Biogenic sediment fluxes in the western Ross Sea

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Although it is clear that deep shelf currents play a major role in the redistribution of biogenic phases on the antarctic margin, the extent to which photic-zone and mid-water-column processes control the flux of organic debris to the seafloor is not yet known. A major impediment to a more complete understanding of the fluxes of key elements like carbon, nitrogen, silicon, and phosphorus in the southern ocean water column has been the absence of year-round environmental monitoring and sampling. Our principal goal during the 1989–1990 field season was to install four sets of time-series sediment traps on winter-over moorings in the western Ross Sea. We also recovered winter-over moorings equipped with current meters and single-cup sediment traps and completed a sediment collection program in Granite Harbor.

Our field work was conducted from the sea ice during November, 1989, and aboard the R/V *Polar Duke* during January and February, 1990. On Polar Duke, we deployed six time-series (15 cups) sediment traps at three sites in the western Ross Sea. These deployments are part of an interdisciplinary, multi-institutional study of the biogeochemical cycles of silicon and carbon in the Ross Sea. The sediment traps will be deployed for 2 years and will provide the first view of sediment fluxes over a monthly time-scale throughout the austral winter and summer in the Ross Sea. These results will complement the water-column production and recycling studies of organic matter (W. Smith, University of Tennessee) and biogenic silica (D. Nelson, Oregon State University), and the shelf current and seafloor sediment studies of D. DeMaster (North Carolina State University) and C. Nittrouer (State University of New York at Stonybrook). The mooring sites (table 1) were located at the ends of sampling transects which traverse areas ranging from ice-free to heavily ice-covered during most of the austral summer. Mooring A is located in a region of highly biosiliceous seafloor sediment (greater than 40 percent opal; Dunbar et al. 1985) and in which a large ice-edge bloom was encountered

Table 1. Samples collected aboard R/V *Polar Duke* during January and February 1990

Floating traps

					Trap location	
Date	Site	Station	Deploy time	Trap depth[a]	Latitude	Longitude
1/12/90	A	1	30h 00m	50, 100, 250	76°30.161′S	167°30.575′E
1/16/90	B	30	24h 15m	50, 100, 225, 250	76°30.182′S	175°02.395′W
1/21/90	C	63	26h 15m	50, 100, 225, 250	72°30.027′S	172°30.038′E
1/31/90	A	133	11h 10m	50, 100, 225, 250	76°29.710′S	167°30.425′E
2/04/90	B	166	19h 15m	50, 100, 225, 250	76°30.336′S	174°59.196′W

Moorings

						Trap location	
Date (1990)	Site	Station	Water depth[b]	Trap depth[a]	Samples collected	Latitude	Longitude
1/12–2/04	A	1	776	231, 725	1,4	76°30.093′S	167°30.309′E
1/17–1/31	B	30	569	231, 519	4,4	76°30.336′S	174°59.128′W
1/22–	C	63	533	231, 483	0,0	72°28.813′S	172°31.470′E

Cores and grab samples

					Core location	
Date (1990)	Station	Water depth[b]	Core length[b]	Collection interval[c]	Latitude	Longitude
Cores						
2/08/90	181	771	2.50	10	76°52.329′S	163°17.281′E
2/08/90	182	871	2.49	10	76°54.748′S	163°04.070′E
2/08/90	183	790	3.42	10	76°55.379′S	162°54.105′E
2/08/90	184	803	3.22	10	76°58.520′S	164°52.233′E
Grab samples						
2/08/90	185	176	—	—	76°59.924′S	164°00.853′E
2/08/90	186	420	—	—	76°54.859′S	164°25.611′E
2/08/90	187	553	—	—	76°52.747′S	164°36.170′E
2/08/90	188	527	—	—	76°50.168′S	164°49.282′E
2/08/90	189	587	—	—	76°47.424′S	165°04.358′E
2/08/90	190	587	—	—	76°43.889′S	165°19.067′E

[a] In meters below sea level.
[b] In meters.
[c] In centimeters.

and studied during January and February, 1983 (Smith and Nelson 1985; Nelson and Smith 1986).

Floating sediment-trap arrays were also deployed during the cruise, typically with traps at 50, 100, 225, and 250 meters for periods of up to 30 hours (table 1). The bottom-anchored moorings at sites A and B were recovered, serviced, and redeployed at the end of the cruise yielding 13 samples of the vertical flux collected over intervals ranging from 3 to 5 days. A mid-deployment cruise to service the moorings is planned for February 1991. All trap samples are curated at Rice University; small splits of curated trap samples are available to other investigators upon request.

During November 1989, we recovered two winter-over moorings; one equipped with current meters and sediment traps in Erebus Basin (table 2; Barry et al., *Antarctic Journal*, this issue), and another single-cup sediment trap deployed for the previous 2 years in New Harbor. We also deployed a seventh time-series sediment trap near the seafloor in an 800-meter deep basin in south central Granite Harbor. Sediments in the deep basins of Granite Harbor are accumulating at rates of 2 to 3 millimeters per year (Macpherson 1987). As part of a collaborative effort with Victoria University (New Zealand), we are using these rapidly accumulating sediments to reconstruct sea ice and oceanographic conditions in the southwestern Ross Sea during the past several thousand years. This sediment-trap deployment will provide the first year-round measurement of the sinking flux for calibration of our paleoclimate indices.

Sediment cores and grab samples collected in Granite Harbor are listed in table 2. Since diatom frustules and freshly produced organic matter provide important paleoclimatic information, we completed a program of pore water analysis to examine early diagenetic modification of these tracers at the seafloor. Two large-diameter gravity cores were split in the field and subsamples were centrifuged to extract interstitial waters. Results of the chemical analyses are shown in the figure. In cores WG-1 and DG-10, the vertical profiles of alkalinity, ammonium, and phosphate are very similar, a strong

Table 2. Samples collected from the sea ice during November 1989.

Moorings

Date (1989)	Site	Water depth[a]	Trap depth[b]	Samples collected	Trap location	
					Latitude	Longitude
1/12–11/02	—	596	178,546	1,1	77°48′0.6″S	166°20′14.835″E
11/17–	A	840	790	0(6 set)	76°59′11.6″S	162°49′30.2″E

Cores and grab samples

Date (1989)	Core	Site	Water depth[a]	Core length[a]	Sample location	
					Latitude	Longitude
Cores						
11/16	WG-1	A	840	0.83	76°59′11.6″S	162°49′30.2″E
11/18	WG-2	F	906	0.90	76°55′24.9″S	163°00′39.4″E
11/23	DG-10	R	824	1.80	76°58′06.4″S	162°37′49.2″E
11/24	DG-11	K	900	1.30	76°54′54.8″S	163°01′33.9″E
Grab samples						
11/20	GS-3	L	232	—	76°52′22.8″S	162°36′59.5″E
11/20	GS-4	M	236	—	76″53′55.0″S	162°39′32.0″E
11/20	GS-5	N	335	—	76°55′09.5″S	162°41′51.5″E
11/20	GS-6	O	340	—	76°56′11.0″S	162°44′47.6″E
11/20	GS-7	P	499	—	76°57′10.8″S	162°45′10.6″E
11/22	GS-8	Q	590	—	76°56′28.6″S	162°30′52.3″E

[a] In meters.
[b] In meters below sea level.

indication that early diagenesis of organic matter via sulfate reduction is the dominant control on the concentration of these dissolved components. The alkalinity gradient observed in WG-1 (equivalent to 82 millimolar per meter) is one of the highest yet reported in continental shelf sediments. Excess alkalinity may be removed by authigenic carbonate precipitation in the sediments. Silicon concentrations of 600 to 800 micromolar are reached at depths of only a few centimeters. This gradient is most likely supported by rapid dissolution of diatom tests in the uppermost portion of the sediment column. Below 2–3 centimeters, the dissolved silicon profiles show much smaller gradients suggesting that silica dissolution is not directly linked to degradation of organic matter. We plan to calculate mass fluxes of dissolved silica and to examine changes in the diatom assemblage due to dissolution within the upper 20 centimeters.

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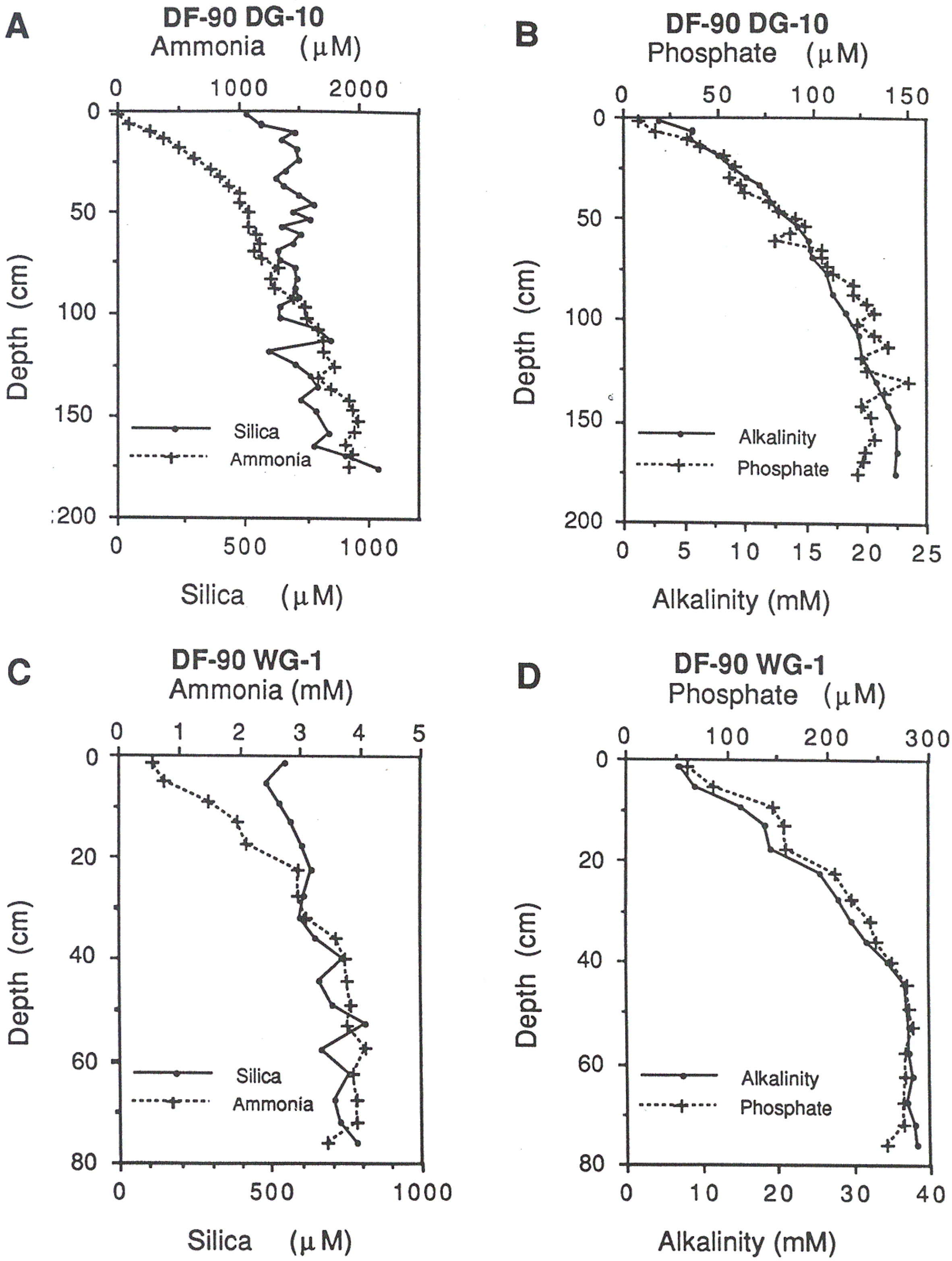

Vertical profiles of interstitial water. A. Ammonium and silica in core DG-10. B. Phosphate and alkalinity in core DG-10. C. Ammonium and silica in core WG-1. D. Phosphate and alkalinity in core WG-1. All samples were centrifuged in the field within 2 hours of core collection. The chemical analyses shown above were completed at McMurdo Station within 2 to 10 days. Additional analyses of dissolved sulfate, magnesium, and calcium are being performed by P. Baker (Duke University). (µM denotes micromolar. mM denotes millimolar. cm denotes centimeter.)