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REMOVAL OF CHEMICAL MATERIALS FROM SEAWATER IN THE ANTARCTIC OCEAN OBSERVED WITH SEDIMENT TRAP EXPERIMENT (EXTENDED ABSTRACT)

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To study the biological productivity in the surface water and the subsequent transport of chemical substances by particulate matter, sediment trap experiments were carried out in the Antarctic Ocean. The array with five NH type sediment traps (TSUNOGAI and NORIKI, 1983) which were moored at depths of 520, 770, 1200, 2260 and 3110 m was deployed for 24 days starting on 20 December 1983 at 61°33′S, 150°27′E, where the water depth was 3580 m. At the adjacent station (61°30′S, 150°02′E, water depth 3920 m), two rotating time-series sediment traps (D type; TSUNOGAI and NORIKI, 1983) were moored at depths of 1460 and 3760 m. Four samples collected at ten-day intervals from 25 December 1983 were recovered with each D type trap. Ignition loss and the concentrations of silicate, aluminum and natural radionuclides such as ^{234}Th, ^{210}Po and ^{210}Pb were determined (NORIKI *et al.*, 1985; HARADA and TSUNOGAI in preparation).

The total mass fluxes observed with the NH type traps (Fig. 1) ranged from 290 to 410 g/m^2·y with the mean value of 360 g/m^2·y. This value is 20–70 times larger than that in the eastern subtropical Pacific and several times larger than that even in the northern North Pacific where the largest flux had been reported in the previous sediment trap experiments. The total mass fluxes obsreved with the time-series D type traps are

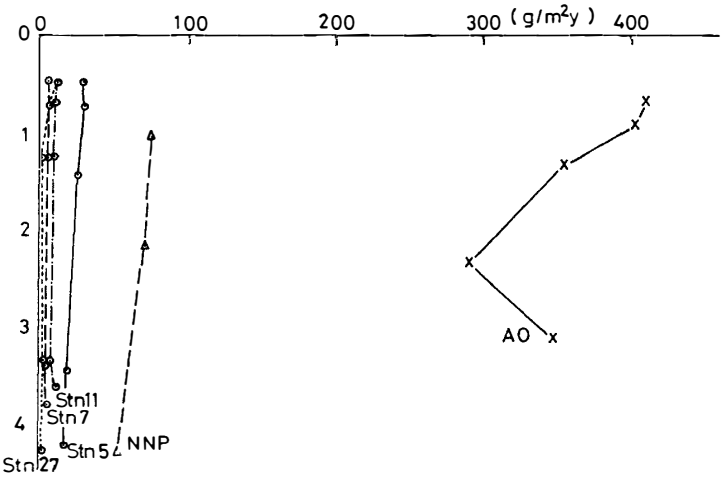

Fig. 1. Total mass fluxes observed with NH type sediment traps in the Antarctic Ocean (AO), the northern North Pacific (NNP; TSUNOGAI et al., 1982) and the eastern Pacific (Stns. 5, 7, 11, 27).

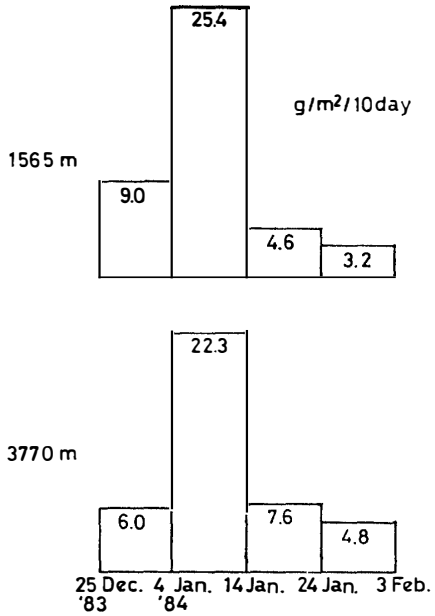

Fig. 2. The temporal variation of the total mass fluxes in the Antarctic Ocean observed with time series D type traps.

Table 1. Vertical variation of composition of settling particles.

Depth (km)	Ignition loss (%)	Biogenic SiO_2 (%)	$CaCO_3$ (%)	Clay (Al) (%) (ppm)
0.52	15.4	77.9	2.3	0.06 (51)
0.77	16.0	80.6	2.0	0.06 (47)
1.20	14.7	80.1	2.0	0.12 (94)
2.26	15.1	82.7	2.1	0.11 (91)
3.11	14.5	83.7	2.2	0.13 (107)
Average	15.1	81.0	2.1	0.10 (78)

shown in Fig. 2. At both two layers, the total mass fluxes from 4 to 14 January were the highest among the four collecting periods. In the next ten days, the fluxes decreased to one-sixth and one-third at depths of 1460 and 3760m, respectively. Furthermore, the temporal variation patterns of fluxes measured with the traps, about 2km far apart, were coincident with each other. Therefore, it is suggested that the total mass flux varies largely in short time scale, and that numerous particles begin to sink to the sea floor at the rate of 200m/day or more.

The concentrations of the major components in the settling particles obtained with NH traps (Table 1) were fairly constant with depth (NORIKI *et al.*, 1985). Large part of the settling particles, more than 80%, were occupied with opal. Therefore, it can be said that the total mass fluxes in the Antarctic Ocean, which shows large temporal variations, are due to the opaline shells produced in surface water during the short period of time. Recently, many scientists have suggested that the biological productivity in the Antarctic Ocean may not be so large as previously believed (HOLM-HANSEN *et al.*, 1977; FUKUCHI, 1980). The result of this study, however, suggests that the net biological production in the Antractic Ocean is extremely high, at least during the sediment trap experiment.

To study the removal mechanism of metals from the Antarctic Ocean, the concentrations of radioactive nuclides which are the isotopes of metal elements were determined. The radionuclides dealt with in this study are ^{234}Th (half life is 24.1 days; the daughter of ^{238}U which is dissolved in seawater), ^{210}Pb (22.2 years; the daughter of ^{226}Ra which is dissolved in seawater) and ^{210}Po (138 days; the daughter of ^{210}Pb). The concentrations of these radionuclides in the settling particles and the particulate fluxes in the Antarctic Ocean are listed in Table 2, together with those in the subtropical

Table 2. Concentrations in the settling particles and particulate fluxes of ^{234}Th, ^{210}Pb and ^{210}Po.

	Depth (m)	^{234}Th		^{210}Pb		^{210}Po	
		conc.	flux	conc.	flux	conc.	flux
Antarctic Ocean 61°33′S 150°27′E	520	349± 9	14.3	9.8± 1.0	4.01	33.9± 2.5	13.9
	770	898± 13	36.7	8.7± 0.3	3.56	35.8± 2.5	14.6
	1200	465± 9	19.0	11.4± 1.0	4.66	46.4± 1.2	19.0
	2260	528± 12	21.6	15.2± 1.5	6.22	49.0± 5.4	20.0
	3110	346± 9	14.2	22.9± 1.6	9.37	62.6± 6.3	25.6
Eastern Pacific 17°29′N 117°03′W	470	3520±250	3.3	66.6± 5.1	0.62	86.7± 6.2	0.8
	690	8470±350	8.4	79.2± 8.2	0.79	99.3± 5.9	1.0
	1220	5540±320	4.5	86.3± 8.8	0.71	122 ± 7	1.0
	3340	4820±260	4.2	173 ±20	1.52	389 ±20	3.4
	3660	3390±140	2.3	188 ±18	1.25	401 ±23	2.7

Unit of the concentrations is dpm/g, and that of the flux is $\times 10^5$ dpm/m^2·y for ^{234}Th and $\times 10^3$ dpm/m^2·y for ^{210}Pb and ^{210}Po.

region of the eastern Pacific where the total mass fluxes were low (HARADA and TSUNOGAI in preparation). The concentrations of these nuclides in the Antarctic Ocean were one order of magnitude smaller than those in the eastern Pacific. As the total mass flux in the Antarctic Ocean was much larger than that in the eastern Pacific, however, the particulate fluxes of the radionuclides in the Antarctic Ocean were also larger than those in the eastern Pacific. The concentrations of ^{234}Th in the settling particles did not show any systematic variation with depth. The concentrations of ^{210}Pb and ^{210}Po in the settling particles, however, increased with increasing depth. This tendency has been revealed in other regions (HARADA and TSUNOGAI in preparation). If the organic parts of the settling particles dissolved within water column, the concentrations of these nuclides would increase with increasing water depth. The concentrations of organic matter (estimated from the ignition loss) and the biogenic silicate, however, did not show any remarkable variation with depth (Table 1). Furthermore, the ratios of ^{210}Pb and ^{210}Po to Al which is considered as a typical element of the lithogenic substance also increased with increasing depth. Then it is suggested that the settling particles collect these metals from seawater during their settling through the water column. The reason why the concentration of ^{234}Th in the settling particles does not show systematic variation with depth may be that the radio-decay in the particles is balanced with the uptake from seawater because of its short half life, 24.1 days.

The particulate fluxes of ^{210}Pb can be estimated from the radioactive disequilibrium of ^{210}Pb and its parent, ^{226}Ra in seawater independently from the sediment trap experiments. Then, we have tried to compare these fluxes. The data of the concentrations of ^{226}Ra and ^{210}Pb in seawater obtained in the GEOSECS expedition (KU and LIN 1976; SOMAYAJULU and CRAIG, 1976) were used in this calculation. The deposition rate of ^{210}Pb from the atmosphere was assumed to be 1600 dpm/m^2·y based on the estimate by TUREKIAN *et al.* (1977). The result of calculation for the Antarctic Ocean is shown in Fig. 3, together with those for the eastern Pacific and the northern North Pacific. In the subtropical region of the eastern Pacific where the biological productivity is low, the fluxes observed with sediment traps range from one-fifth to one-eighth of fluxes

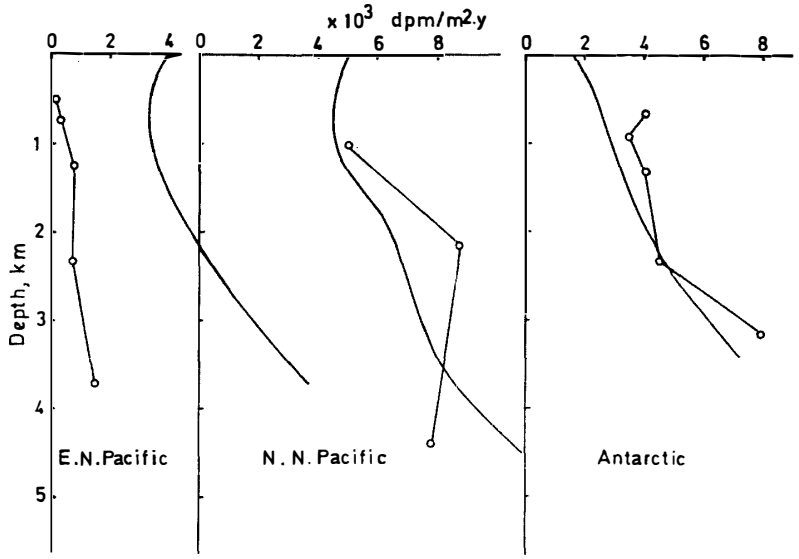

Fig. 3. Observed and calculated fluxes of ^{210}Pb. —○—: observed, —: calculated.

calculated from the inventories of ^{226}Ra and ^{210}Pb in the seawater. On the other hand, in the Antarctic Ocean and the northern North Pacific where the biological productivities are relatively high, the observed fluxes are nearly equal to or somewhat larger than the calculated fluxes. It is suggested that there may be a transport of these metals from the oligotrophic region to the eutrophic region, even in deep seas.

It is concluded that the total mass flux in the Antarctic Ocean is large because of its high biological productivity at least during the period of this sediment trap experiment, and that metals such as Th, Pb and Po are effectively removed from the water column of the Antarctic Ocean.

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