Sediment-trap experiments in the central and western Ross Sea, January and February 1990

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As part of an interdisciplinary, multi-institutional study of the biogeochemical cycles of carbon and silicon on the Ross Sea continental shelf, we deployed both drifting and moored arrays of particle interceptor traps at three sites in the central and western Ross Sea during January and February, 1990. Particle transport and dissolution/degradation dynamics in the southern ocean water column control a variety of important processes including nutrient regeneration, delivery of food to benthic communities, and preservation of sediment records of climate change. Many features of the carbon and silicon cycles on the antarctic continental shelf are not observed in lower latitudes and appear to be controlled by a combination of unusual seasonality, great water depths, low temperatures, and high current energies. One of our goals is to establish budgets for surface production, vertical and horizontal transport, and seabed accumulation of important bioactive phases in this unique setting.

During the 1990 *Polar Duke* cruise, we deployed particle interceptor traps at three sites during January and February (table 1). Sites A and C are in the central and northern portions of the western Ross Sea; site B is located in the central Ross Sea. Drifting arrays consisted of three or four Rice University Mk III single-cup sediment traps (2,000-square-centimeter collection

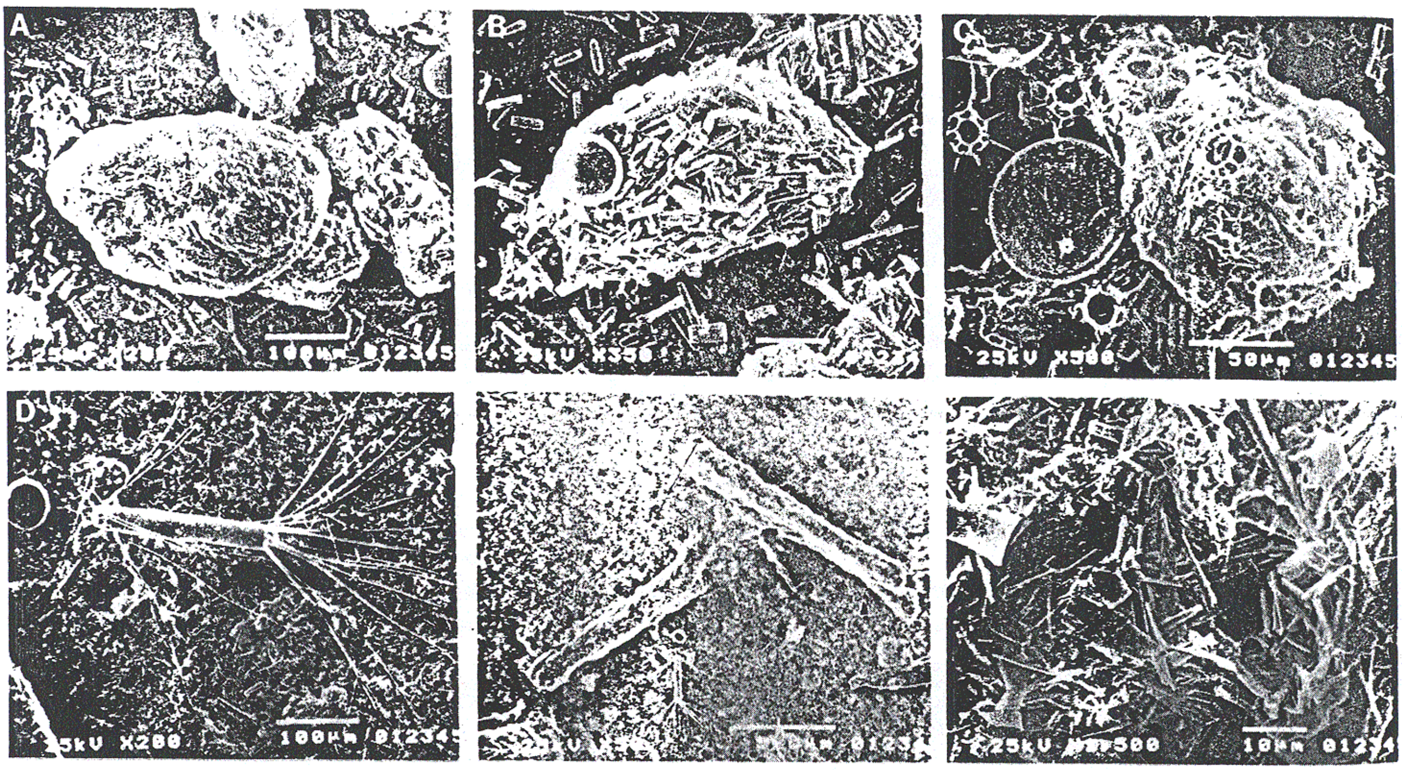
Table 1. Sediment trap samples collected from *Polar Duke* January and February 1990

Site	Latitude	Longitude	Depth (in meters)	Start date	Number of cups	Duration (in days)
Site A						
Mooring	76°30.093′S	167°30.309′E	231	12 Jan 1990	1	3.60
Mooring	76°30.093′S	167°30.309′E	725	12 Jan 1990	6	3.60
						4.00
						4.00
						4.00
						4.00
						3.30
Drifter	76°30.161′S	167°30.575′E	50, 100, 250	12 Jan 1990	1	1.25
Drifter	76°29.710′S	167°30.425′E	50, 100, 225, 250	31 Jan 1990	1	0.47
Site B						
Mooring	76°30.336′S	174°59.128′W	231, 519	17 Jan 1990	4	2.60
						4.00
						4.00
						3.40
Drifter	76°30.182′S	175°02.395′W	50, 100, 225, 250	16 Jan 1990	1	1.02
Drifter	76°30.336′S	174°59.196′W	50, 100, 225, 250	4 Feb 1990	1	0.80
Site C						
Drifter	72°30.027′S	172°30.038′W	50, 100, 225, 250	21 Jan 1990	1	1.10

area) suspended at depths of 50, 100, 225, and 250 meters between a bottom weight and surface float radio beacon. Deployment times ranged from 11 to 30 hours; traps were unpoisoned. Moored arrays deployed at the three sites included both shallow and deep 15-cup time series traps built at Oregon State University as well as current meters and transmissometers. Trap cups were poisoned with sodium azide. Moorings at sites A and B were set to collect at intervals of from 2.5 to 4 days during the cruise and were recovered and redeployed in mid-February. In this article, we report only the short-term sediment fluxes collected during the 1990 austral summer.

We observed pronounced variability in magnitude and chemical composition of the vertical flux as well as particle morphology between sites and between surface and deep traps during the cruise. The highest biogenic fluxes occurred at site A (table 2) where samples were generally enriched in biogenic opal (up to 83 weight percent) and relatively depleted in organic carbon (3 to 14 percent). Between 1 and 4 February 1990, the biogenic opal flux to 725 meters averaged 24.6 millimoles per square meter per day, the highest opal flux ever recorded in the Ross Sea. Nearly all opal delivered to the mid- and deep water column consisted of unbroken diatom tests of the genus *Nitzschia*, many of which settled within fecal pellets. Ellipsoidal fecal pellets 150 to 300 micrometers in length were a dominant component (up to 80 percent by weight) of the drifting traps (figure) with fluxes of up to 19,000 pellets per square meter per day.

The lowest biogenic fluxes during the cruise were recorded at site B. Samples were depleted in biogenic silica (13 to 47 percent) and enriched in organic carbon (up to 26 percent). There was considerable diversity in the biosiliceous components at site B, in contrast to the nearly monospecific diatom assemblage observed at site A. This was the only site where we observed significant fluxes of calcium carbonate, mainly as tests of the planktonic foraminifer *Neogloboquadrina pachyderma*. Fecal pellets were smaller and less common than at site A. More than 50 percent of the total vertical flux was contained within loosely bound aggregates of organic debris approximately 1 to 2 millimeters across. Vertical sediment fluxes at site C were intermediate between those recorded at sites A and B. Compositionally, the trapped material was similar to that recovered at site A, with a relatively high silicon-to-carbon ratio. Only



Scanning electron microscope photographs of particulate material collected in Ross Sea sediment traps, January and February 1990. *A.* Ellipsoidal fecal pellet from second drifter deployment at site A (100 meters). Note intact organic membrane surrounding pellet. (Scale bar = 100 micrometers.) *B.* Ellipsoidal pellet from same sample as in *A.* Pellet consists mainly of unfragmented tests of the diatom *Nitzschia curta.* Note absence of membrane. More than 70 percent of all pellets at site A lacked an organic coating. (Scale bar = 50 micrometers.) *C.* Small ellipsoidal pellet from first drifter deployment at site B. These pellets have low length-to-diameter ratios and often exhibit an organic coating. Pellets at site B contain a more diverse microfossil assemblage, including the silicoflagellate *Distephanus speculum* as well as *Nitzschia* spp. diatoms. (Scale bar = 50 micrometers.) *D.* Large test of *Corethron criophilum* which had settled as an individual particle at site C. (Scale bar = 100 micrometer.) *E.* Large, cylindrical pellets, probably produced by euphausiids recovered from drifting traps at site C. (Scale bar = 500 micrometers.) *F.* Closeup of surface of pellet in *E.* These large pellets contain thoroughly fragmented diatomaceous debris. They sink rapidly, but when they degrade in the water column, they release very fine opal particles that are easily maintained in suspension and dissolved. (Scale bar = 10 micrometers.)

Table 2. Opal and carbon fluxes in the Ross Sea, January and February 1990

Site	Flux[a] Biogenic opal	Organic carbon
Site A		
231 meters		
Mooring (3.6 days)	5.3	3.3
Drifter 1 (early)	0.7	0.8
Drifter 2 (late)	4.2	2.9
725 meters		
Mooring (22.9 days)	14.6	4.8
Site B		
231 meters		
Mooring (14.0 days)	0.3	0.9
Drifter 1 (early)	0.2	0.5
Drifter 2 (late)	1.2	3.1
Site C		
250 meters		
Drifter	2.2	1.5

[a] In millimoles per square meter per day.

one type of fecal pellet was observed at site C; a large cylindrical variety (figure) which increases in abundance with depth in the upper 250 meters. Similar pellets in the Antarctic Peninsula region have been ascribed to euphausiids (Bodungen 1986).

Our results reveal large spatial and temporal variability in the magnitude and style of the vertical biogenic sediment flux. Opal fluxes were approximately one order of magnitude higher in the western Ross Sea than at the same latitude in the central Ross Sea. Organic carbon fluxes were also higher in the west, although by only a factor of 2 to 4. Near-bottom fluxes in the western Ross Sea are higher than fluxes to 250 meters. This is opposite the trend observed in the central Ross Sea and consistent with mid-and deep-water transport of biosiliceous debris from east-to-west as we have previously suggested based on seafloor sediment distribution (Dunbar et al. 1985). Fecal pellets and large aggregates clearly play an important role in vertical transport. Dense, rapidly settling pellets such as those observed at sites A and C are less likely to be transported large distances by shelf currents than the large, low-density aggregates observed at site B. The extent to which the observed difference in biogenic sedimentation between the western and central Ross Sea may reflect a genuine long-term disparity in surface productivity is not yet known. Further refinement awaits integration of particle flux results with near-surface productivity data as well as the long-term perspective offered by surface-sediment accumulation studies and our winter-over trap samples.

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