Diatoms from Surface Sediments of the Saint Anna Trough (Kara Sea)

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Abstract - 15 samples from surface sediments of the St. Anna Trough served as the basis of this study. 91 recent species (29 genera) were identified, of which 30 belong to the class *Centrophyceae* and 61 belong to the class *Pennatophyceae*. Besides that 11 reworked Paleogene species were found. True marine planktic diatom species constitute 92-98% of all specimens in the surface sediments. The biogeographical composition of the thanatocoenoses corresponds to biocoenoses inhabiting the water masses of the Arctic seas. In the surface sediments, arctoboreal and bipolar planktic and kryopelagic species are prevailing, which reflect the low temperatures and the seasonally ice-covered environment: *Melosira arctica, Fragilariopsis oceanica, Poroira glacialis, Thalassiosira gravida, T. antarctica* (spores), *T. kryophila, T. hyalina*, and *T. nordenskiöldii.* Warm-water species are absent in the sediments, probably because Atlantic waters have cooled significantly before entering the St. Anna Trough.

Introduction

The St. Anna Trough is a subbathyal depression with depths down to 620 m, separating the northern Kara Sea and Barents Sea shelves (Figure 1). The hydrological regime (Rudels et al., 1994) of the northern Kara Sea is controlled by the inflow of several water masses into the St. Anna Trough area. Atlantic waters derived from the North Atlantic Drift flow across the Barents Sea, further along the St. Anna Trough, and finally enter the intermediate waters of the Arctic Ocean. Another branch of Atlantic water, turning east around northern Svalbard and sinking below the low-salinity surface layer while flowing along the Barents Sea continental margin, reaches the St. Anna Trough from the North at depths of 100-450 m. Another important water mass is constituted from freshwater transported mainly by the large Siberian rivers Ob and Yenisei. According to data obtained during cruise 9 of RV "Professor Logachev" in 1994, the upper water layer in the central and southern St. Anna Trough has temperature between 1-2.4 °C, while in the North and Northeast they vary from -0.1 to -1.2 ° C (Ivanov et al., 1995).

The field of salinity on ocean surface tests significant freshening due to summer melting of floating ice. Salinity of surface waters in the trough changed in summer 1994 in the limits from 30.00 up to 33.75‰.

Materials and methods

Diatoms were studied in 15 samples of surface sediments collected during cruise 9 (1994) of RV "Professor Logachev" in the St. Anna Trough from stations with water depths of 100-605 m (Figure 1). The treatment of diatom valves was carried out only slightly changed according to the method described by Schrader and Gersonde (1978). Dried and weighed sediment (15-20 g) was boiled first with H_2O_2 (30%), then with HCl (30%) and then was washed out by distilled water. The sediment was cleaned of clay by washing out 5-6 times with Na_3PO_4 *

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$12H_2O$ (5%). To extract the diatom frustules, the sediment was treated by heavy liquid (2.6 g/cm^3) according to the method described by Glejzer et al. (1974). The counting of diatoms per 1 gram of dry sediment was done according to a formula proposed by Kvasov and Jakovshikova (1971):

$K = b * n * y / a * m * x$

where
b = dilution in ml
n = the number of rows in a slide
y = the number of counted frustules
a = weight of sediment in grams
m = the volume of a drop (0.02-0.03 ml)
x = the number of analyzed rows.

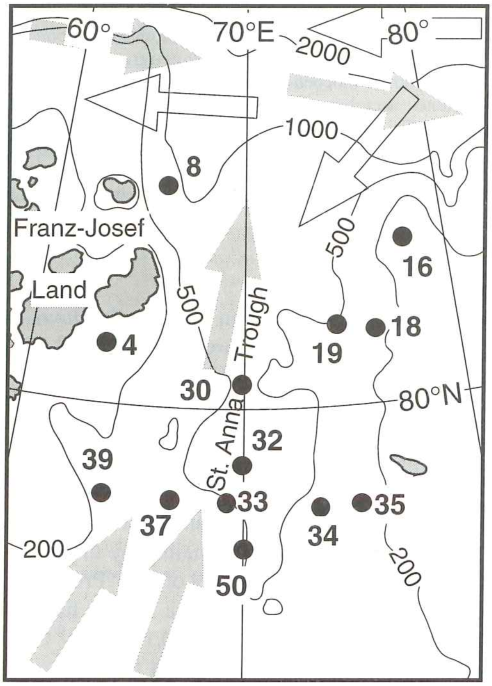

Figure 1: Core locations and currents in the St. Anna Trough area. Bathymetry is given in meters below sea level. White arrows mark the flow direction of low saline Arctic surface water; gray arrows mark the flow of Atlantic water (submerged north of 80°N).

Results and Discussion

Bottom sediments of the northern part of the Kara Sea contain relatively low amounts of diatoms. The number ranges from 10 to 750 frustules per gram of dry sediment. The silty sands from stations 4, 16, 19, and 30 contain rich assemblages of recent diatoms with minor admixtures of Paleogene species. Silty muds from stations 32, 33, 34, and 35 contain a poor composition of modern and Paleogene diatoms, and in cores 8, 18, 37, 39, and 50 they contain only reworked Paleogene species. 93 recent species and varieties (29 genera) and 11 reworked species (6 genera) were identified. Among the recent diatoms, 30 taxa belong to the class *Centrophyceae* and 63 taxa belong to the class *Pennatophyceae*.

The representatives of phytoplankton are mainly centric species such as: *Thalassiosira gravida* and *Th. antarctica* (16-25%), *T. nordenskiöldii* (10-16%),T. *kryophila* (16%), *Th. hyalina* (1-8%), *Porosira glacialis* (20%) and *Coscinodiscus oculus-iridis* (10-11%). The second group, present in lower amounts, is a group of kryopelagic and kryointersticial species, dwelling on lower and marginal sea ice surfaces: *Melosira arctica* (2-4%), *Fragilariopsis oceanica* (2-12%), *F. cylindrus* (>1%), *Nitzschia frigida* (2%), *N. polaris* (>1%), *Navicula cancelata* var. *gregori* (2%), *Nav. directa* (1%), *Nav. reinhardtii* var. *tschuktschorum* (4%). Species of the genera *Thalassiosira* (9 taxa), *Navicula* (11 taxa), *Diploneis* (10 taxa) and *Nitzschia* (10 taxa) are the most numerous.

All species found in sediments from the St. Anna Trough have been found previously already in the Kara Sea and are enclosed in the list of Kara Sea diatoms (148 species and varieties) compiled by Makarevich and Koltsova (1989) from own investigations and literature data (Zabelina, 1930, 1946; Kiselev, 1935; Usachev, 1938, 1949, 1968). Observations of ice diatoms the deep Arctic Basin by Horner (1982) showed that the bloom near in the ice margin mainly consists of pennatic diatoms, whereas the bloom of phytoplankton in ice-free areas is dominated by centric diatoms. *Fragilariopsis oceanica* and *F. cylindrus* are abundant in both habitats. In spring plankton, the most abundant species are *Thalassiosira gravida*, *T. nordensköldii*, *Fragilariopsis oceanica* and *Porosira glacialis* (Usachev,1968; Grant and Horner, 1976). All these species are dominant in the assemblage composition in surface sediments of the St. Anna Trough. They are also typical for diatom compositions found in sediments under ice packs (Sancetta, 1982; Williams, 1986).

The true marine diatoms in the described assemblages constitute 92-98% (Figure 2). Brackishwater euryhaline species, dwelling on sea ice are also present (up to 7%). Species of this group are: *Thalassiosira hyperborea* var. *septentrionalis*, *Achnanthes taeniata* , *A. brevipes*, *Diploneis interrupta*, *D. stroemii*, *D. smithii*, *Nitzschia hybrida* var. *kryokonites*, *Amphora laevis* var. *laevissima*, *Navicula kjellmanii*. Freshwater species such as: *Aulocoseira islandica* subsp. *helvetica*, *A. granulata*, and *Amphora ovalis* contribute up to 3% of the sediment assemblage.

The existence of brackishwater species may be explained by a freshening effect of melting sea ice. The salinity in a thin layer below the sea ice can be strongly variable from 15 to 29‰ (Melnikov, 1989). This fact may allow algae with different salinity tolerances to exist below sea ice. In 1994 during cruise 9 of RV "Professor Logachev" the surface water salinity at some stations had decreased to 13-16‰, probably from increased atmospheric precipitation. The presence of freshwater diatoms in the assemblages allows to suggest that they had lived in sea ice, which was formed in a proximal freshwater-dominated environment and then drifted to the open sea. A current transport from the southern Kara Sea to the St. Anna Trough seems rather unlikely.

In sediments from the majority of stations, the frustules of planktic, mostly neritic species are prevailing (92-98%; Figure 2). Panthalassic species constitute up to 12% (*Coscinodiscus oculus-iridis*, *C. curvatulus* var. *kariana*, *Actinocyclus curvatulus*). In samples from stations with a water depth of about 100 m, the littoral species constitute up to 30%. This may be explained by a mechanism of ice flora forming on account of planktic and benthic species (Melnikov, 1989). In shallow waters the species distribution and quantitative composition of ice algae is dominated by benthic species, whereas in deep sea regions it is dominated by planktic species.

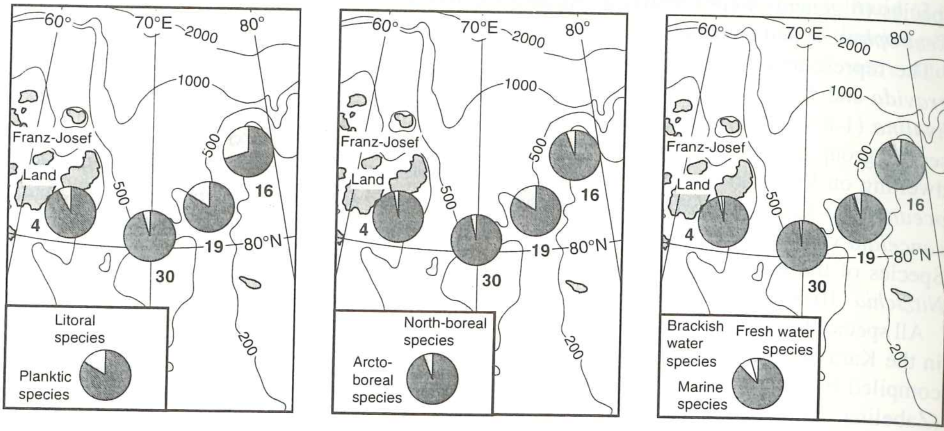

Figure 2: Diatom species composition of surface samples from stations 4, 16, 19, and 30 according to habitat (left), biogeography (center), and facies types (right).

In general, the composition of thanatocoenoses in the analyzed sediments corresponds to the biogeography of biocoenoses inhabiting the water masses of Arctic shelves. Bipolar and arctoboreal diatoms constitute 83-97% (Figure 2). In this region the temperatures of the surface waters reach 0-1°C in summer and sink to -1.8 ° C in winter.

The diatom assemblage of analogous species composition was established by Karpuz and Schrader (1990) in surface sediments of the Nordic Seas by factor analysis. They called it sea-ice assemblage (Factor 3) and it is confined to maximum ice expansion in the Norwegian and Greenland seas.

The structure of the diatom assemblage in surface sediments from the St. Anna Trough is similar to the structure of the thanatocoenosis found in the northern regions of the Barents Sea (Djinoridze,1986). We propose that this is a consequence of the strong water exchange between these basins and the very similar hydrological characteristics of the predominant water masses.

Some differences are traced in the structure of thanatocoenoses in the St. Anna Trough (Figure 2). In sediments of the western part arctoboreal, bipolar planktic and kryopelagic species are more abundant. In sediments of the eastern part, bordering shoal waters, the littoral species have relatively higher percentages.

The results of diatom analysis of surface layer of bottom sediments in the St. Anna Trough reveal their low satiation with diatoms. Only 30% of the studied samples contain representative diatom assemblages (38-60 taxa) in numbers of 100-750 frustules per gram of sediment. Only a small part (about 25%) of the known species variety in the planktic diatom flora of the modern Kara Sea is preserved in the sediments. As a result, spores of only 5 out of 34 species of the genus *Chaetoceros* found in modern plankton were registered in the sediments.

Spores of *Melosira arctica*, *Porosira glacialis*, *Thalassiosira gravida*, and *T. antarctica* are most abundant in sediments of the St. Anna Trough. The generally low amount of diatoms, which is also noted by Polyakova (1997) for the southern Kara Sea, is probably a result of the unfavorable accumulation conditions, which promote the dissolution of diatom valves during their precipitation: Low silica concentrations, a pronounced density stratification of the waters, and strong bottom currents.

The occurrence of reworked Paleogene and Cretaceous species in the sediments is a peculiarity of the diatom thanatocoenoses of surface sediments in the St. Anna Trough. It indicates that the modern bottom sediments to a strong extent are formed from erosion of reworked underlying rocks.

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Appendix 1: Modern Diatoms

Genus and species name	Facies	Habitat	Biogeography	Station numbers								
				4	16	19	30	32	33	34	34d	35
Achnanthes arctica	m	l	ar		1	1						
Achnanthes brevipes	b	l	cp		1							
Achnanthes septata	m	l	ab	1			1					
Achnanthes taeniata	e	n	ar				1					

Appendix 1 (continued):

Genus and species name	Facies	Habitat	Biogeography	Station numbers								
				4	16	19	30	32	33	34	34d	35
Actinocyclus curvatulus	m	p	nb		2	1						
Amphora eunotia	m	l	ab				1					
Amphora laevis var. laevissime	b	l	ab	1			1					
Amphora ovalis	fr	l	cp			1	4					
Amphora proteus	m	l	ab	5	1	1	1					
Amphora terroris	m	l	ab	1	1		3				1	
Aulacosira granulata	fr	l	cp		1	7	1			1		1
Aulacosira islandica subsp. helvetica	fr	l	cp				1				3	
Aulacosira italica	fr	l	cp		1	10	2					
Bacillaria socialis	m	l	cp	3	1	8				1		2
Bacterosira fragilis	m	n	ab	40			20					
Campylodiscus thuretii	m	l	nb	1	1	5	14					
Chaetoceros debilis	m	n	ab				1					
Chaetoceros furcellatus	m	n	ab	5	2							
Chaetoceros karianus	m	n	ab				3					
Chaetoceros mitra	m	n	ab			1	1					
Chaetoceros diadema	m	n	ab	2	2	3	10					
Cocconeis californica	m	l	ab	3								
Cocconeis costata	m	l	cp		2	1						
Cocconeis placentula	fr	l	cp		1							
Cocconeis scutellum	m	l	cp	1			2					
Coscinodiscus asteromphalus	m	p	sb		1							
Coscinodiscus curvatulus var. kariana	m	p	ab		7	8	4			2	5	
Coscinodiscus marginatus	m	p	nb		1							
Coscinodiscus oculus-iridis	m	p	ab		10		6	1	1	10	4	10
Diploneis coffaeformis	m	l	nb				1					
Diploneis interrupta	m	l	ab		2	1	1					
Diploneis litoralis	m	l	ab		1							
Diploneis litoralis var. clathrata	m	l	ar	1			2					
Diploneis smithii	b	l	cp	22	3	2	10					1
Diploneis smithii var. borealis	b	l	cp	2	1	1	20					
Diploneis smithii var. rhombica	b	l	cp	1	2	1	1					
Diploneis stroemii	m	l	nb	1								
Diploneis subcincta	m	l	ab	31	12	15	5					1
Diploneis suborbicularis	m	l	nb		4							
Entomoneis hyperborea	m	n	ar	2								
Entomoneis kjellmanii var. kariana	m	n	ab	1								
Fragilaria lapponica	fr	l	cp		1							
Fragilariopsis cylindrus	m	n	ar	10	1	1	3					
Fragilariopsis oceanica	m	n	ar	64	3	3	57				1	
Gomphonema exguum var. arctica	m	l	ab				2					
Grammatophora angulosa	m	l	ab				10					
Grammatophora arctica	m	l	ar	3	1							
Hantzschia weyprechtii	m	l	ab				1					1
Lycmophora jurgensii	m	l	ab				1					
Melosira arctica	m	n	ar	4	20	50	30			1	1	2
Navicula abrupta	m	l	ab				4					
Navicula cancellata	m	l	ab				1					
Navicula cancellata var. gregori	m	l	ab				14					
Navicula directa	m	l	ab	1			5					
Navicula distans	m	l	ab	2								
Navicula glacialis	m	l	ar	2			1					
Navicula kariana	m	l	ab		1							
Navicula kjelmannii	m	l	ab	2								

Appendix 1 (continued):

Genus and species name	Facies	Habitat	Biogeography	Station numbers								
				4	16	19	30	32	33	34	34d	35
Navicula palpebralis var. angulosa	m	l	nb		2							
Navicula reichardtii var. tschuktschorum	m	l	ab		2		20					
Navicula spectabilis	m	l	nb		2	1						
Nitzschia frigida	m	n	ar	2			14					
Nitzschia hybrida	b	l	ar				6					
Nitzschia hybrida var. kryokonites	b	l	ab				2					
Nitzschia insignis	m	l	nb				3					
Nitzschia insignis var. arctica	m	l	ar	2								
Nitzschia mitcheliana	m	l	ab				1					
Nitzschia polaris	m	l	ar	1	3	1	1					
Nitzschia seriata	m	n	ab				1					
Nitzschia triblionella var. levidensis	b	l	cp			1						
Nitzschia triblionella var. victoriae	b	l	ar			1	7					
Odontella aurita	m	n	ab		2							
Paralia sulcata	m	l	nb		5	10						
Pinnularia lata	fr	l	na			1						
Pinnularia quadratarea var. baltica	m	l	nb		1		1					
Pinnularia quadratarea var. stuxbergii	m	l	ab		1		1					
Porosira glacialis	m	n	bp	140	12	20	60				1	2
Rhizosolenia hebetata f. hiemalis	m	p	ab		1	3						
Rhizosolenia setigera var. arctica	m	n	ar	1								
Scoliotropis laterostrata	m	l	ab	1								
Stephanodiscus rotula	fr	p	cp	1	1	1						
Synedra kamtschatica var. finmarchica	m	l	ab	1			2					
Tetracyclus lacustris	fr	l	na			1	1					
Thalassiosira angulata	m	n	nb	5	2	1						
Thalassiosira anguste-lineata	m	p	cp	4	10	10	5					2
Thalassiosira antarctica	m	n	bp	50	10	30	40				2	
Thalassiosira hyperborea	m	n	ab	4	2	2	24					2
Thalassiosira gravida	m	n	bp	51	10	20	30			1	2	3
Thalassiosira hyalina	m	n	ab	24	2		3			2		
Thalassiosira kryophila	m	n	ab	14	10	2	10			2		
Thalassiosira latimarginata	m	n	ab	1	2	1						
Thalassiosira nordenskiodii	m	n	ab	32		1	74					
Thalassiothrix longissima	m	n	ab	4	1	4	2					
Trachyneis aspera	m	l	ab	5	1	1	1					

ABBREVIATIONS
Facies: m = marine; b = brackishwater; fr = freshwater; e = euryhaline.
Habitat: n = neritic; p = panthalassic; l = littoral.
Biogeography: ar = arctic; ab = arcto-boreal; bp = bipolar; nb = north-boreal; sb = south-boreal; cp = cosmopolitan; na = north-alpic.
Absolute abundance of diatoms is given per slide (18x18 mm)

Appendix 2: Paleogene Diatoms

Genus and species name	Facies	Habitat	Biogeo-graphy	Station Numbers													
				4	16	19	30	32	33	34	34d	35	37	39	50	8	18
Coscinodiscus payeri	m	p	(r)							1					1		1
Costopyxis broschii	m	n	(r)				1						1		1		
Costopyxis schulzii	m	n	(r)												1		
Grunowiella gemmata	m	n	(r)					1			1		1				
Hemiaulus polymorphus	m	l	(r)			1			1								1
Hyalodiscus radiatus	m	l	ab			2		1	1	10	2	3				10	2
Paralia ornata	m	l	(r)										1			1	1
Paralia sulcata var. biseriata	m	l	(r)	11	2	22	10	1	7	5	11	30	1	8	1	12	15
Pyxidicula polaris	m	n	(r)											1		3	
Pyxidicula turris	m	n	(r)		1	1		1		1		2	1	1			
Pyxilla gracilis	m	n	(r)					1								6	

ABBREVIATIONS
Facies: m = marine
Habitat: n = neritic; p = panthalassic; l = littoral.
Biogeography: ab = arctoboreal; (r) = resedimented.
Absolute abundances of diatoms are given per slide (18x18 mm)