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A study on nano- and microdiatoms in the intertidal zones of Zhongshan Station, Antarctica*

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Abstract The present paper deals with the composition and distribution of nano- and microdiatoms in sands and grits covered by ice and snow in the intertidal zones of the Zhongshan Station in Larsemann Hills (69°21′~ 69°25′S, 76°00′~76°25′E), East Antarctica. The samples were collected from seven sand-grit flat stations in January 1989 and February 1990. The highest cell density of nano- and microdiatoms occurred at Station B. The cell concentration was 0.8×10^3~ 3651×10^3 cells per gram sand in January 1989 and 4.5×10^3~ 2618×10^3 cells per gram in February 1990 respectively. The nano- and microdiatoms in the intertidal zones were small in cell size and high in abundance. The dominant species was *Navicula glaciei*.
Key words Zhongshan Station, intertidal zones, nano- and microdiatoms.

1 Introduction

Zhongshan Station is located in the Larsemann Hills , Antarctica. The coastal intertidal zones in the Zhongshan Bay and Nella Fjord are mainly composed by sand and gravel, and those in the Progress Bay by sand. Nano- and microdiatoms are very abundant in the sand and gravel and they may be served as food for fish, shellfish and other microanimals directly or indirectly. So they play an important role in the Antractic ecosystem. This paper presents the composition, distribution and similarities of them among the stations.

2 Materials and Methods

Nano- and microdiatoms samples were collected from the sand and graval on the surface (2 cm deep) in the coastal intertidal zones of Zhongshan Station, Antarctica, in January 1989 and February 1990 respectively (Fig. 1, Table 1). The samples were preserved with 5% buffered formaline. The detalied methods were described in the previous papers (Zhu, 1989, 1991).

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Table 1. The contents of sand and gravel with nano- and microdiatoms in Zhongshan Station, Antarctica

Station		Contents of sand and gravel (%)			Name	Sample color
		Gravel	Sand	Silt		
Zhongshan Bay	A	16.37	83.32	0.31	Sand	Pale brown
	B	47.08	52.17	0.75	Gravelly sand	Brown, pale brown
Progress Bay	C	18.01	81.49	0.50	sand	Brown, pale brown
	D	18.01	81.49	0.50	Sand	Brown, pale brown
Nella Fjord	E	16.70	81.66	1.64	Sand	Pale brown
	F	52.43	45.55	2.01	Sandy gravel	Pale brown, brown

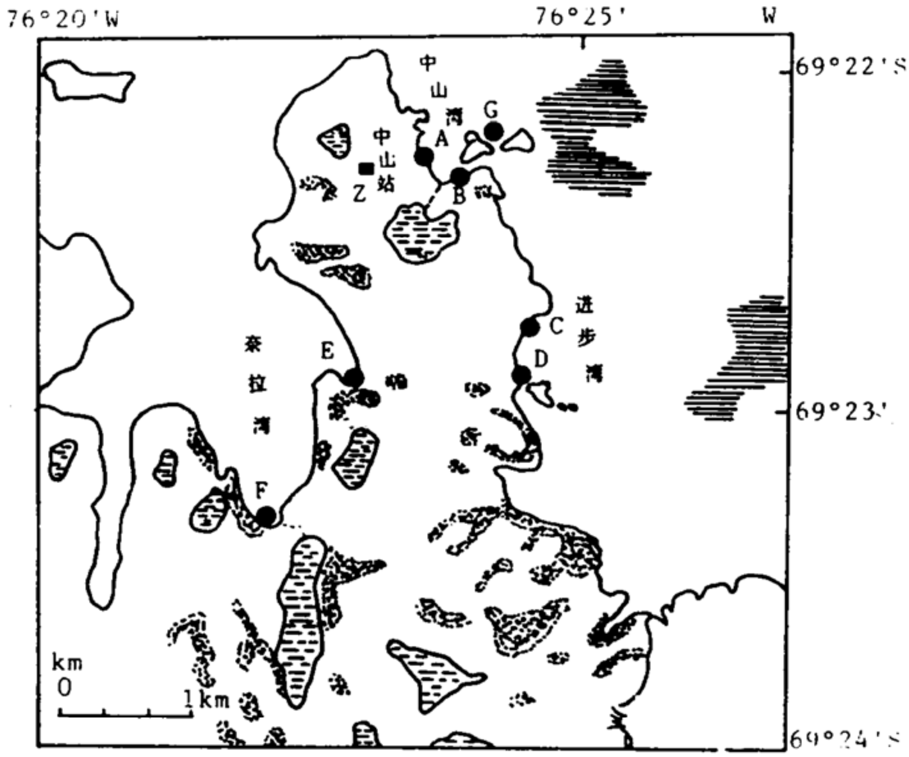

Fig. 1. Sampling stations.

3 Results

3.1 *Distribution of nano- and microdiatoms*

In the intertidal zones of Zhongshan Station, the distribution pattern of nano- and microdiatoms in January 1989 was similar to that in February 1990. High cell concentration was located at Station B of the Zhongshan Bay. The cell density was 365×10^3 ind./g in January and 2618×10^3 ind./g in Feburary. The lowest cell density was distributed at Station A of the Zhongshan Bay. It was 0.8×10^3 ind./g in January and 4.5×10^3 ind./g in Feburary repectively (Fig. 2, 3).

3.2 *Composition of the nano- and microdiatoms*

114 species belonging to 28 genera were identified by using both light and electron microscope. Among them, 68 species were distributed in the Zhongshan Bay, 77 in the

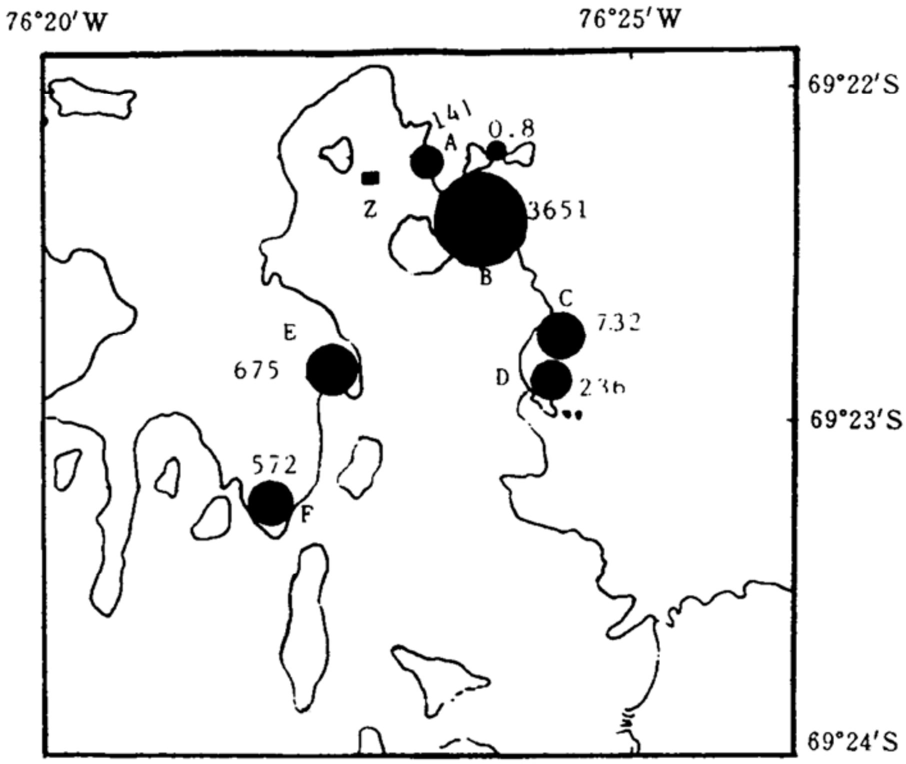

Fig. 2. The quantitative distribution of nano- and microdiatoms of Zhongshan Station, Antarctica in January ,1989. The number in the figure show the cell abundance ($\times 10^3$/g).

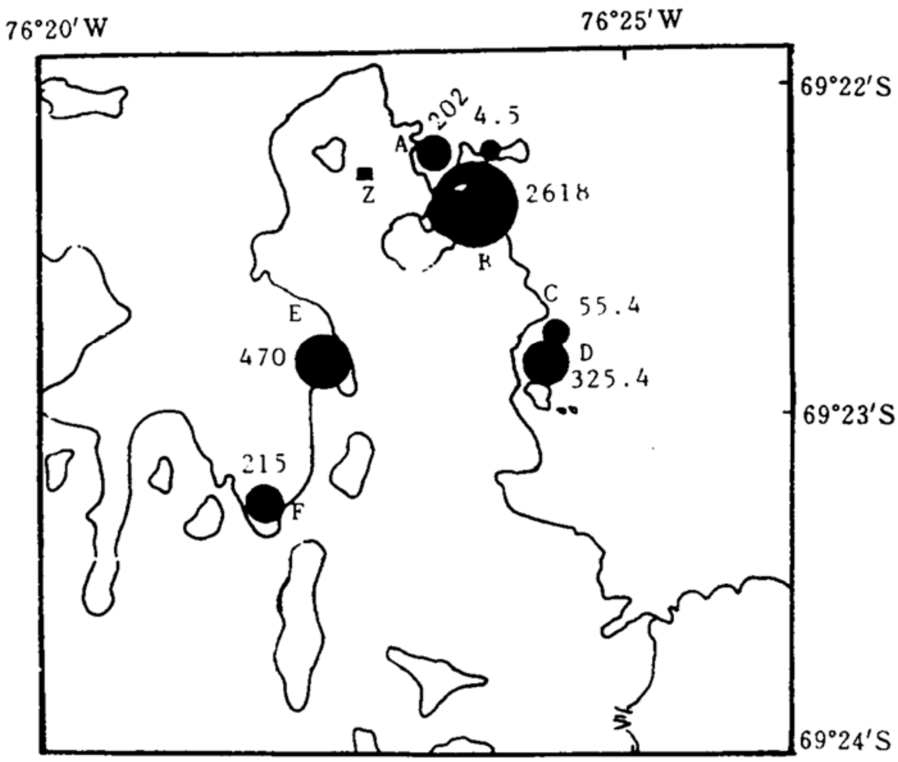

Fig. 3. The quantitative distribution of nano- and microdiatoms of Zhongshan Station, Antarctica in February, 1990. The number in the figure show the cell abundance ($\times 10^3$/g).

Progress Bay and 64 in the Nella Fjord. Most species belong to the genera of *Navicula* and *Nitzschia*, amounting to 21 species and 20 species respectively (Table 2).

Table 2. Specific composition of nano- and microdiatoms in the intertidal zones of Zhongshan Station, Antarctica

	Bacillariophyta	Zhongshan Bay	Progress Bay	Nells Fjord
1.	*Achnanthes antarctica* M. Per.	A	D	A
2.	*A. bongrainii* M. Per.	A	R	R
3.	*A. brevipes* Ag.	C	C	—
4.	*A. brevipes* v. *intermedia* (Kütz.)Cl.	—	R	—
5.	*A. charcotii* M. Per.	—	C	C
6.	*A. lanceolata* (Breb.)Grun.	—	R	—
7.	*Achnanthes* sp.	R	C	R
8.	*Actinocyclus adeliae* Mang.	R	C	C
9.	*A. karstenii* V. H.	—	—	R
10.	*A. oliverianus* O'Meara	C	—	—
11.	*A. radiatus* Rattr.	C	—	—
12.	*Actinocyclys* sp.	R	—	C
13.	*Amphiprora kjellmanii* v. *subtilissima* V. H.	A	A	C
14.	*A. kufferathii* Mang.	—	C	R
15.	*A. oestrupii* V. H.	—	—	C
16.	*Amphora bongrainii* M. Per.	—	—	R
17.	*A. capitellata* Freng.	—	R	—
18.	*A. liouvillei* M. Per.	D	A	A
19.	*A. petermannii* M. Per.	—	R	C
20.	*A. pulchella* M. Per.	—	R	C
21.	*Asteromphalus hookeri* Ehr.	—	R	—
22.	*A. parvulus* Kar.	R	—	—
23.	*Biddulphia anthropomorpha* V. H.	—	R	—
24.	*B. obtusa* (Kütz.) Ralfs	R	R	R
25.	*B. striata* Kar.	R	—	R
26.	*Chaetoceros dichaeta* Ehr.	R	C	—
27.	*C. gaussii* Heid—Kolbe	A	A	C
28.	*Charcotia australis* (Kar.) M. Per.	—	R	—
29.	*C. irregularis* M. Per.	—	C	R
30.	*Cocconeis costata* Greg.	R	R	R
31.	*C. fasciolata* (Ehr.) Brown	C	C	R
32.	*C. infirmata* Mang.	—	R	—
33.	*C. litigiosa* V. H.	—	R	—
34.	*C. pinnata* Greg.	R	R	R
35.	*Corethron criophilum* Castr.	R	—	—
36.	*Coscinodiscus argus* Ehr.	R	—	R
37.	*C. decrescens* Grun.	—	—	R
38.	*C. kryophilum* Grun.	—	R	—
39.	*C. subtilis* Ehr.	—	R	—
40.	*C. tumidus* f. *fasciculata* Rattr.	—	R	—
41.	*C. undulosus* v. *antarctica* Mang.	—	C	—
42.	*Eucampia balaustium* Castr.	C	R	C
43.	*Fragilaria islandica* v. *stricta* M. Per.	—	C	—
44.	*F. striatula* Lyng.	A	A	C
45.	*Gomphonema angustatum* (Kütz.) Rabh.	R	—	—
46.	*G. exiguum* v. *arcticum* (Grun.) Cl.	—	—	C
47.	*G. helvelicum* v. *lenuis* (Fricke) Hust.	R	—	—
48.	*Grammatophora antarctica* M. Per.	R	—	—
49.	*G. charcotii* M. Per.	R	—	—
50.	*Gyrosigma compactum* (Grev.) Cl.	R	—	—
51.	*G. subsalinum* v. *antarctica* Freng. et Or.	R	—	—
52.	*Hantzschia amphioxys* (Ehr.) Grun.	—	—	R
53.	*H. antarctica* M. Per.	—	—	R
54.	*Licmophora antarctica* v. *minor* Freng. et Or.	—	—	R
55.	*L. decora* Heiden—Kolbe	—	—	C
56.	*L. gracilis* (Ehr.) Grun.	—	—	C
57.	*Melosira adeliae* Mang.	C	—	—
58.	*M. charcotii* M. Per.	C	—	—
59.	*M. nummuloides* (Dyllw.) Ag.	C	—	—
60.	*M. subhyalina* V. H.	—	R	—
61.	*M. sulcata* (Ehr.) Kütz.	—	R	—
62.	*Navicula antarctica* Freng.	R	R	R
63.	*N. bongrainii* M. Per.	R	—	—
64.	*N. cancellata* Donkin	R	—	C

	Bacillariophyta	Zhongshan Bay	Progress Bay	Nells Fjord
65.	*N. contenta* Grun.	D	A	C
66.	*N. contenta* v. *biceps* Arnott	C	A	R
67.	*N. contenta* v. *paralela* Peters	A	C	A
68.	*N. cryptocephala* Kütz.	—	R	C
69.	*N. frequens* V. H.	C	C	A
70.	*N. glaciei* V. H.	D	D	D
71.	*N. gourdonii* M. Per.	D	D	D
72.	*N. hahnii* v. *stricta* M. Per.	—	R	—
73.	*N. intermedia* v. *antarctica* M. Per.	—	R	—
74.	*N. jejunoides* V. H.	R	—	C
75.	*N. longa* Greg.	—	R	—
76.	*N. mutica* Kütz.	R	R	C
77.	*N. mutica* v. *producta* Grun.	R	C	D
78.	*N. muticopsis* V. H.	R	A	A
79.	*N. muticopsis* f. *capitata* Carlson	R	C	A
80.	*N. muticopsis* v. *cymbellides* M. Per.	—	—	C
81.	*N. radiosa* Kütz.	R	—	—
82.	*Navicula* sp.	C	A	A
83.	*Nitzschia acicularis* (Kütz.) W. Smith	C	A	C
84.	*N. angularis* v. *tenuistriata* V. H.	—	R	—
85.	*N. angustissima* v. *delicatula* M. Per.	—	C	—
86.	*N. closterium* (Ehr.)W. Smith	R	—	—
87.	*N. closterium* f. *tenuissima* Mang.	C	—	R
88.	*N. curta* (V. H.) Hasle	D	D	D
89.	*N. cylindrus* (Grun.) Hasle	C	A	R
90.	*N. dissipata* (Kütz.) Grun.	R	R	R
91.	*N. dissipata* v. *antarctica* M. Per.	A	C	A
92.	*N. frigida* Grun.	R	—	—
93.	*N. granulata* v. *gelida* M. Per.	R	—	—
94.	*N. heimii* (Mang.) Hasle	R	A	C
95.	*N. lecointei* V. H.	—	R	C
96.	*N. linearis* (Ag.) W. Smith	R	A	A
97.	*N. obliquecostata* (V. H.) Hasle	R	R	—
98.	*N. Polaris* v. *antarctica* M. Per.	C	A	R
99.	*N. stellata* Manguin	R	R	—
100.	*N. sublineata* Hasle	C	A	A
101.	*N. sublineata* v. *ambigua* M. Per.	C	R	R
102.	*Nitzschia* sp.	R	R	C
103.	*Pinnularia quadratarea* v. *antarctica* Per.	—	C	—
104.	*P. quadratarea* v. *constricta* (Castr.) A. Sch.	R	R	A
105.	*P. quadratarea* v. *stuxbergii* (Cl.)Cl.	—	R	—
106.	*Pleurosigma decorum* W. Smith	R	—	—
107.	*Synedra antarctica* M. Per.	R	C	A
108.	*S. barbutula* Kütz.	—	R	—
109.	*Rhoicosphenia curvata* (Kütz.) Grun.	—	—	C
110.	*Thalassiosira antarctica* Comber	R	—	—
111.	*T. lentiginosus* (Jan.) Fryx.	—	R	R
112.	*Trachyneis aspera* (Ehr.) Cleve	—	R	—
113.	*T. aspera* v. *antarctica* M. Per.	R	R	—
114.	*Tropidoneis antarctica* (Grun.) Cleve	—	R	—

* D: represents dominant ($>10^4$); A: represents abundant ($10^3\sim10^4$); C: represents common($10^2\sim10^3$); R: represents rare($<10^2$).

3. 3 Composition and cell concentration of domanant species

In the intertidal zones of Zhongshan Station, nano- and microdiatoms are very abundant, with *Navicula glaciei* as dominant species. The highest cell density was at Station B of the Zhongshan Bay. The mean cell density of all stations was 639.42×10^3 ind. /g in January 1989, which occupied 74. 5% of total cell concentration. It was 160.46×10^3 ind. /g in February 1990, which occupied 28. 9% of total cell density. ***Navicula gourdonii*** ranks the second. It was mainly distributed at Station B. The mean cell density was 80.37×10^3 ind. /g in January 1989 and 268.37×10^3 ind. /g in February 1990, which occupied 9. 45% and 48. 3% of the total cell density respectively (Table 3).

Table 3. The cell abundance of main nano- and microdiatoms in the intertidal zones of Zhongshan Station, Antarctica

Species	Abundance of nano- and microdiatoms ($\times 10^3/g$)																	
	January 1989									February 1990								
	Zhongshan Bay			Progress Bay		Nella Fjord		Average abundance	Percentage (%)	Zhongshan Bay			Progress Bay		Nella Fjord		Average abundance	Percentage (%)
	A	A'	B	C	D	E	F			A	A'	B	C	D	E	F		
Navicula glaciei	84.8	0.5	2957	398.4	144.1	491.2	400	639.42	74.5	49.4	2.2	429	37.7	186.2	285	136	160.46	28.9
Navicula gourdonii	3	0.01	492.8	8.2	2.2	0	56.4	80.37	9.4	20.6	0.1	1781	0.2	33.1	8.2	37.9	268.73	48.3
Nitzschia curta	6.1	0.13	55.4	118.1	20	76.9	2.4	39.86	4.6	29	0.5	76.8	4.4	23.5	0	0	19.12	3.4
Navicula contenta	10.8	0.03	61.6	27.4	0	40	12	21.69	2.5	22	0.2	837	0.6	0	0	2.5	15.54	2.8
Navicula mutica v. *producta*	0	0	0	0	0	0	51.2	7.3	0.9	0	0	0	0	1.7	136	0	19.71	3. 5
Achnanthes antarctica	0	0	0	471	7.6	21.6	4	11.49	1.3	7	0.05	36.8	3.6	18.3	2.3	3.1	10.21	1.8
Fragilaria striatula	3.5	0	0	54.8	0	0	0	8.33	1.0	2	0	65.5	0	0	0	0	9.64	1.7
Amphora liouvillei	8.5	0.04	49.3	0	7.6	6.7	1.2	10.68	1.2	7	0.7	9.1	0.2	2.2	2.5	2	3.36	0.6
Total	116.7	0.71	3616.1	654	181.5	636.4	527.2	818.94	95.4	137	3.75	3235.2	46.7	265	434	181.5	506.77	91

4 Discussion and summary

(1) The nano- and microdiatoms are very abundant in the intertidal zones of Zhongshan Station during the ice malting period. The sand and gravel on the surface of the intertidal zones appear pale brown in color or to be brown diatom layer. Our study results suggest that diatom cell concentration is not related to the contents of sand and gravel , but to the ice snow. In winter season, the intertidal zones are covered by ice and snow. In summer time, the temperature goes up(maximum air temperature is 8. 70℃ and minimum is −1. 30℃) in Zhongshan Station. During this time, a lot of diatoms enter into the sand and gravel, thus, forming the acme of cell concentration in summer. Hoshiai found diatom layer multiplied rapidly under the sea ice in Autumn (March and April) and Spring (October～December) near Syowa Station. The main species are *Nitzschia* and *Amphiprora*, etc. (Hoshiai,1972,1981).

(2) The diatom cell density is highest at Station B of the Zhongshan bay. Among the identified 114 species of nano- and microdiatoms, 26 species are endemic in the Progress Bay, 19 in the Zhongshan Bay and 12 in the Nella Fjord. But 38 species of diatoms are common,and 8 species in all three Bays,are very abundant. They are: *Navicula glaciei*, *Navicula gourdonii*, *Nitzschia curta*, *Navicula conteuta*, *Navicula mutica* Var. *producta*, *Achnauthes antarctica*, *Fragilaria striatuuula* and *Amphora liouvilei*. They occupied 95. 4% of the total cell concentration in January and 91% in February respectively. Among them, *Naviula glaciei* is the most abundant species.

(3) The nano- and microdiatoms in the intertidal zones of Zhongshan Station are small in cell size and high in cell density. The cells with a length of <30 μm occupied more than 80% of diatoms. The mean lenth of the *Navicula glaciei* is 20 μm and its mean width is 6. 0 μm. They are distributed extensively in the sea ice of coastal intertidal zones, Antarctica. Whitaker and Richardson (1980) found that in winter *Navicula glaciei* was an important species in the sea ice. Chlorophyll a is 244 mg • m^{-2}, cell density reaches to 10^7 individually, and the very common species is in shallow mud area in summer. *Navicular glaciei* was very abundant in sea ice near Great Wall Station (Lü *et*

al., 1991). According to the study, we conclude that the *Navicula galaciei* play an important role in Antarctic ecosystems.

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