THE DIATOMS COLLECTED BY THE U. S. S. CACOPAN IN THE ANTARCTIC IN 1947[1]

BY

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For investigation of the Diatomaceae, a series of water samples was collected from the U. S. S. CACOPAN by filling a citrate bottle either with surface water obtained with a bucket or with water obtained from various depths with Nansen bottles. The positions at which samples were collected in the Antarctic are plotted on Fig. 1. Of the main previous Antarctic Expeditions (CHALLENGER, DEUTSCHER SUDPOLAR, VALDIVIA and DISCOVERY) only the CHALLENGER collected much diatom material on the Pacific and Indian Ocean side of the Antarctic continent. Five stations were occupied by the CHALLENGER in this area, but most of the diatom material obtained was from bottom sediments. The species of diatoms found at each station by the CACOPAN are listed in Table I with notations indicating the relative abundance of diatoms at each station. Further information on each station (Depth, Temperature, etc.) is given in the APPENDIX.

Identification and estimation of abundance were carried out on semi-permanent strewn plankton mounts. The diatoms were washed six times in distilled water, allowed to settle for 24 hours between washings, and the supernatant water drawn off by means of a fine pipette attached to a vacuum pump. After the final washing a few drops of the sediment were placed on a slide, gently warmed until dry, and a permanent mount prepared. For a critical examination of the species a mountant with a high refractive index is necessary. For this purpose Hyrax (a synthetic resin with a refractive index of 1.71) was used. These preparations give excellent results and last for many months.

According to the hydrographic data (Pritchard and LaFond, MS.), the Antarctic Convergence is not sharply defined in the region from which most of the diatom samples were taken, but lies somewhere between Lat. 59° S. and 63° S. The surface water temperature difference—about 6° C.—between stations 42 and 44 is an indication that the Convergence had been crossed, and all higher numbered stations were therefore situated to the north of the Convergence. It appears

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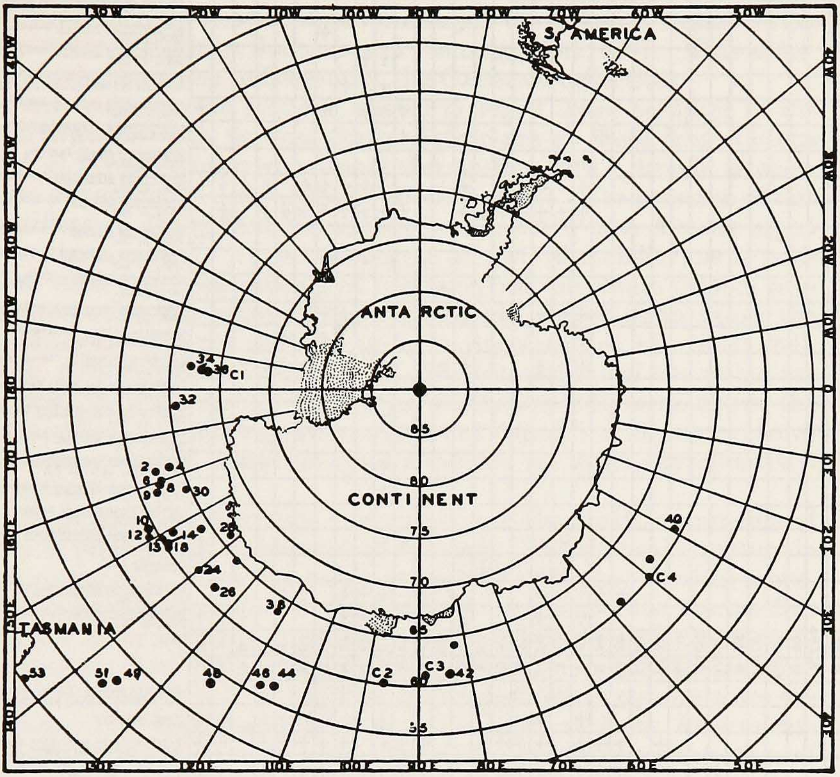


Figure 1. Chart of Antarctic stations.

from Table I that the Antarctic Circumpolar surface water south of the Convergence supports an extremely rich phytoplankton population compared with the striking paucity of phytoplankton in the surface waters to the north of the Convergence. The phytoplankton wealth of the Antarctic waters has frequently been commented upon before (Hendey, 1937; Hart, 1934). Hart has suggested that the diminished population in the subtropical and tropical regions is a result of the almost complete lack of nutrient salts in the surface waters of these regions, while in the polar regions nutrients cannot be regarded as a limiting factor at any time, since the content never falls below a minimum of about 0.9 μg.-at. PO_4 per liter, which is well above diatom needs. Hart considers that the high nutrient content is due to the fact that the spring break-up of the ice packs releases a supply that is never exhausted. Another cause of this nutrient surplus, and probably the main cause, is the marked vertical mixing of the Antarctic waters

Station Number	2	4	6	8	9	10	12	13	14	18	24	26	28	30	32	34	36	38	40	42	44	46	48	49	51	53	55	59	61	63	65	67	70	72	74	76
Relative Diatom Abundance	C	C	C	C	VA	A	C	A	A	C	C	A	R	C	R	C	C	VA	C	A	R	VR	VR	VR	VR	O	VR	O	VR	VR	O	O	O	VR	VR	VR
Actinocyclus bifrons Karsten, 1905, p. 92.						+																														
Actinocyclus janus Karsten, 1905, p. 92.																		+																		
Amphora peragallorum van Heurck, 1909, p. 7.																				+																
Asteromphalus brookei Bailey, 1856, p. 2.							+																													
Asteromphalus elegans Greville, 1859, p. 161.									+	+							+																			
Asteromphalus heptactis (Brébisson) Ralfs ex Pritchard, 1861, p. 838.								+		+		+								+																
Asteromphalus parvulus Karsten, 1905, p. 90.	+					+	+		+	+	+									+																
Asteromphalus roperianus Ralfs ex Pritchard, 1861, p. 838.	+										+	+									+															
Chaetoceros chunii Karsten, 1905, p. 117.																				+																
Chaetoceros criophilum Castracane, 1886, p. 78.		+	+	+		+	+	+	+	+			+	+		+	+	+	+	+																
Chaetoceros dichaeta Ehrenberg, 1844, p. 200		+		+	+	+	+	+	+	+	+			+	+	+	+	+	+	+																
Chaetoceros didymum Ehrenberg, 1845, p. 75.	+																													?						
Chaetoceros neglectum Karsten, 1905, p. 119									+																											
Chaetoceros pelagicum Cleve, 1873, p. 11.			+										+																							
Chaetoceros peruvianum Brightwell, 1856, p. 107.					+	+	+	+	+		+	+		+		+		+	+	+	+															
Charcotia bifrons (Castracane) M. Peragallo, 1921, p. 78.					+		+													+																
Corethron criophilum Castracane, 1886, p. 85.		+	+	+	+	+	+	+	+	+		+	+	+				+	+	+																
Coscinodiscus australis Karsten, 1905, p. 79.												+																								
Coscinodiscus excentricus Ehrenberg, 1840, p. 146.										+																										
Coscinodiscus gracilis Karsten, 1905, p. 78.				+																																
Coscinodiscus lentiginosus Janisch, In Schmidt, 1878, p. 58.		+	+	+		+			+	+																										
Coscinodiscus lineatus Ehrenberg, 1839, p. 129.										+		+																								
Coscinodiscus minimus Karsten, 1905, p. 78.												+																								
Coscinodiscus simbirskianus Grunow, 1884, p. 81.	+									+	+	+							+																	
Cocconeis sp.	+			+											+																					+
Dactyliosolen antarcticus Castracane, 1886, p. 75.					+	+		+	+	+		+						+		+	+	+														
Eucampia balaustium Castracane, 1886, p. 97.	+	+	+					+	+	+		+						+		+																
Station Number	2	4	6	8	9	10	12	13	14	18	24	26	28	30	32	34	36	38	40	42	44	46	48	49	51	53	55	59	61	63	65	67	70	72	74	76
Relative Diatom Abundance	C	C	C	C	VA	A	C	A	A	C	C	A	R	C	R	C	C	VA	C	A	R	VR	VR	VR	VR	O	VR	O	VR	VR	O	O	O	VR	VR	VR
Eucampia cornuta (Cleve) Grunow ex van Heurck, 1880-5, pl. 95b, f. 5.								+																												
Fragilaria sp.	+			+	+					+								+		+																
Fragilariopsis antarctica (Castracane) Hustedt in Schmidt, 1913, pl. 299, f. 9-14	+	+		+	+	+	+	+		+	+	+			+	+	+	+		+	+	+		+												
Fragilariopsis antarctica f. bouvet Karsten, 1905, p. 123.	+	+		+	+	+	+	+	+	+	+	+			+	+	+	+		+	+	+					+							+		
Grammatophora marina (Lyngbye) Kützing, 1844, p. 128.																	+	+				+														
Guinardia flaccida (Castracane) H. Peragallo, 1892, p. 107.		+				+			+		+							+																		
Navicula trompii var. major Heiden & Kolbe, 1928, p. 625.										+								+																		
Nitzschia closterium (Ehrenberg) W. Smith, 1853, p. 42.	+	+		+			+	+							+			+		+																
Nitzschia seriata Cleve, 1883, p. 478.	+	+	+	+	+	+	+	+	+	+	+	+				+		+	+	+	+	+							+						+	
Pinnularia lanceolata Heiden & Kolbe 1928, p. 598.						+																														
Pleurosigma directum Grunow, 1880, p. 53.						+				+												+														
Rhizosolenia alata Brightwell, 1858, p. 96.						+		+															+												+	
Rhizosolenia alata f. indica (Peragallo) Hustedt, 1929, p. 602.						+														+																
Rhizosolenia alata f. inermis (Castracane) Hustedt, 1929, p. 602.		+	+	+	+	+	+	+	+	+	+							+	+	+	+				+					+						
Rhizosolenia antarctica Karsten, 1905, p. 95.				+														+																		
Rhizosolenia bidens Karsten, 1905, p. 98.																				+																
Rhizosolenia delicatula Cleve, 1900, p. 28.					+							+																								
Rhizosolenia hebetata f. semispina (Hensen) Gran, 1905, p. 55.			+		+	+	+	+	+	+		+								+																
Rhizosolenia styliformis v. longispina Hustedt in Schmidt, 1914, pl. 316, f. 5-7, 12.											+			+							+															
Schimperiella antarctica Karsten, 1905, p. 88.												+																								
Synedra pelagica Hendy, 1937, p. 335.	+	+	+	+		+	+	+	+	+					+		+	+	+	+																
Thalassiosira antarctica Comber, 1896, p. 491.					+					+		+						+																		
Thalassiosira decipiens (Grunow ex van Heurck) Jørgensen, 1905, p. 96.		+		+				+																												
Thalassiothrix longissima v. antarctica				+	+	+	+	+		+	+	+						+		+																
Tropidoneis antarctica (Grunow) Cleve, 1894, p. 24.	+		+		+		+			+		+						+			+															
Tropidoneis glacialis v. constricta Heiden & Kolbe, 1928, p. 656.																+																				
Rhizosolenia styliformis Brightwell, 1858, p. 95.							+																													

and weak thermal stratification resulting in the ascent of nutrient-rich deep water (Sverdrup, Johnson and Fleming, 1942: 620). This nutrient surplus was also indicated by the CACOPAN collection.

Four hydrographic stations, shown in Fig. 1, were occupied in the polar waters. The vertical thermal structure at these four stations (Fig. 2) reveals a marked seasonal thermocline with a drop in temperature of nearly 5° C. at depths of 20–40 meters.[2] The presence of this stratification shows that the surface waters there have already spent some time as such. A certain degree of vertical stability, as is indicated here, has been considered necessary for maximum diatom production, otherwise many of the diatoms are carried down below the euphotic zone (Gran and Braarud, in Sverdrup, et al., 1942: 789). Thus, although data on the actual nutrient content of the water are lacking, the high diatom population in the euphotic zone above the thermocline (in surface waters which are "aged") is strong evidence that there is still a sufficiency of nutrients for good phytoplankton production.

On crossing the Antarctic Convergence to the north, a pronounced drop in phytoplankton population is noted. The thermal structure in this region (Fig. 3) can be taken as an indication that vertical movement between the waters of the euphotic zone above the thermocline and the lower layers is much reduced, and thus the replenishment of nutrients is slow. The paucity of diatom cells here may indicate that the vernal bloom is over and that the surface water nutrients are depleted. The appearance of a summer form such as *Rhizosolenia hebetata* f. *semispina* and the absence of the primitive resting stage of *Rhizosolenia hebetata* are indications that the population is a summer one.

The species concentration found at each depth at the hydrographic stations is as follows:

Station C1		*Station C2*		*Station C3*		*Station C4*	
Depth (feet)	*No. of Species*	*Depth (feet)*	*No. of Species*	*Depth (feet)*	*No. of Species*	*Depth (feet)*	*No. of Species*
0	3	0	1	0	8	0	3
50	1	50	7	50	9	50	8
100	1	100	7	100	6	100	8
200	1	200	1	200	5	200	8
300	0	300	2	300	1	300	0
500	0	500	1	600	0	500	0
900	0	900	1			650	0

As each species was usually represented by only one or two frustules, the number of species can be taken as an indication of diatom concen-

[2] There is no winter thermocline in Antarctic waters (Sverdrup, et al., 1942: 609).

Table I. Species and Abundance of Diatoms. VA—very abundant, A—abundant, C—common, R—rare, VR—very rare, O—None detected.

tration. The depths at which a Secchi disc could be seen at these four stations were as follows: Sta. C1, 90 ft.; Sta. C2, 55 ft.; Sta. C3, 41 ft.; Sta. C4, 68 ft. Diatoms flourish best in somewhat subdued

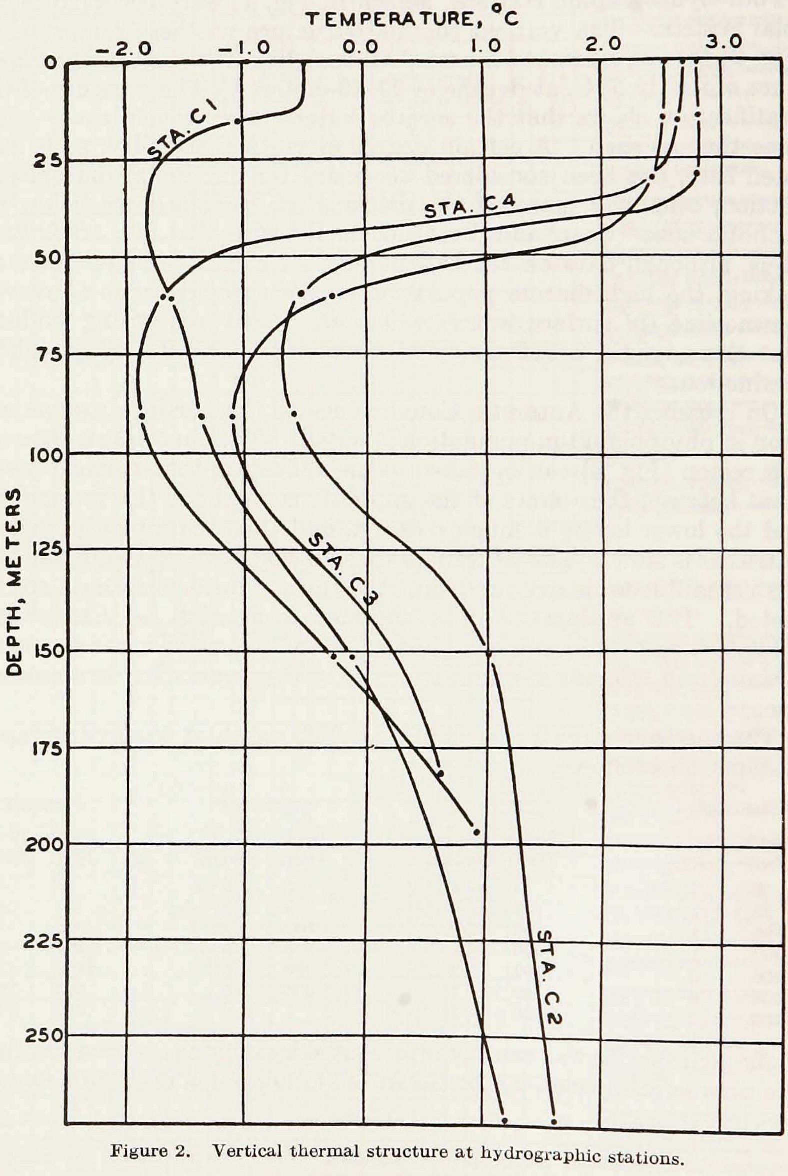
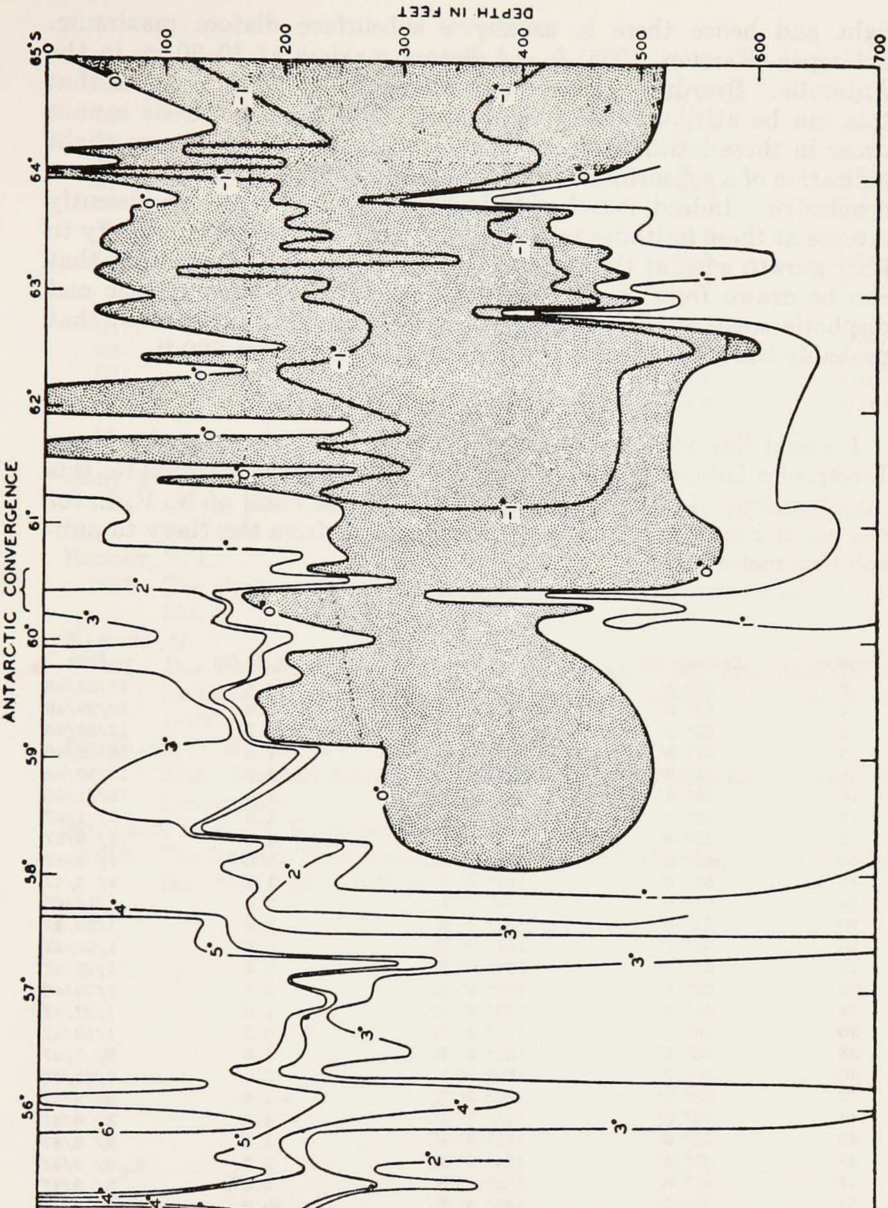


Figure 2. Vertical thermal structure at hydrographic stations.


DEPTH IN FEET
DEPTH IN METERS
ANTARCTIC CONVERGENCE
65°S
64°
63°
62°
61°
60°
59°
58°
57°
56°
55°

light and hence there is usually a subsurface diatom maximum. Schimper (Karsten, 1905) found diatom maxima at 40–80 m. in the Antarctic. Sverdrup, Johnson and Fleming (1942: 781) consider that this can be attributed only to sinking, since photosynthesis cannot occur in these latitudes below 50 m. Although there is some slight indication of a subsurface diatom maximum in the above data, it is not conclusive. Indeed, it is doubtful whether sunlight is ever sufficiently intense at these latitudes to become lethal to diatoms or inhibitory to their growth even at the extreme surface. The only conclusions that can be drawn from the present data are (a) that the euphotic and disphotic zones at these stations are extremely shallow, and (b) that probably the lower limit of the disphotic zone is about 200 ft.

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APPENDIX

Surface Samples

Station	*Latitude (S)*	*Longitude*	*Temp. (° C.)*	*Date*
2	62° 2′	162° 3′ E.	−0.8	12/28/46
4	62° 5′	162° 0′ E.	1.0	12/29/46
6	62° 2′	159° 2′ E.	0.7	12/30/46
8	61° 8′	158° 2′ E.	1.8	12/30/46
9	61° 0′	156° 2′ E.	2.0	12/30/46
10	59° 3′	152° 0′ E.	1.9	12/31/46
12	59° 2′	150° 4′ E.	1.5	1/ 1/47
13	59° 5′	148° 8′ E.	1.0	1/ 2/47
14	60° 0′	150° 6′ E.	1.6	1/ 3/47
18	59° 9′	148° 8′ E.	1.3	1/ 5/47
24	61° 0′	140° 0′ E.	2.4	1/18/47
26	61° 0′	137° 3′ E.	1.9	1/20/47
28	65° 7′	141° 6′ E.	−0.4	1/22/47
30	64° 5′	156° 0′ E.	0.8	1/23/47
32	65° 5′	176° 1′ E.	2.1	1/25/47
34	66° 9′	173° 8′ W.	1.6	1/27/47
36	68° 1′	174° 7′ W.	−0.2	1/28/47
38	63° 5′	121° 8′ E.	1.0	2/ 7/47
40	60° 7′	29° 7′ E.	3.0	2/21/47
42	63° 9′	82° 3′ E.	−1.4	3/ 2/47
44	56° 6′	115° 7′ E.	4.6	3/ 6/47
46	55° 9′	117° 6′ E.	1.6	3/ 6/47
48	53° 4′	124° 7′ E.	5.7	3/ 7/47
49	47° 3′	135° 6′ E.	9.0	3/ 8/47
51	46° 1′	136° 5′ E.	10.9	3/ 9/47
53	40° 2′	143° 1′ E.	17.0	3/11/47
55	39° 5′	144° 2′ E.	18.1	3/11/47
59	32° 1′	165° 0′ E.	21.7	3/22/47

APPENDIX

Surface Samples

Station	*Latitude (S)*	*Longitude*	*Temp. (° C.)*	*Date*
61	29° 9′	170° 0′ E.	24.0	3/23/47
63	26° 3′	175° 6′ W.	24.3	3/24/47
65	22° 6′	179° 7′ W.	27.4	3/24/47
67	18° 4′	174° 9′ W.	29.0	3/25/47
70	14° 2′	170° 3′ W.	30.7	3/26/47
72	09° 9′	165° 9′ W.	30.0	3/27/47
74	03° 5′	159° 5′ W.	27.6	3/29/47
76	01° 6′ N.	154° 9′ W.	27.6	3/30/47
HYDROGRAPHIC STATIONS				
C1:	68° 43′ S.	174° 55′ W.	−0.5	1/30/47
C2:	59° 55′ S.	96° 45′ E.	2.8	2/11/47
C3:	60° 55′ S.	88° 55′ E.	2.6	2/13/47
C4:	59° 57′ S.	40° 30′ E.	2.5	2/19/47

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