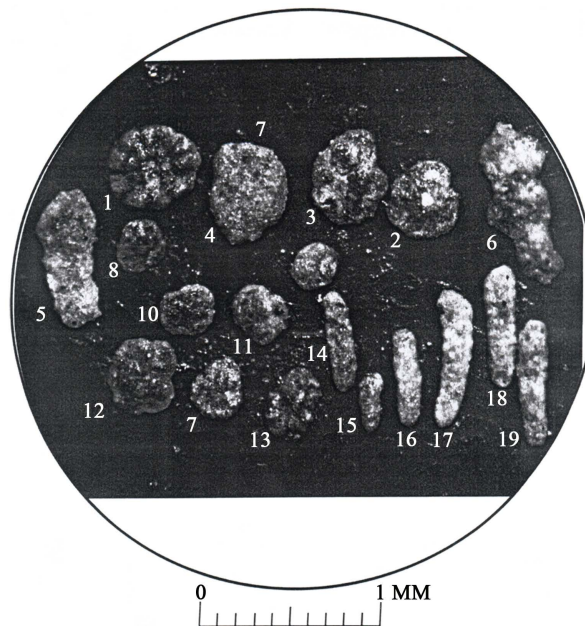


Figure 3. Foraminifera assemblage with *Gaudryinopsis angustus*. Western Siberia, Parusovaya borehole 1016, interval 1012.0 - 1019.9 m, 4.65 m beginning of core, depth 1016.65 m; Cretaceous system (K), upper part (K₂), Turonian stage (K_{2t}), lower substage (K_{2t1}), Kuznetsovskian Horizon. 1: *Labrospira stata* Podobina; 2: *Labrospira collyra* (Nauss); 3: *Haplophragmoides rota* Nauss *sibiricus* Zaspelova; 4: *Asarotamina antisia* Podobina; 5 - 6: *Haplophragmium incomprehensibile* (Ehremeeva); 7 - 12: *Trochammina wetteri* Stelck et Wall; 13: *Trochammina subbotinae* Zaspelova; 14 - 19: *Gaudryinopsis angustus* Podobina.

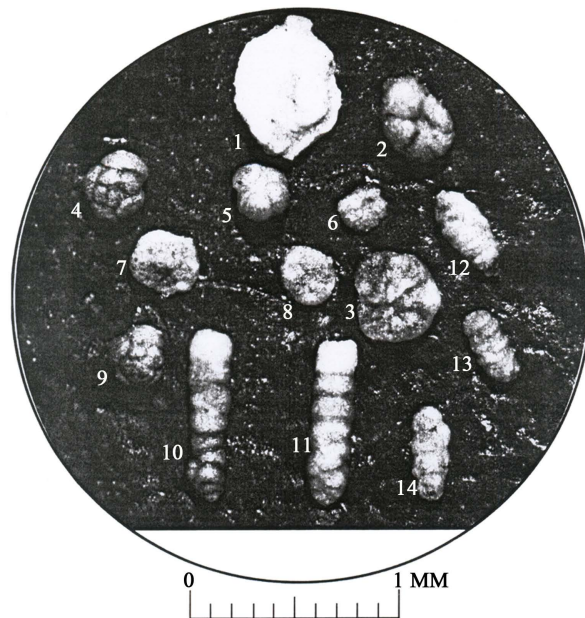


Figure 4. Foraminifera assemblage with *Gaudryinopsis angustus*. Western Siberia, Parusovaya borehole 1016, interval 1012.0 - 1019.0 m, 5.4 m beginning of core, depth 1017.4 m; Turonian stage (K_{2t}), lower substage, Kuznetsovskian Horizon. 1: *Lituotuba cf. confusa* (Zaspelova); 2: *Haplophragmoides crickmayi* Stelck et Wall; 3: *Haplophragmoides rota* Nauss *sibiricus* Zaspelova; 4 - 9: *Trochammina wetteri* Stelck et Wall; 10 - 11: *Pseudoclaulina hastata* (Cushman); 12 - 14: *Gaudryinopsis angustus* Podobina.

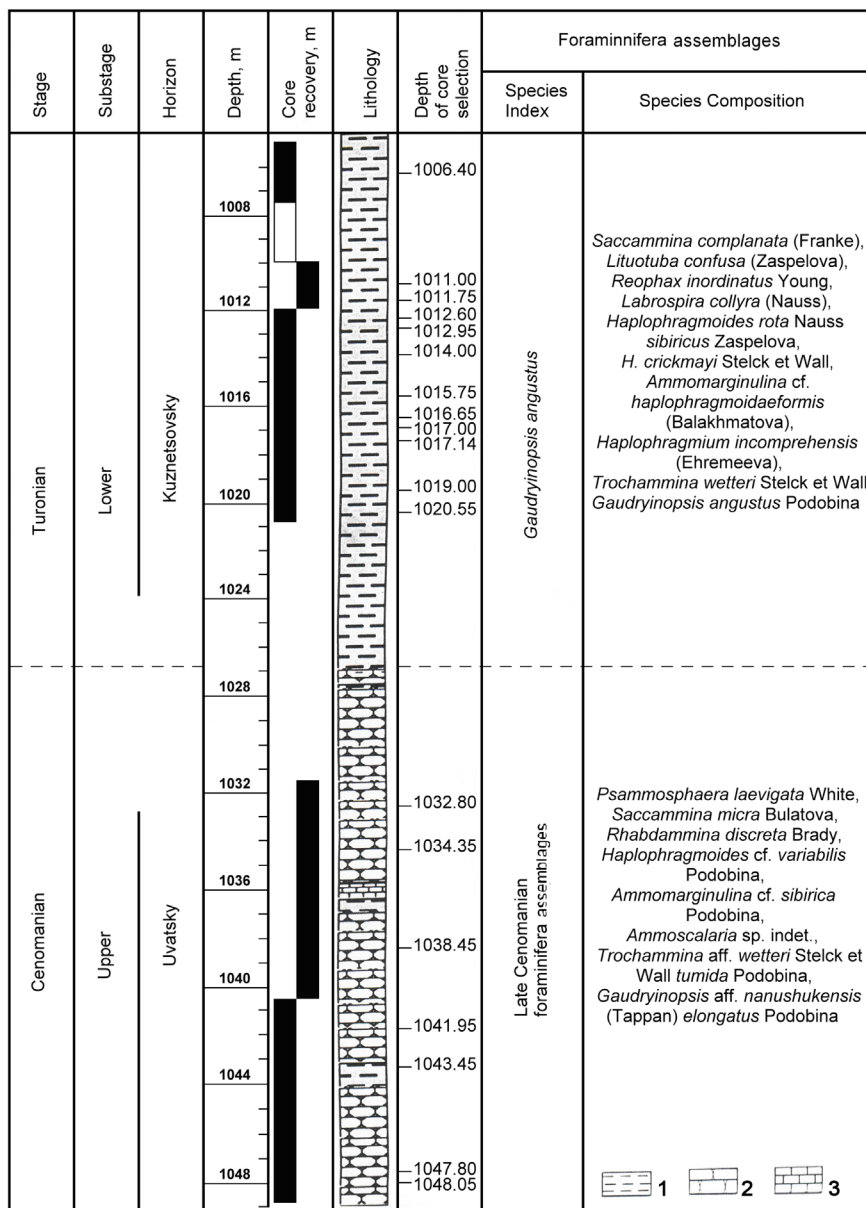


Figure 5. Lithology and microfaunistic Cenomanian–Turonian characteristic of the section of the Parusovaya borehole 1016 (interval 1006.40 m - 1048.05 m). 1: argillite; 2: millstone grit; 3: carbonized millstone grit.

The *Asarotamina* genus previously established by P. Bronniman in the Holocene of the Brazilian shelf was first discovered for Western Siberia in the lower Turonian stage of the Parusovaya area.

A new Early Turonian species of the genus concerned—*A. antisa* Podobina is different from the standard Holocenian one and is found in the lower Turonian stage in the north [7].

Assemblage with *Gaudryinopsis nanushukensis elongatus* of Late Cenomanian discovered in the section of borehole 1016 of the Parusovaya area differs from that of Van-Eganskaya and other areas [14]. It is significantly impoverished in

its systematic composition, agglutinated quartz-siliceous shells of separate species are poorly preserved, and it is not easy at all to establish index-species and characteristic accompanying species.

Early Turonian assemblage with *Gaudryinopsis angustus* established almost in all the selected samples of the section of borehole 1016 from the bottom of the Kuznetsovskian Horizon is diverse, and index-species is predominant. This assemblage is identical with the complexes studied by V. M. Podobina in many sections of Western Siberia [2] [3] [7]. Background information of the foraminiferal assemblages and Cenomanian-Turonian biostratigraphy of the section, borehole 1016 of Parusovaya area in the far North of West-Siberian province (northern district) which comes close to the micropalaeontological zones of the Canadian province was added for comparison.

4. Results of Investigation

4.1. Cenomanian and Turonian Biostratigraphy

4.1.1. Cenomanian Stage

Cenomanian stage and its deposits of marine genesis in the northern district were first distinguished by V.M. Podobina [13] on the basis of the finds of distinctive *Inoceramus pictus Sowerby* and foraminifera. Later on, Cenomanian foraminifera assemblages were discovered in the sections of the Uvatskian Horizon in other areas of the northern district. They suggest marine conditions of deposits' formation due to the emergence of Late Cenomanian boreal transgression [8]. Late Cenomanian foraminifera of seven sections of boreholes of the Van-Eganskaya area [14] had been previously studied in detail. In the section of borehole 1016 of the Parusovaya area being studied only the layers with *Gaudryinopsis nanushukensis elongatus* of the bottom of the upper zone—*Trochammina wetteri tumida*, *Ammobaculites kansasensis* earlier established for the part of the section concerned have been traced.

Upper Substage Uvatskian Horizon

From the rocks with the interval 1031.5 - 1048.8 m (borehole 1016) eight samples from noncalcareous grey aleurolites with sublayers of light-grey millstone grit traced have been selected. Grains of quartz, mica plates, separate agglutinated big-grained foraminiferal shells, black chitinous shell linings in the form of imprints of their former chambers are predominant in the washed-out big-grained fractions. Most of foraminifera shells from the Uvatskian Horizon of the area concerned are poorly preserved so that species character is difficult to distinguish. Along with the indicated remains of organisms, yellowish fragments of diatomaceous flora in the form of small rounded disks are encountered.

In all 8 samples selected from the Uvatskian Horizon hardly distinguishable remains of foraminiferal shells are predominant. Along with them, however, the species of Late Cenomanian mainly without species determinations—*Haplophragmoides*, *Ammomarginulina*, *Trochammina*, *Verneuilinoides*, *Gaudryinopsis* were established among well preserved forms. Along with them, index-species of

one of the assemblages—*Gaudryinopsis nanushukensis elongatus*—was distinguished (Figure 2).

In some samples studied the following species—*Psammosphaera laevigata* White, *Saccamina micra* Bulatova, *Rhabdammina discreta* Brady, *Haplophragmoides cf. variabilis* Podobina, *Ammomarginulina cf. sibirica* Podobina, *Ammoscalaria* sp. indet, *Trochammina aff. wetteri* Stelck et Wall *tumida* Podobina, *Gaudryinopsis aff. nanushukensis* (Tappan) *elongatus* Podobina are determined. Flattened remains of the shells of *Ammomarginulina* and *Trochammina* genera are the most numerous ones.

Separate pseudomorphoses of calcareous shells of foraminifera Rotaliida order and ostracoda are established. It is necessary to update data on foraminifera and stratigraphy of Cenomanian-Turonian northern district of Western Siberia because industrial and renewable hydrocarbon reserves are assigned to this part of the section.

4.1.2. Turonian Stage

Lower Substage Kuznetsovskian Horizon

Well-preserved agglutinated quartz-siliceous foraminifera were discovered in 12 samples from the interval 1005.0 - 1019.9 m of the section (borehole 1016). Lithologically, the samples are represented by noncalcareous dark-grey argillite of the Kuznetsovskian Horizon. In the sample at depth 1016.4 m remains of bivalve shells as well as foraminifera were found. In Early Turonian assemblage together with *Gaudryinopsis angustus* Podobina the representatives of *Haplophragmoides*, *Trochammina* and *Gaudryinopsis* genera are predominant, the number of index-species of shells in some samples attaining 50 and more specimens. In addition to *Trochammina wetteri* Stelck et Wall, this species significantly prevails in terms of quantity over other species. The species composition of the assemblage together with index-species *Gaudryinopsis angustus* is the following: *Psammosphaera laevigata* White, *Saccamina complanata* (Franke), *Lituotuba confusa* (Zaspelova), *Reophax inordinatus* Young, *Labrospira collyra* (Nauss), *Haplophragmoides rota* Nauss *sibiricus* Zaspelova, *H. crickmayi* Stelck et Wall, *Asarotamina antisa* Podobina, *Ammomarginulina haplophragmoideaformis* (Balakhmatova), *Haplophragmium incomprehensibile* (Ehremeeva), *Trochammina subbotinae* Zaspelova, *Trochammina wetteri* Stelck et Wall, *Gaudryinopsis angustus* Podobina, *Pseudoclavulina hastata* (Cushman), *Uvigerinammina manitobensis* (Wickenden). Shells with the exception of completely white azarotammin and lituotrub are of light-grey colour with a predominant fine-grained structure of the wall. Among the enumerated species for the part of the section concerned (lower Turonian), *Ammomarginulina haplophragmoideaformis* (Balakhmatova), *Uvigerinammina manitobensis* (Wickenden), *Gaudryinopsis angustus* Podobina are the most characteristic ones. In the assemblage *Trochammina* and *Gaudryinopsis* are predominant which suggests relatively deep-water and favourable conditions of existence. In one sample at depth 1019.6 m foraminifera shells are coarse-grained, index-species is individual. By

and large, the assemblage, however, is Early Turonian although the conditions of shells' dwelling at the indicated depth were less favourable as compared with Early Turonian foraminifera associations lying above. (**Figure 3** and **Figure 4**)

In sample at depth 1019.6 m remains of bivalve shells as well as foraminifera were found.

Unfortunately, between the selection depth of the lower sample from the Kuznetsovskian Horizon and the samples from the upper parts of the Uvatskian Horizon a significant interval in core selection is observed and therefore, we did not manage to trace the boundary between the indicated horizons and hence that of the lower Turonian and upper Cenomanian stages (**Figure 5**).

The boreal transgression which began in Late Cenomanian significantly expanded in Early Turonian and occupied the territory of not only the Parusovaya area being studied but spread all over Western Siberia: in the south it came to the Kazakhstan hills, in the west-up to the Urals, and in the east it is observed up to the meridian of Napas settlement (on the Tym river) [15]. The hydrological regime (depth, temperature, chemical composition of water and other factors) was favourable for a widespread foraminiferal development of Early Turonian assemblage with *Gaudryinopsis angustus*.

5. Results of the Research

Twenty core samples selected from the section of borehole 1016 of the Parusovaya area have been studied. From each sample of the section concerned mainly represented by grey aleurolites and millstone grits (the Uvatskian Horizon) and dark-grey argillites (the Kuznetsovskian Horizon) agglutinated quartz-siliceous foraminiferal shells have been discovered. Late Cenomanian foraminifera were determined in the Uvatskian Horizon. **Figure 2** illustrates the Late Cenomanian foraminiferal assemblage at depth 1041.95 m. As opposed to the other samples selected from the Uvatskian Horizon, the foraminiferal assemblage with *Gaudryinopsis nanushukensis elongatus* has been established here. In the other sections of the northern palaeobiogeographical district (Van-Eganskaya area) [14], the layers with this assemblage are the bottom of Late Cenomanian zone with *Trochammina wetteri tumida*, *Verneuilinoides kansasensis*. In the section of the Uvatskian Horizon, borehole 1016 of Parusovaya area (interval 1032.8 - 1048.05 m) poorly preserved agglutinated foraminifera has been found in other specimens. Therefore, **Figure 5** ("index-species" column) shows a general Late Cenomanian foraminiferal assemblage without indicating the index-species of the upper zone.

In contrast to the Late Cenomanian, shells of Early Turonian foraminifera assemblage are well-preserved, and have been found their characteristic species, including *Gaudryinopsis angustus* Podobina index-species. According to the number of specimens in the assemblage, the representatives of Ataxophragmiida order are predominant which is indicative of a favourable hydrological regime of a marine basin (depth, temperature, salinity, gas composition) which is asso-

ciated with deepening and expanding Early Turonian boreal transgression.

This transgression, as contrasted to the Late Cenomanian one, occupied almost in the entire territory of Western Siberia that contributed to the foraminiferal assemblage development together with *Gaudryinopsis angustus* encompassing all species characteristic of the Kuznetsovskian Horizon.

Figure 3 and **Figure 4** illustrate the main species of the assemblage concerned from borehole 1016 (**Figure 3**, depth 1016.65 m, **Figure 4**, depth 1017.4 m). The encompassing deposits of the interval which refers to the Kuznetsovskian Horizon (interval 1006.4 - 1020.55 m) as evidenced by foraminifera, correspond to lower Turonian (the lower part of the Kuznetsovskian Horizon) and are a good biostratigraphic reper.

The correlation of the Late Cenomanian-Turonian foraminiferal (micropalaeontological) zones of West Siberian and the Canadian provinces within the boundaries of the Arctic palaeobiogeographical realm is provided (see **Table 1**).

Micropalaeontological zones of the Cenomanian-Turonian of the West Siberian province correspond to those of the Canadian province (Western Canada, Northern Alaska), which suggests a similarity of the conditions of their dwelling. Taxa (genera, species) of agglutinated quartz-siliceous forms are predominant. In the lower Turonian of the Canadian province a layer of pelagic forms (Pelagic, genera *Hedbergella*) has been observed. Just the same layers have been found at this stratigraphic level within the range of some sections of boreholes (borehole 1002, the Van-Eganskaya area, etc.) of the northern district of the West Siberian province.

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