B-1 1 Studies on Vertical Flux of Particulate Carbon in the Ocean and Factors Controlling the Chemical Fluxes

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Abstract An aim of this work is to have better understanding on vertical and horizontal transport of organic matter from the coastal areas to the intermediate through deep water layers of the open ocean, because this process is one of the main processes for uptake of anthropogenic carbon dioxide by the ocean.

The time series sediment trap experiment was conducted in the site located in the extremely south end of the Japan trench to collect sinking particles at the depths of 1.0, 3.5, 5.5 and 8.5km from March, 1992 to March, 1993. Organic carbon and biogenic silica fluxes ranging from 2.0 to 8.3mgC/m^2/day and 6.5 to 9.9mgSi/m^2/day respectively were measured with distinctive seasonal variation. However much higher values of organic carbon and biogenic silica fluxes of 9.44 mgC/m2/day and 26.8mgSi/m^2/day respectively were measured in the sinking particles collected from the sediment trap deployed at 8.5km depth.

Detailed analyses of vertical profiles of organic carbon and nitrogen, and biogenic and lithogenic silica fluxes indicated that significant amounts of organic carbon and biogenic/lithogenic silica were transported from two sources consisting of the particles produced by phytoplankton photosynthesis in the surface and subsurface waters and derived from the land and continental shelf areas to the deep layers of the open ocean.

Key Words Ocean, Organic Matter, Carbon Flux, Sediment Trap, Biogenic Particle, Biogenic Silica

1. Introduction

Ocean has been understood as one of the mine factors controlling the concentration of atmospheric carbon dioxide in global scale, therefore many works were conducted to assess the significance of physical and chemical-biological processes especially focused

on air-sea exchange of carbon dioxide, production and degradation of organic matter in the surface through deep water layers, vertical and horizontal transport of organic matter produced in the surface water layers and intrusion of surface water mass bearing high concentration of carbon dioxide into the intermediate through deep waters.

Vertical transport of organic matter in aid of downward transport of the particles with organic matter has been much interested to understand the sequestration processes of carbon dioxide into the intermediate through deep waters, of which residence time of the waters was assessed to be more than a few thousand years. However, it has been reported that there is some contradiction between the vertical flux of organic matter determined by sediment trap experiment and the values calculated from the consumption rate of dissolved oxygen in the deep waters calculated by the difussion-advection model (Handa, 1991), suggesting that horizontal transport of the particles from the coastal areas to the intermediate through deep waters of the open ocean will give us significant clue to solve such problems on the difference between the organic carbon flux by the sediment trap works and the consumption rate of dissolved oxygen in the deep waters (Monaco, 1990, Biscay and
Anderson, 1994).

2. Research Objective

An aim of this work is to elucidate horizontal transport fluxes and processes of particulate organic carbon and nitgogen from the coastal and continental shelf areas to the deep ocean of the northwestern North Pacific in the Sagami Trough to the triple janction located in extremely south of the Japan Trench off Honsu Island of Japan by using of sediment trap experiments.

3. Materials and Methods

Sediment trap was deployed from March of 1992 to March of 1993 at the experimental site (34°10.27'N, 141°58.36'E; water depth:8.931m) in the triple junction area of the extremely south end of the Japan Trench off Honsu Island to determine total mass flux, from which organic carbon and nitrogen and biogenic silica fluxes were determined. The particulate samples were collected under 5% solution of formaldehyde to prevent degradation of organic materials by micrial degradation every 26days.

Sediment trap experiment was also conducted in the site (35°09,06'N, 139°44.44'E) of the mouth of Tokyo Bay in Aug.22-25, 1993 by deploying a series of sediment traps from the bottom of the euphotic layer to 10m above the surface of the bottom sediment.

Eight surface sediment samples (0-1cm depth of the bottom sediment) were collected from the mouth of Tokyo Bay and Sagami Bay of Sagami Trough.

4. Results and Discussion

4・1 Vertical Fluxes of chemical materials from the Mouth of Tokyo Bay to the continental shelf area

Vertical fluxes of these chemical parameters tended to slightly increase depth in this experimental site, however extremely high value of total mass flux was observed in the trap deployed at 10m above the bottom of the sediment. It is conceivable that considerable amount of chemical materials is supplied from the mouth of Tokyo Bay to the continental shelf area along the surface of the bottom sediment. Chemical composition of the particles supplied to the continental shelf areas seems to be different in the depths of the traps deployed (Fig. 1). It was distinctive that lithogenic materials tended to become more abundant with depth and accounted for 20.0 % and 74.2% of total mass flux at 100m and 400m depths respectively, however vertical fluxes of organic matter, opal silica (biogenic silica) and calcium carbonate tend to decrease with depth of the trap deployed, indicating that particles consisting of much abundance in lithogenic silica with some organic matter, calcium carbonate and organic matter are agent to transport chemical materials from the mouth of Tokyo Bay to the continental shelf areas. From the data shown in Fig. 1, it can be seen clearly that supply of chemical materials occurring in the boundaries between the inland bay and the coastal areas takes place along the surface of the bottom sediment.

Organic matter fluxes of 410 and 4,300 mg/m^2/day were determined in 100 and 400m depths of the mouth of Tokyo Bay respectively. Recently, horizontal transport of organic matter from the edge of the continental shelf was calculated to be 190-350, 67-225 and 490mg/m^2/day in Mid-Atlantic Bight (Biscaye et al. 1988), East China Sea (Matsumoto, 1995) and Tokyo Bay (Yanagi et al. 1993) respectively. Comparing these data, almost comparable values were obtained in the surface to mid depth of the sediment trap experiment in this work, however much higher value of the horizontal organic matter flux was obtained in 400m depth, clearly indicating that it is absolutely necessary to determine horizontal fluxs of chemical materials including especially organic carbon and nitrogen in the water layers near the bottom of this coastal area. Otherwise, it is very difficult to understand the role of the coastal areas as a significant source of organic matter to the intermediate through deep waters in the open ocean.

4・2 Chemical flux and characteristic features of the sinking particle in the Japan Trench area

Sinking particles were collected at the depths of 0.92, 3.5, 5.4 and 8.4km of the sediment trap site located near the triple junction of the Japan Trench by time-series sediment trap every 26 days and analyzed for organic matter, calcium carbonate, opal and lithogenic material to determine vertical fluxes of these materials as well as total mass

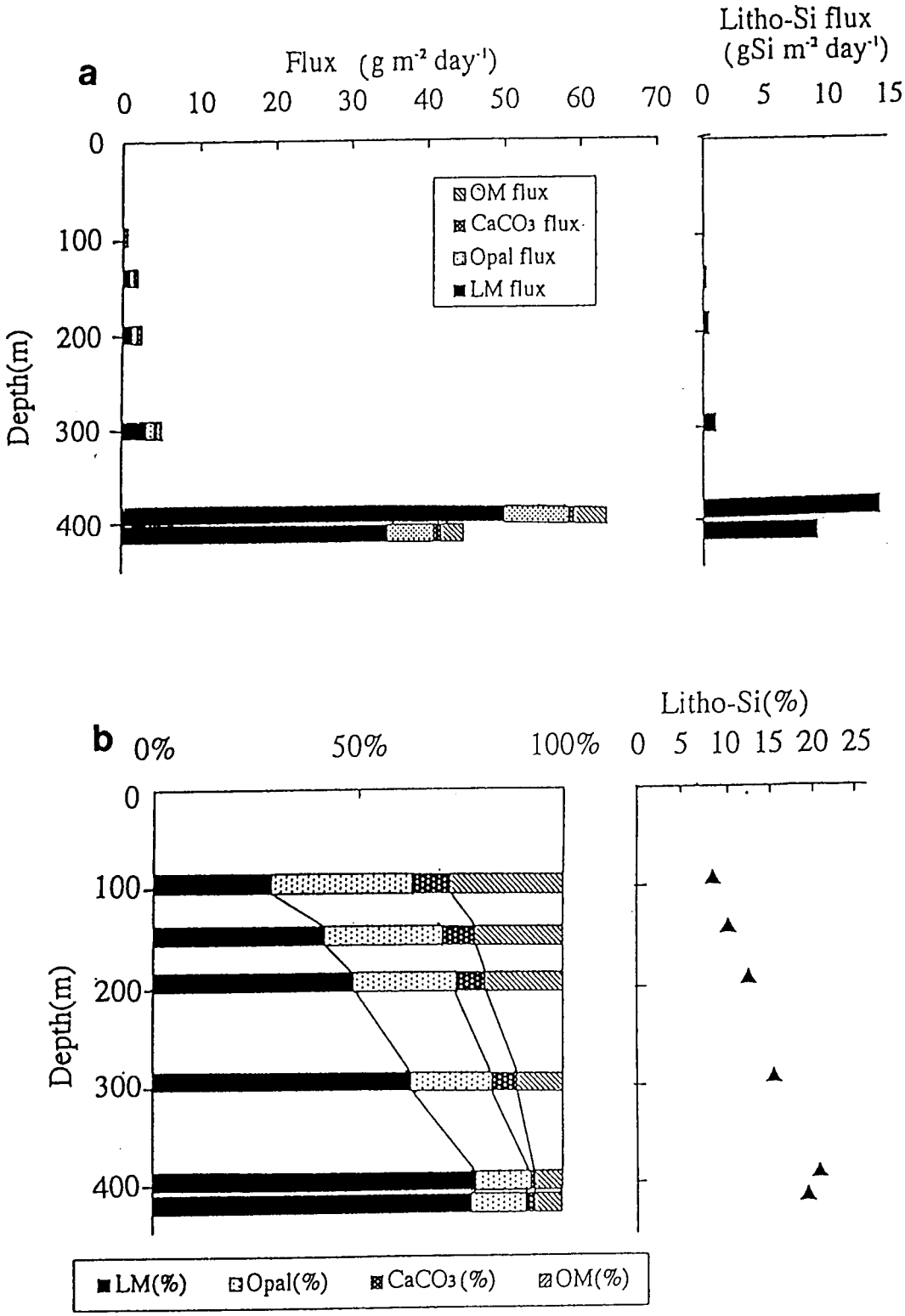

Fig. 1 Vertical fluxs of chemical matrials and chemical composition, of the siking particles collected from the mouth of Tokyo Bay

flux.

Vertical flux of organic matter tended to decrease with depth from 0.92 to 5.4km depth, however much higher values of organic matter were found in 8.4km depth, indicating that horizontal transport of this materials along the bottom sediment is also demonstrated in this area (Fig. 2). Chemical composition of the sinking particles was clearly different from sample to sample. Vertical fluxes of organic matter, calcium carbonate and opal tended to decrease with depth due to the biological degradation and dissolution, while vertical flux of lithogenic matter was almost constant in the sinking particles collected in 0.92 to 5.4km depths. Much higher value of the lithogenic matter flux was found in 8.4km depth, indicating that horizontal transports of the terrestrial materials through the surface to the bottom sediment also occurs in the Sagami Trough toward the Japan Trench.

Vertical profiles of the fluxes for each of the chemical materials were written as following equations,

$$\ln F_{\text{mass flux}} = -1.23\times10^{-4}\times D+4.98 \quad \text{----------(1)}$$

$$\ln F_{\text{organic matter}} = -2.54\times10^{-4} D +2.74 \quad \text{----------(2)}$$

$$\ln F_{\text{calcium carbonate}} = -1.91\times10^{-4} D+4.23 \quad \text{----------(3)}$$

$$\ln F_{\text{Opal}} = -1.51\times10^{-4} D+3.66 \quad \text{----------(4)}$$

$$\ln F_{\text{LM}} = o.70\times10^{-4} D+3.16 \quad \text{----------(5)}$$

where F is vertical flux of chemical materials in mg/m^2/Day, D is depth (in km) where sediment trap is deployed. If we extrapolate this equation to 8.4km depth. then we can get the values for vertical fluxes of chemical materials from the surface of the ocean. Therefore, the difference between the values of the vertical fluxes of the chemical materials observed by sediment trap experiment and calculated by these equations, must be the particles transported from the coastal areas through the bottom water above the sediment(horizontal transport or horizontal flux)(Fig. 3). Thus, from these results obtained, it can be clearly concluded that large amount of organic matter is supplied from the coastal areas through the bottom water above the sediment. It is obvious the opal (biogenic silica) is also supplied from the coastal area to 8.4km depth of the Japan Trench, suggesting that diatom frustule must be a most probable source of the organic matter for the particles transported from the coastal area to the bottom of the Japan Trench.

5. References

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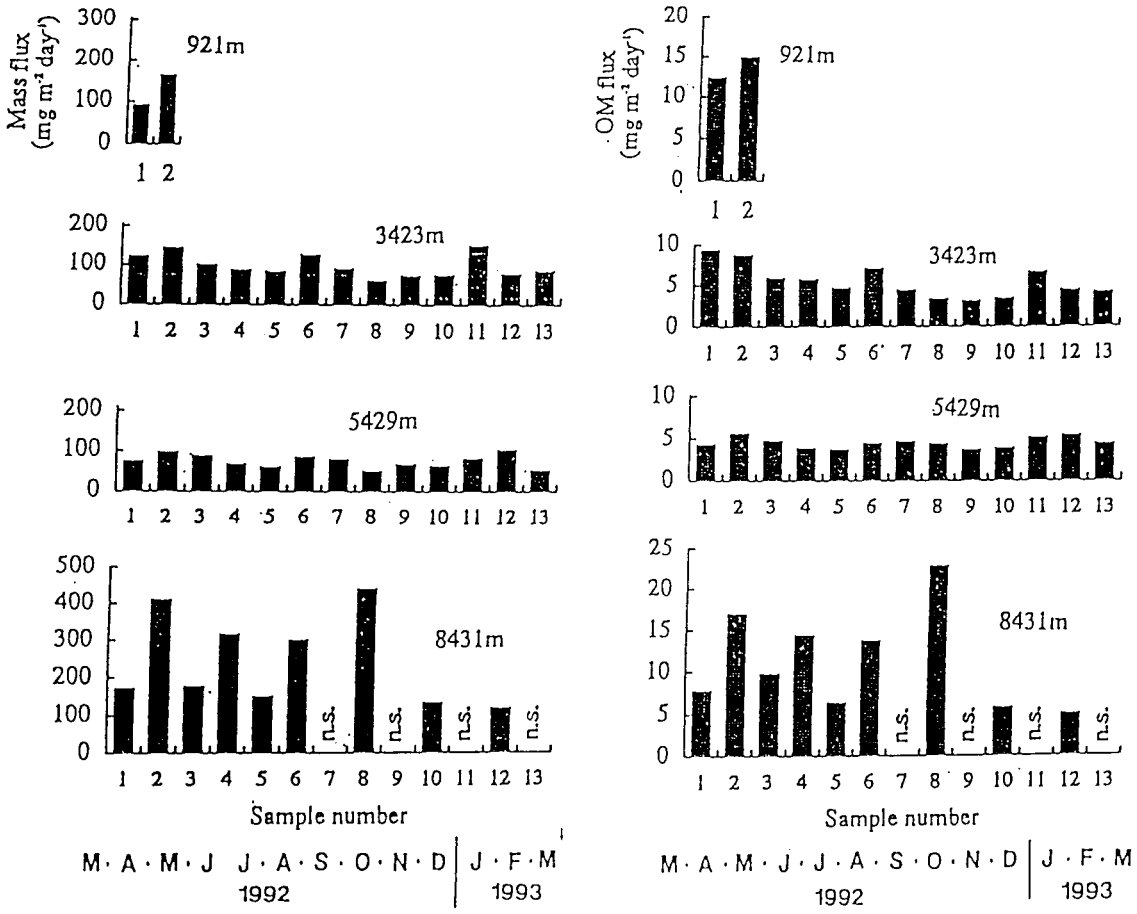

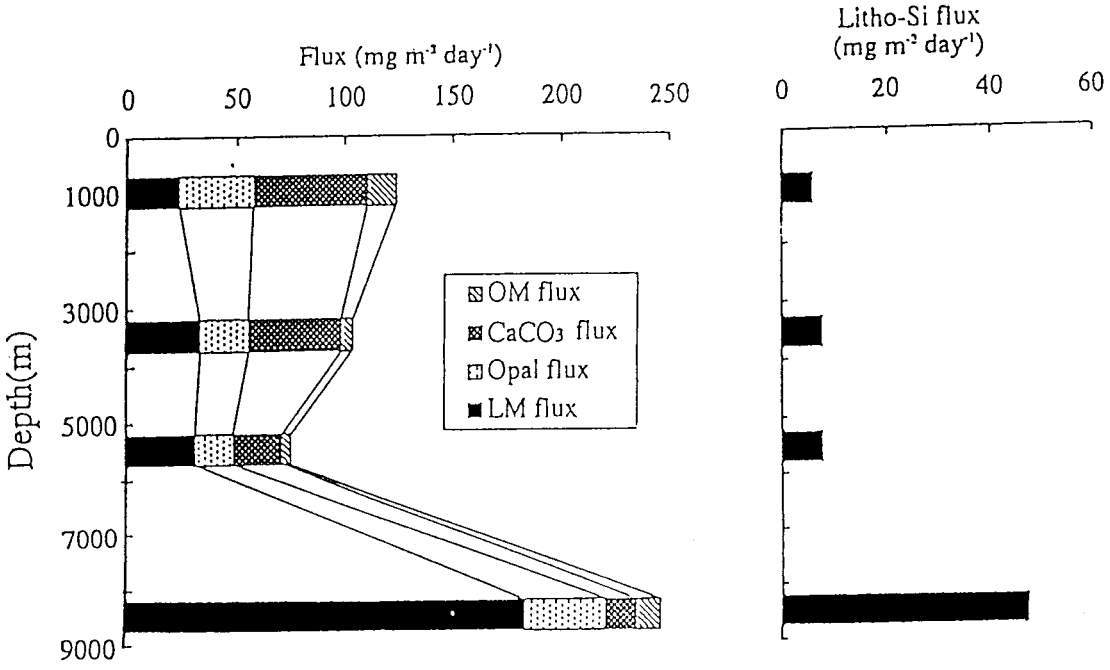

Fig. 2 Vertical fluxes of chemical materials and chemical composition, of the sinking particles collected from Japan Trench

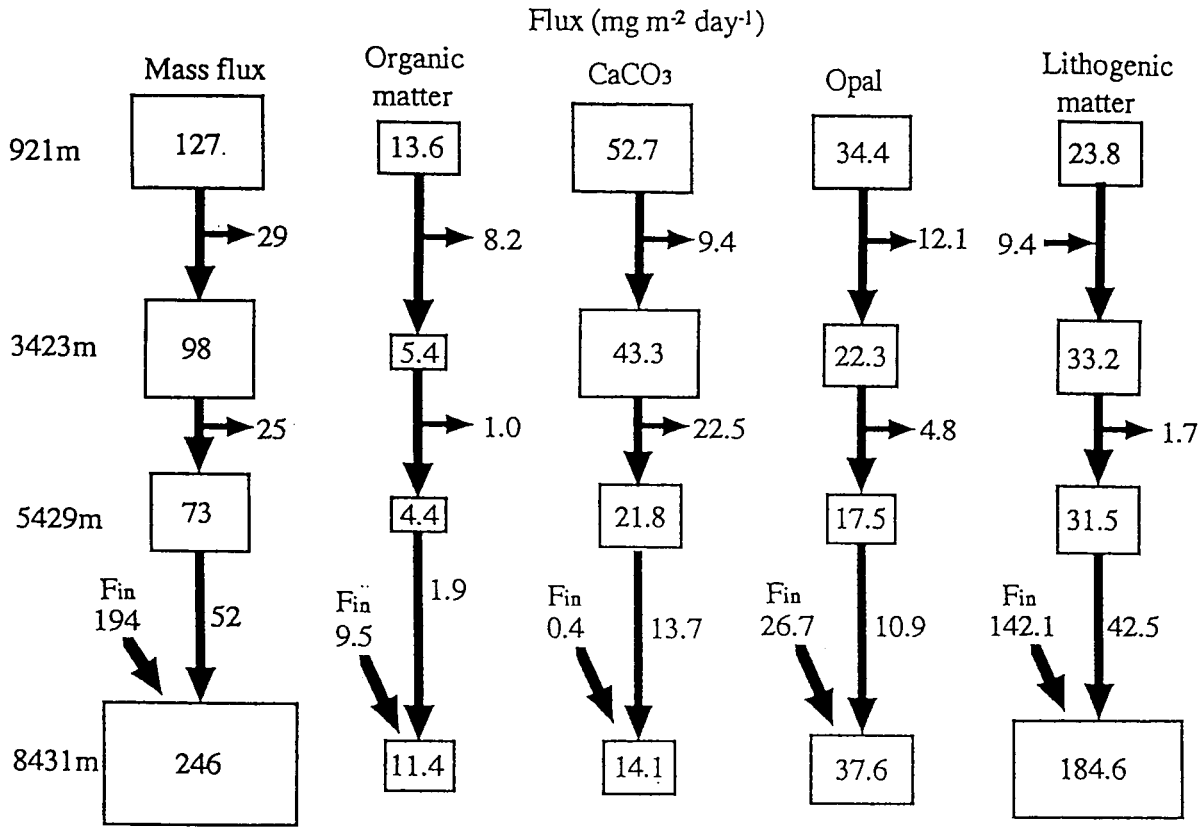

Fig. 3 Vertical change in chemical fluxes in Japan Trench and horizontal input of chemical materials to 8.4km depth

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