Palaeogene agglutinated foraminifera of the West Siberian biogeographical province

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ABSTRACT

A comparison has been made between West Siberian and Arctic Canadian microfossil assemblages, in particular, of quartz-siliceous agglutinated foraminifera from the Talitsky and Lyulinvorsky horizons with similar ones from Reindeer and Richards Formations. Based upon their similarity in taxonomic composition, these areas have been assigned to the same circum-polar Arctic biogeographical region as separate West Siberian and Canadian provinces. Within the Arctic Region, a change from agglutinated to calcareous foraminifera is observed in marine Palaeogene sequences in both provinces. This change is attributable to events of the palaeogeographical variations offered by American investigators (McNeil, 1990 and others). According to their data the Palaeocene-Eocene Arctic "gulf" had almost no connection with the Atlantic Ocean, and endemic agglutinated foraminifera developed in isolation. The Eocene/Oligocene boundary was marked by major tectonic and palaeobiological changes. Since the Oligocene, the Arctic "gulf" has turned into the present-day Arctic Ocean as a result of sea-floor spreading between Greenland and Norway (Briggs, 1987; McNeil, 1990, 1997). Owing to the establishment of marine connections between the Arctic and Atlantic Oceans at the Eocene/Oligocene boundary, endemic agglutinated foraminifera were replaced by calcareous benthic foraminifera, similar to those in Western Europe. The occurrence of Oligocene planktonic and benthic calcareous foraminifera in the Tavdinsky horizon of Western Siberia and only benthic foraminifera in the Kagmallit Formation of Arctic Canada may be explained by their migration from the Atlantic Ocean owing to the formation of wide and deep strait between Greenland and Norway (McNeil, 1990; Podobina, 1997, 1998).

INTRODUCTION

Diverse groups of micro-organisms including agglutinated foraminifera have been studied from marine Palaeogene sections of Western Siberia for many decades (Ushakova, 1957, 1959; Lipman *et al.*, 1960; Lipman, 1997; Freiman, 1960, 1969; Kiselman, 1978; Podobina, 1975, 1988, 1990, 1996, 1997, 1998) (Figure 1).

A number of problems in the dating of local strata arose because of the endemism of quartz-siliceous agglutinated foraminifera that widely occur within Western Siberia and the fact that planktonic forms are only found at specific levels. The age assignment of the Tavdinsky horizon - the upper sequence of the marine Palaeogene - especially gave rise to much controversy. This unit is correlated to the Lower Oligocene level of the International Common Scale according to foraminifera (Ushakova, 1957, 1959; Freiman, 1969; Podobina, 1975, 1988, 1998) and ostracoda (Lubimova *et al.*, 1960); but to the Upper Eocene according to spore-pollen assemblages, dinocysts (Kulkova, 1987), diatoms and silicoflagellates (Gleser, 1986).

Discussion of Stratigraphy and Paleobiogeography

The age of the lowest Palaeogene stratum - the Talitsky horizon - became more definite as a result of finding endemic quartz-siliceous agglutinated foraminifera together with calcareous forms similar to those known from Palaeocene deposits in Western Europe and the Zauralie (the area near the eastern slope of the Urals) (Podobina, 1990). Some typical calcareous benthic foraminifera (*Cibicidoides favorabilis*) occur in the Turgai Strait (Sarbai quarry) commonly with planktonic forms (*Acarinina subsphaerica* and others) (Podobina & Amon, 1992). The Palaeocene age of the Talitsky horizon is therefore well documented and established by many investigators. The age of middle part of marine Palaeogene section – the Lyulinvorsky horizon - containing agglutinated foraminifera and radiolaria is also disputable. It is divided from bottom to top into three subhorizons, or according to Shatsky (1989) into three independent horizons bearing the names Serovsky, Irbitsky, and Nyurolsky.

New methods had to be found for determining the age of the Lyulinvorsky horizon and its subhorizons as well as the overlying Tavdinsky horizon. First of all, it was necessary to determine the biogeographical affinities of the West Siberian Province during the Palaeogene.

The author ascertained that a comparison of West Siberian microfossil assemblages, in particular, foraminifera from these horizons had to be

In: Hart, M.B., Kaminski, M.A., & Smart, C.W. (eds) 2000. Proceedings of the Fifth International Workshop on Agglutinated Foraminifera. *Grzybowski Foundation Special Publication*, 7, 387-396.

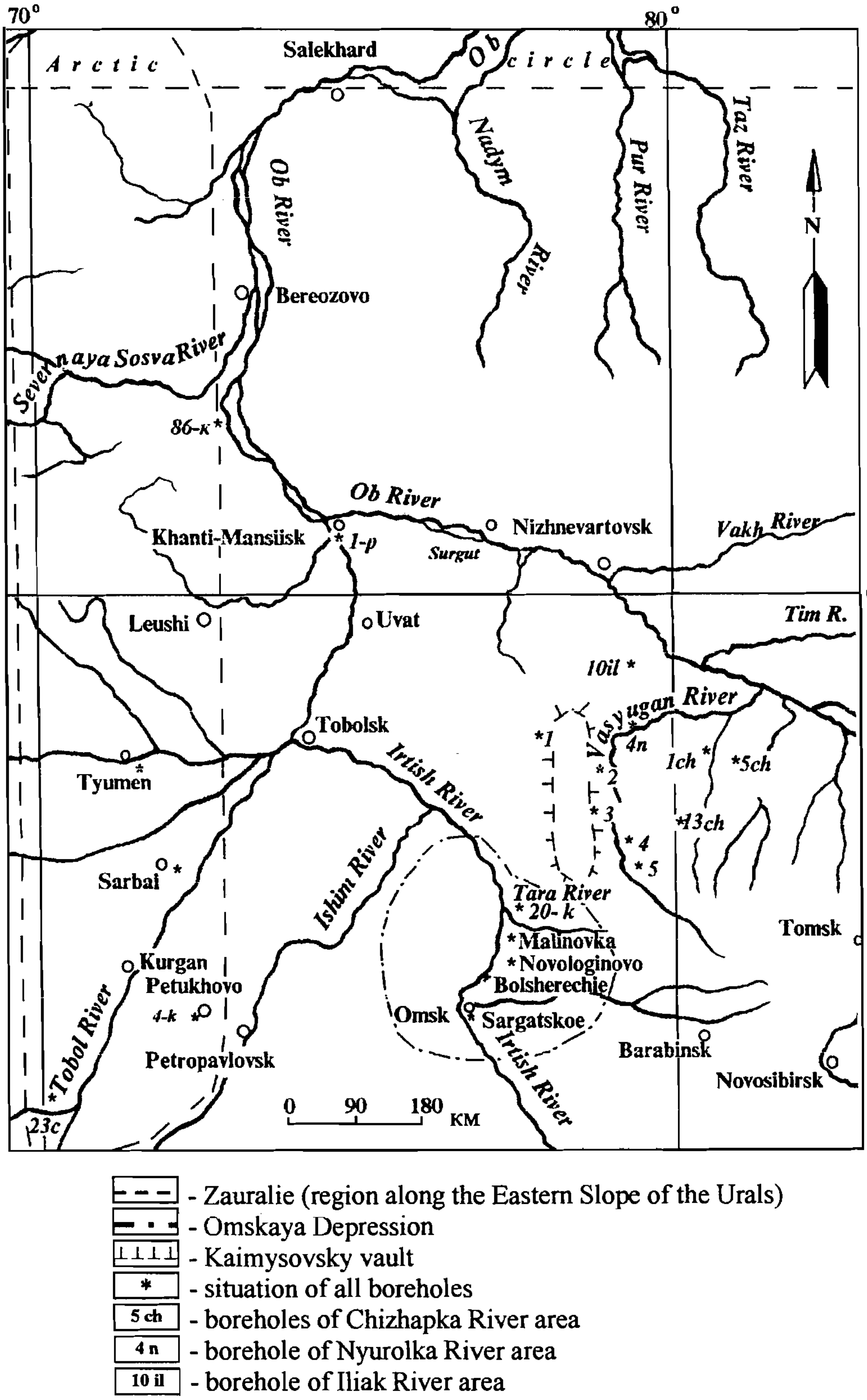

Figure 1. Locality map of the studied localities and boreholes in the West Siberian Plain.

carried out with analogous assemblages from Arctic Canada, Alaska, and the adjoining areas of the Arctic. Similarity in taxonomic composition throughout these areas suggested a single Arctic circum-polar biogeographical region. Assemblages of quartz-siliceous agglutinated foraminifera from the Talitsky and Lyulinvorsky horizons are not comparable with those from European sections which form part of the Boreal-Atlantic region and differ by the presence of calcareous secreted and agglutinated forms of the same chemical composition.

In both the Talitsky to Lyulinvorsky horizons in Western Siberia and the Reindeer to Richards Formations in Arctic Canada, a change from agglutinated foraminifera to secreted calcareous forms was distinctly observed within the marine Palaeogene sections in the Arctic region (Podobina, 1975, 1988, 1997, 1998; McNeil, 1989, 1990, 1997). After studying changes in foraminiferal assemblages within the marine Palaeogene section, North American investigators deciphered tectonic and oceanic events in the following way: Marine circulation was restricted during the Palaeocene and Eocene in the Arctic basin, including Western Siberia. This created conditions required for the development of endemic agglutinated foraminiferal populations. Palaeogeographic reconstructions offered by North American investigators (Briggs, 1987; McNeil, 1990, 1997) have shown that the configuration of the Palaeocene-Eocene Arctic Ocean differed considerably from its present-day analogue and was thus named the "Arctic Gulf" by McNeil (1990). It is seen from this palaeogeographical reconstruction that the Arctic Gulf had almost no connection with the Atlantic basin, as Greenland and Norway were divided by narrow shallow-water straits that served apparently as an ecological barrier for the migration of calcareous foraminifera from the Atlantic basin and vice versa. The Arctic Gulf extended through Western Siberia and was only intermittently connected with the southern seas through the narrow Turgai Strait (Figure 2).

Microfaunal assemblages from Arctic Canada and the Arctic were documented earlier by Petracca (1972), Staplin (1976), Young & McNeil (1984) and McNeil (1985, 1989, 1990, 1997). Their studies indicate that endemic agglutinated foraminifera of the Arctic Gulf were developing in isolation during the Palaeocene-Eocene phase of Arctic marine history. Three notable transgressive cycles are observed in the Arctic Gulf territory, dated as Late Palaeocene, Early Eocene, and Middle to Late Eocene (McNeil, 1990). Three levels of development of planktonic foraminfera correspond to these transgressive cycles in the territory of Western Siberia (Figure 2). Two of these levels are relatively widespread here (possibly, Ypresian and Priabonian). Palaeocene planktonic foraminifera are distributed locally and in single sections (Novologinovo and others) in the southwest part of Siberia (the Omskaya depression) (Figure 1). The interpretation of the oxygen isotope records reveals a gradually decreasing temperature from 10°C in the Early Eocene to 5°C by the Eocene/Oligocene boundary (McNeil, 1990). The transition from the Eocene to the Oligocene is marked by large tectonic and considerable biological changes in the Northern hemisphere (Pomerol & Premoli-Silva, 1986). Since the Oligocene, the Arctic Gulf has turned gradually into the present-day Arctic ocean as a result of sea-floor spreading between Greenland and Norway (Briggs *et al.*, 1987). Marine connections were established and gradually expanded between the Arctic and Atlantic Oceans. As indicated earlier, Palaeocene-Eocene agglutinated foraminifera were replaced within the Arctic region at this boundary by calcareous secreted species, more similar to Western European ones.

The occurence of calcareous benthic foraminifera in formations such as the Oligocene Kugmallit Formation of Arctic Canada is explained by their migration from the Atlantic Ocean thanks to the establishment of a wide and deep strait between Greenland and Norway (McNeil, 1990). This also promoted marine conditions suitable for calcareous benthic foraminifera in the territory of Western Siberia (Podobina, 1989, 1996, 1997, 1998).

As indicated earlier, the underlying Eocene deposits (Lyulinvorsky horizon) as well as Oligocene ones include, in contrast to the Arctic sections, two levels of planktonic foraminifera corresponding apparently to periods of transgression that broadened marine connections into the Arctic Gulf. The first level is represented mainly by flattened *Planorotalites* (*P. pseudoscitulis*, *P. planoconicus*) and *Acarinina pentacamerata.* These occurrences are confined to the upper layers of the Lower Lyulinvorsky subhorizon and are typical of the Early Eocene. Additionally, *Anomalinoides ypresiensis* (ten Dam) *ovatus* Podobina – a characteristic species of the Ypresian stage, was found in the calcareous benthic assemblage. In the second level, the planktonic foraminifera *Globigerina officinalis* Subbotina (a Late Eocene species), was found by Kiselman (1978) in the eastern part of Western Siberia within the lower layers of the Upper Lyulinvorsky subhorizon (the Nyurolsky horizon of S.B.Shatsky). I have observed it in the basin of the Chizhapka River in Borehole 5-k (Podobina, 1990), and in sections of the central area near the Kaimysovsky vault, within the Vasyugan River basin, in Borehole 2. Eocene calcareous benthic and planktonic foraminifera apparently migrated into the southern half of Western Siberia mainly from across the strait in the Circumpolar Urals during the transgression, broadening the Arctic Gulf.

The author assessed the Palaeocene-Eocene agglutinated foraminifera from Arctic Canada, Alaska, the adjoining territory of the Arctic (McNeil, 1989, 1990, 1997), and Western Siberia (Podobina, 1988, 1989, 1990, 1996, 1997) from published works and her own collections of specimens and recognised regional similarities within the whole Arctic Gulf. Based on this faunal similarity, a single Arctic circum-polar biogeographic region can be defined (Figure 2). Two provinces are established within this region: West Siberian and Arctic (Arctic Canada, Alaska with the adjoining territory of the Arctic) which differ by their generic and especially specific composition. Quartz-siliceous agglutinated foraminifera are represented within the West Siberian province mainly by the genera *Reophax*, *Glomospira*, *Trochamminoides*, *Labrospira*, *Haplophragmoides*, *Asanospira*,

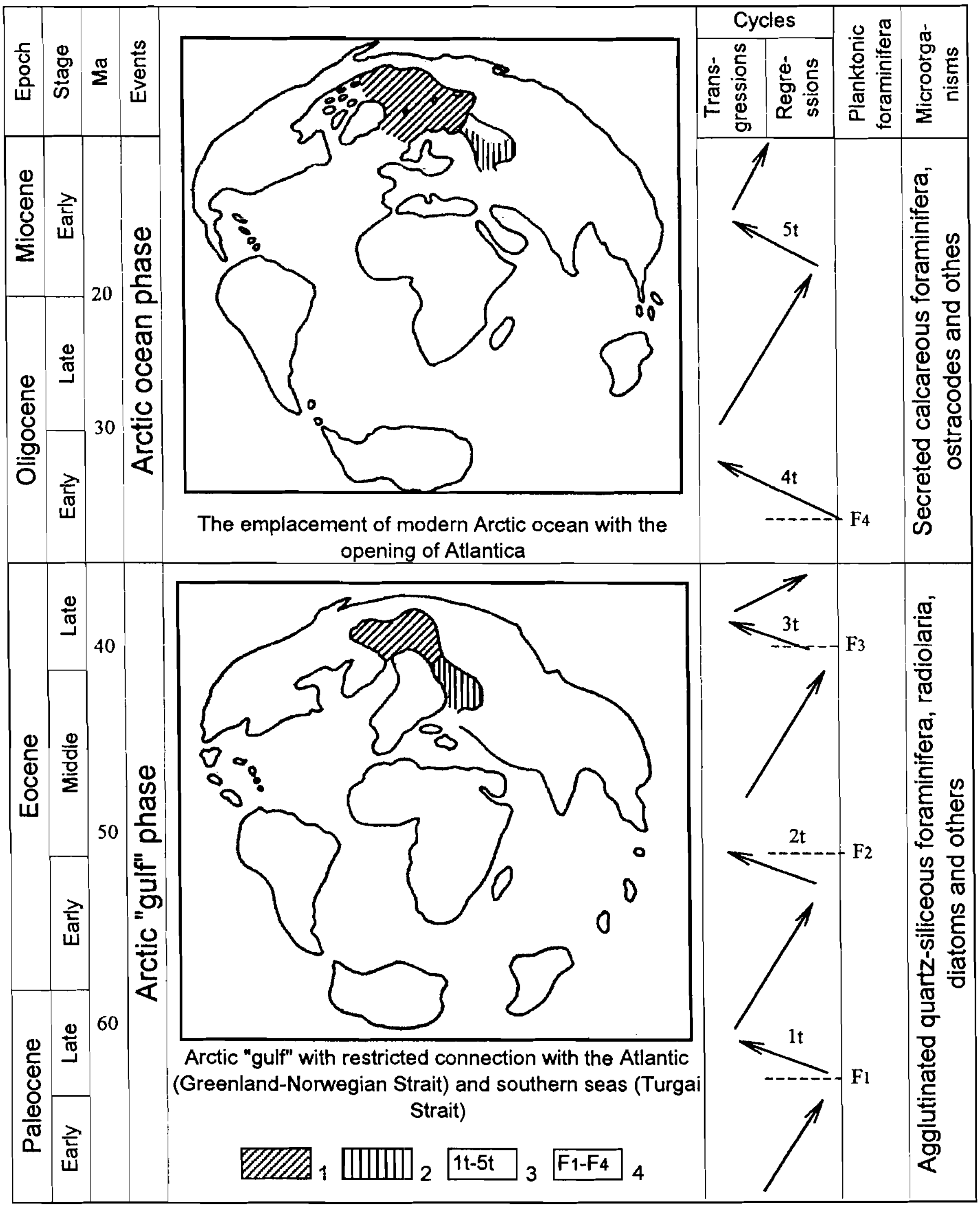

Figure 2. Palaeogene paleobiogeographic reconstruction of the Arctic basin (modified after Briggs, 1987; McNeil, 1990, 1997; Podobina 1997, 1998). 1. Arctic province. 2. West Siberian province. 1t-5t. Transgressive cycles (McNeil, 1990). F1-F4. Planktonic foraminiferal levels in Western Siberia. F1. Danian with globigerinids. F2. Ypresian with *Acarinina pentacamerata* and *Planorotalites* spp.. F3. Priabonian with *Globigerina officinalis*. F4. Rupelian with *Globigerina* spp.

Cribrostomoides, *Cyclammina*, *Ammoscalaria*, *Ammomarginulina*, *Textularia*, *Gaudryinopsis*, *Trochammina*, *Verneuilinoides*, and others. Palaeocene assemblages with *Ammoscalaria friabilis* and *Glomospira gordialiformis*-*Cibicidoides favorabilis* and Middle Eocene assemblages with *Gaudryinopsis subbotinae* (Plates I-II) are more widespread among them. In future studies it will be necessary to examine foraminiferal assemblages from both provinces jointly with North American scientists to reveal further similaritites and dissimilaritites. Hence, after studying the biogeographic dynamics of the Arctic basin in the individual Palaeogene stages one could correlate with confidence provincial assemblages of foraminifera and other associated organisms within the Arctic biogeographic region. The comparison of assemblages from different regions, especially in the absence of open marine organisms, leads to mistakes in age determination, as was the case with previous interpretations of Palaeogene strata in Western Siberia. We have seen from the works of McNeil (1989, 1990, 1997) and Podobina (1988, 1989, 1990, 1997, 1998) that Eocene strata turned out to be older according to different micro-organism groups correlated with those from the Boreal-Atlantic region, than the age dating determined by the correlation of foraminifera within the Arctic circum-polar biogeographic region.

Lower Oligocene foraminiferal assemblages in the Tavdinsky horizon, as well as the North American ones, differ greatly from the underlying Palaeocene-Eocene assemblages in the Talitsky and Lyulinvorsky horizons. Representatives of calcareous benthic foraminifera, mainly elphidiids and nonionids, are widely distributed in the Lower Oligocene. Numerous rotaliids, mainly the typical species *Cibicidoides pseudoungerianus* (Cushman), occur in sections of the Tavdinsky horizon in the southern Zauralie and on the territory of southwestern Western Siberia (the Omsk Depression). These species all possibly migrated through the strait from the north. The possibility of the existence of straits in the northern Zauralie, despite the rise of the central Arctic and the northern part of Western Siberia during the Oligocene, is not excluded. Atlantic microfauna and, first of all, calcareous secreted foraminifera may have entered through these straits. An Early Oligocene planktonic foraminiferal assemblage associated with calcareous benthic forms was found in a 100 m thick section of the Tavdinsky horizon in Petukhovo village (borehole 4-k), in southwestern Western Siberia. It is similar to an Atlantic assemblage described from the South Atlantic (Krasheninnikov & Pflaumann, 1977). A similar, but poorly developed assemblage was found to the north in the Tavdinsky horizon section in the central area of the West Siberian Plain (the Kaimysovsky vault, boreholes 1, 2, 3, 4) as well as in the east, in the basin of the Chizhapka River (borehole 13-k). Typical Early Oligocene foraminifera comprise this assemblage with the following species identified: *Paragloborotalia angulisuturalis* Bolli, *P. postcretacea* (Mjatliuk), *Globanomalina barbadoensis* Blow, *Globigerina ouchitaensis gnaucki* Blow & Banner, *G. praebulloides* Blow, *G. ampliapertura* Bolli, *G. angiporoides* Hornibrook, *G. senilis* Bandy, and others. These Early Oligocene planktonic forms probably appeared in Western Siberia from the Atlantic Ocean through the North Urals Straits.

The information about Early Oligocene planktonic foraminifera in the South of Western Siberia (Tavdinsky horizon) is known from the works of Ushakova (1957, 1959). Freiman (1969) published data on the section near Petukhovo village (borehole 4-k), and later these assemblages were studied in detail by Podobina (1988, 1998). Ushakova (in Subbotina *et al.*, 1964) thoroughly investigated representatives of benthic elphidiids and established three zones, or three subzones (Podobina, 1997, 1998) within the *Cibicidoides pseudoungerianus-Evolutononion decoratum* Zone of the Tavdinsky horizon (Table 1). North American investigators did not find planktonic foraminifera in the sections studied by them, but defined the absolute age of the Kugmallit Formation corresponding to the Oligocene on the basis of Sr 87/86 isotope correlation. Data for this correlation were derived from calcareous benthic foraminifera and a single mollusk analysis. Additionally, McNeil (1988, 1990) summarised data on other groups of organisms (spores and pollen, dinoflagellates) and proved the correspondence of the Kugmallit Formation to the Oligocene epoch.

The lower part of the Oligocene (P-18), corresponding to the lower half of the Kugmallit Formation in Arctic Canada, was traced within Western Siberia in the Tavdinsky horizon using mainly the above planktonic foraminifera, but also benthic calcareous species.

CONCLUSIONS

Two phases in the geological history of the Arctic basin resulted in the clear definition of the Eocene/Oligocene boundary based on foraminifera and in a more exact age determination for local strata in Western Siberia. The Palaeocene to Eocene phase of the significantly isolated Arctic Gulf is characterised by the development mainly of quartz-siliceous agglutinated foraminifera. From the Oligocene, sea-floor spreading between Greenland and Spitsbergen took place. The North Zauralian Strait made possible the migration of calcareous forms from the Arctic and Atlantic basins. The rise of the North Western Siberia border together with the Arctic territory due to tectonic events have been observed simultaneously since the Oligocene. It is possible that the planktonic foraminifera migrated into Western Siberia through the North Urals Straits. The synthesis of foraminiferal investigations in the Northern hemisphere and, especially, the recognition of tectonic transformations from the beginning of the Oligocene, has made it possible to assign more exactly ages to marine Palaeogene strata and delimit the boundary between the Eocene and Oligocene in Western Siberia.

ACKNOWLEDGEMENTS

The author cordially thanks Prof. Malcolm Hart and the Grzybowski Foundation for financial support to participate in IWAF-5. The author is also grateful to Dr. David H. McNeil for comments and valuable advice on the preparation of the manuscript.

Table 1. Correlation of zonal scales based on benthic foraminifera for western Europe, the Turgai Strait, Western Siberia, and Arctic North America.

System	Division	Subdivision	Stage	ZONES OF PLANKTONIC FORAMINIFERA (Decision of ISC, 1989) with alterations made by V.M.Podobina (*)	ZONES ON BENTHIC FORAMINIFERA: WESTERN EUROPE Netherland (Doppert, Neele, 1983)	ZONES ON BENTHIC FORAMINIFERA: TURGAI STRAIT (Podobina, 1998; Benyamovsky, 1989 - Paleocene)	ZONES ON BENTHIC FORAMINIFERA: WESTERN SIBERIA (Podobina, 1998)	ZONES ON BENTHIC FORAMINIFERA: Horizon	ZONES ON BENTHIC FORAMINIFERA: ARCTIC NORTH AMERICA, CANADA (Mc Neil, 1997)	Formation
PALEOGENE	OLIGOCENE	lower	Rupelian	Globigerina ampliapertura, Globigerina tapuriensis	Cibicidoides ungerianus, Rotaliatina bulimoides	Cibicidoides ungerianus, Rotaliatina bulimoides	Cibicidoides pseudoungerianus, Evolutononion decoratum	Tavdinsky	Valvulineria dixoni	Kugmallit
	EOCENE	upper	Priabonian	Globigerina centralis	Vaginulinopsis decoratus, Pseudohastigerina micra; Nummulites, Eponides	Labrospira honesta, Anomalinoides granosus	Слои с Reophax Labrospira honesta	Lyulinvorsky	Haplophragmoides richardsensis	Richards
				Globigerina corpulenta						
				Globigerina tropicalis						
		middle	Bartonian	Globigerina turcmenica	Planulina, Cibicides (Cibicidoides)	Gaudryinopsis subbotinae	Gaudryinopsis subbotinae		Portatrochammina tagluensis	Reindeer
				Hantkenina alabamensis						
			Lutetian	Acarinina rotundimarginata		Cibicidoides tenellus	Слои с Bolivinopsis spectabilis			
				Acarinina bullbrooki						
		lower	Ypresian	Morozovella (*) aragonensis	Anomalinoides ypresiensis, Gaudryina hiltermanni	Anomalinoides ypresiensis ovatus, Cibicides carinatus	Textularia carinatiformis sibirica, Anomalinoides ypresiensis ovatus		Portatrochammina aklakensis	
				Morozovella (*) subbotinae						
	PALEOCENE	upper	Thanetian	Acarinina acarinata	Bulimina trigonalis, Cibicidoides proprius	Acarinina subsphaerica, Cibicides reinholdi	Glomospira gordialiformis, Cibicidoides favorabilis	Talitsky	Reticulophragmium boreale	
				Acarinina subsphaerica						
				Acarinina djanensis						
			Selandian	Morozovella (*) conicotruncata			Ammoscalaria friabilis			
				Morozovella (*) angulata						
		lower	Danian	Acarinina inconstans	Pararotalia globigeriniformis, Rotalia saxorum	Globoconusa daubjergensis, Cibicidoides lectus, Reussella paleocenica	Brotzenella praeacuta	Gankinsky	Verneuilinoides exvadum	Fish River
				Globoconusa daubjergensis						
				Globigerina taurica						

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PLATE 1

Selandian and Thanetian stages

Ammoscalaria friabilis and *Glomospira gordialiformis* - *Cibicidoides favorabilis* Zones

1a-b. ***Glomospira gordialiformis*** **Podobina**
Nr. 822 in Tomsk State University coll. Western Siberia, Tomsk region, Chizhapka River, borehole 1-k, depth 310,0 m; Talitsky horizon, Thanetian (80x)

2a,b. ***Labrospira granulosa*** **(Lipman)**
Nr. 823 in Tomsk State University coll. Western Siberia, Tomsk region, Iliak River, borehole 10, depth 486,0 m; Talitsky horizon, Selandian (80x)

3a,b. ***Adercotryma horrida*** **(Grzybowski)**
Nr. 824a in Tomsk State University coll. Western Siberia, Tomsk region, Iliak River, borehole 10, depth 493,0-486,0 m; Talitsky horizon, Selandian (80x)

4a,b. ***Cyclammina coksuvorovae*** **Uschakova**
Holotype Nr. 512/140 in VNIGRI coll. Western Siberia, Tyumen region, Khanty-Mansiisk borehole 1-p, depth 690,0-682,0 m; Talitsky horizon, Selandian (72x) (Subbotina et al., 1964, p. 145, pl. XIV, Ia, b)

5a,b. ***Asanospira grzybowskii*** **(Mjatliuk)**
Nr. 192 in VSEGEI coll. Western Siberia, Tyumen region, Tyumen borehole 1-k, depth 375,0 m; Talitsky horizon, Thanetian (80x)

6a,b. ***Ammoscalaria friabilis*** **Lipman**
Nr. 1566 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 1, depth 590,0 m; Talitsky horizon, Selandian (100x)

7a-c. ***Trochammina intacta*** **Podobina**
Nr. 1565 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 2, depth 464,0 m; Talitsky horizon, Selandian (80x)

8a-c. ***Verneuilinoides paleogenicus*** **(Lipman)**
Nr. 1567 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 2, depth 464,0 m; Talitsky horizon, Selandian (80x)

PLATE 2

Lutetian, Bartonian and Priabonian stages

Gaudryinopsis subbotinae and *Labrospira honesta* Zones

1. ***Reophax difflugiformis*** **Brady**
Nr. 1553 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 1, depth 454,0 m; Lyulinvorsky horizon, Lutetian-Bartonian (60x)

2. ***Reophax subfusiformis*** **Earland**
Nr. 1554 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 1, depth 464,0 m; Lyulinvorsky horizon, Lutetian-Bartonian (60x)

3. ***Labrospira granulosa*** **(Lipman)**
Nr. 1555 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 3, depth 408,0 m; Lyulinvorsky horizon, Lutetian-Bartonian (100x)

4. ***Haplophragmoides deplectus*** **Podobina**
Nr. 1556 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 2, depth 464,0 m; Lyulinvorsky horizon, Lutetian-Bartonian (100x)

5. ***Textularia carinatiformis*** **(Morosova)**
Nr. 1557 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 2, depth 464,0 m; Lyulinvorsky horizon, Lutetian-Bartonian (60x)

6. ***Trochammina infirma*** **Podobina**
Nr. 1559 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 2, depth 464,0 m; Lyulinvorsky horizon, Lutetian-Bartonian (60x)

7. ***Gaudryinopsis subbotinae*** **Podobina**
Nr. 1560 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 3, depth 396,0 m; Lyulinvorsky horizon, Lutetian-Bartonian (60x)

8-9. ***Labrospira honesta*** **Podobina**
8. Nr. 394 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan and Nyurolka Rivers, borehole 4-n, depth 375,0-368,0 m; Lyulinvorsky horizon, Priabonian (60x)
9. Nr. 1563 in Tomsk State University coll. Western Siberia, Tomsk region, Vasyugan River, borehole 3, depth 383,0 m; Lyulinvorsky horizon, Priabonian (60x)

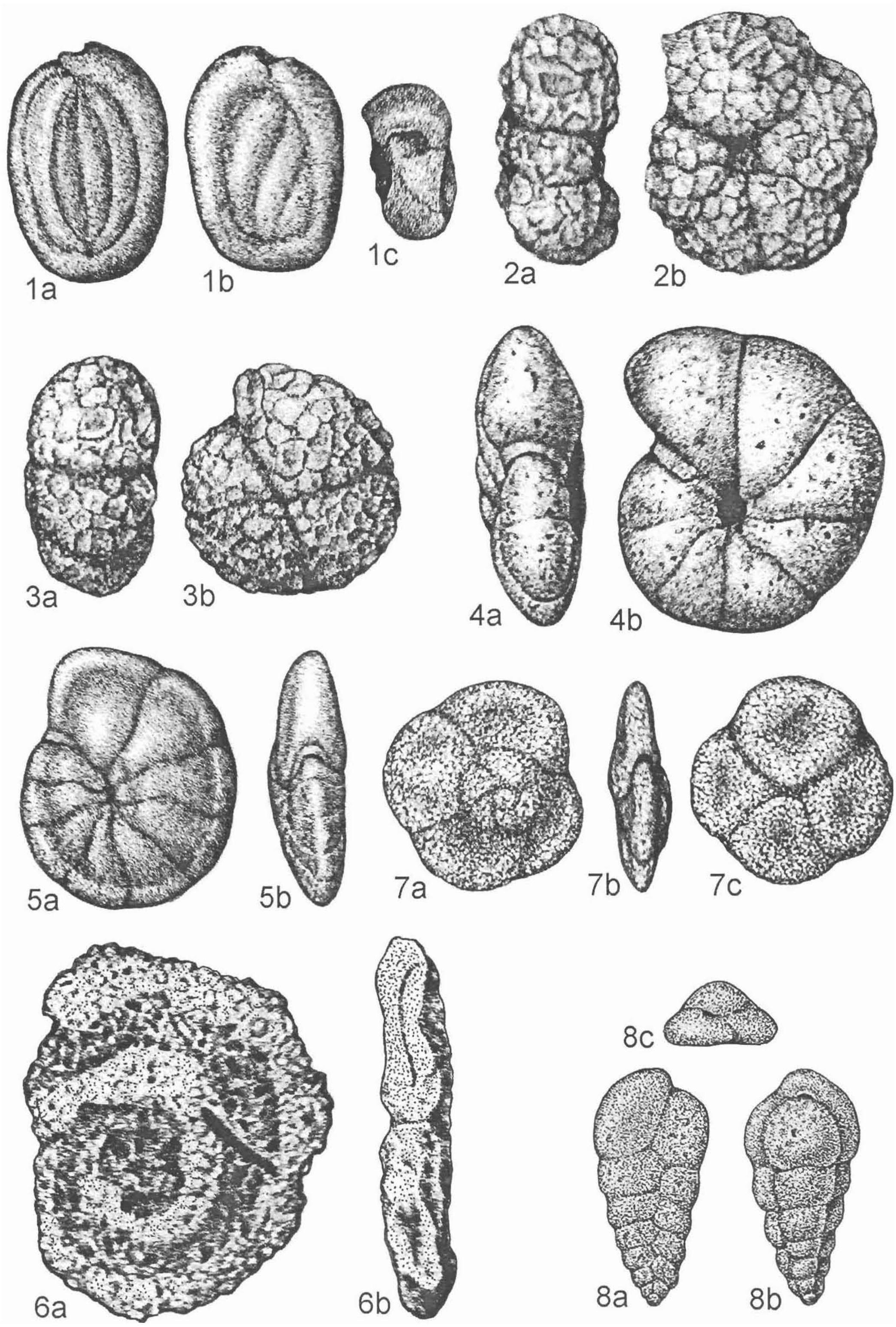

Plate 1. Selandian and Thanetian agglutinated foraminifera from the *Ammoscalaria friabilis* and *Glomospira gordialiformis - Cibicidoides favorabilis* Zones. See detailed explanations on page 394.

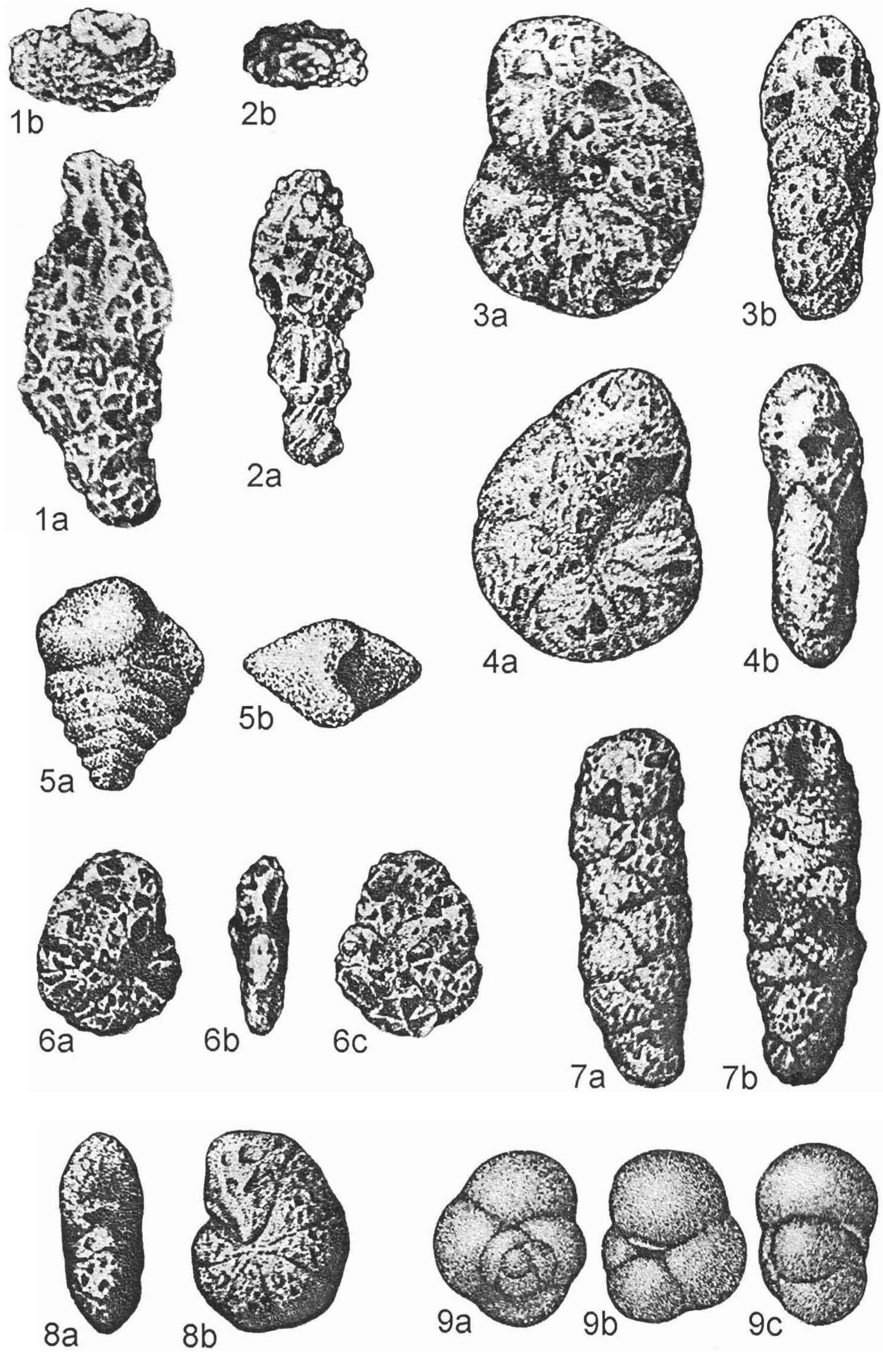

Plate 2. Lutetian, Bartonian and Priabonian Foraminifera from the *Gaudryinopsis subbotinae* and *Labrospira honesta* Zones. See detailed explanations on page 394.