

Lithogenic Fluxes to the Northern Indian Ocean - an Overview

by

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With 4 Figures and 5 Tables

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Abstract

Lithogenic fluxes to the northern Indian Ocean, measured by time-series sediment traps, exhibit a strong seasonality with the bulk of the material (40 to 80 %) being deposited during the southwest monsoon period. This seasonality is more pronounced in the Arabian Sea than in the Bay of Bengal. The western and central Arabian Sea receive predominantly eolian dust from the Somali-Arabian deserts while the eastern Arabian Sea and the Bay of Bengal receive mostly fluvial material from the rivers draining the Himalayas and the Indian Peninsula. Annual lithogenic fluxes in the Bay of Bengal (8.6 to 28.0 g m⁻²) are about five times that of the Arabian Sea (2.6 to 5.4 g m⁻²). Increase of lithogenic flux with depth is seen in areas where fluvial input is more due to scavenging of the standing stock of suspended matter by sinking biogenic aggregates. In areas where eolian sediments predominate there is no significant increase of lithogenic flux with depth. Trap fluxes are comparable to Holocene sedimentation rates only in the Arabian Sea and the offset between the two is less than a factor of 2. In the central and southern Bay of Bengal trap fluxes are higher by a factor of 5.

1. Introduction

The northern Indian Ocean comprising of the Arabian Sea, the Bay of Bengal, the Andaman Sea and the Laccadive Sea, comes under the seasonally reversing monsoon gyre (Wyrтки, 1973). Tremendous lithogenic influx due to erosion of the Himalayas has resulted in the formation of two of the largest deep sea fans in the world ocean namely the Bengal and the Indus fan (Curry, 1974; Kolla and Kidd, 1982). Both deep sea fans

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have formed predominantly due to turbidites originating from the mouths of the Indus and the Ganges-Brahmaputra river systems. Most of the turbidity flows have taken place during Pleistocene and earlier times of lowered sea level and are thought to be inactive during the Holocene (Kolla and Macurda, 1988). Hemi-pelagic sediments are found at the surface, and turbidities are rare in the upper 50 - 100 cm portion of the cores. There is also a substantial eolian influx from the deserts and arid lands bordering the area and an estimated 450×10^{12} g of eolian dust finds its way into the northern Indian Ocean (Prospero, 1981).

In the Arabian Sea there are some disagreements regarding the relative importance of fluvial and eolian input in the formation of recent hemi-pelagic sediments. Kolla et al., (1976 a) state that fluvial sediments derived from the Indus, Narmada and other rivers dominate the eastern Arabian Sea and eolian components are restricted to the western Arabian Sea. Goldberg and Griffin (1970) and Sirocko (1989) on the other hand feel that the Indus sediments are trapped mainly on the continental shelves and eolian components dominate the entire Arabian Sea.

Ocean circulation and biological processes also influence lithogenic particle sedimentation. Dispersion and advection of lithogenic particles is controlled by ocean circulation patterns while their vertical flux is influenced by biological processes of aggregation and scavenging. Biological control on lithogenic particle sedimentation has been demonstrated from sediment trap experiments during the last decade (Deuser et al., 1983; Honjo, 1982; Ramaswamy et al., 1991).

In this paper I have used results from continuing sediment trap experiments to i) quantify the present fluxes of lithogenic matter in the northern Indian Ocean, ii) understand physical and biological factors controlling lithogenic fluxes in this area and iii) to compare present day lithogenic fluxes to that during the Holocene.

2. Study Area

The most distinctive climatic feature of the northern Indian Ocean is the seasonally reversing wind pattern known as the monsoons (Wyrski, 1973). About 80 % of the rainfall on the Indian Sub-continent and more than 90 % of the eolian flux from the Arabian deserts occur during the SW monsoon period. In addition, meltwater from the Himalayan glaciers also contribute significantly to the river runoff during the summer months (Rao, 1979).

About one third of the world's river discharge of suspended sediments are from the rivers draining the Himalayas with the Ganges-Brahmaputra alone contributing about 2,200 million tonnes and the Irrawady river another 300 million tonnes (Holeman, 1968; Lisitzin, 1972). The Indus formerly supplied more than 450 million tonnes of suspended sediment, but due to the construction of dams and barrages the present suspended sediment discharge is less than 45 million tonnes (Milliman et al., 1984). Other important rivers flowing into the northern Indian Ocean are Narmada and Tapi (60 mt), Godavari, Krishna, Mahanadi and Cauvery (200 mt).

Suspended matter of rivers draining the Himalayas have over 80 % illite and chlorite (Konta, 1985) and is strikingly different from that of the peninsular rivers which have more than 60 % smectites (Naidu et al., 1985). Eolian dust also has illite as the dominant clay mineral (Goldberg and Griffin, 1970; Sirocko and Lange, 1991).

The monsoons also affect the surface water circulation, sea surface temperature and biological productivity of the northern Indian Ocean. During the summer monsoon, upwelling all along the Arabian Sea and advection of the nutrient-rich upwelled waters combined with injection of nutrients into the photic zone due to wind stress increases the biological productivity and fluxes of particles dramatically (Nair et al., 1989). In the Bay of Bengal coastal upwelling is suppressed due to the tremendous freshwater discharge from the rivers. Nevertheless, particle fluxes are significantly higher during the SW monsoon period (Ittekkot et al., 1991).

Holocene hemi-pelagic sedimentation rates decrease from over 20 cm ky⁻¹ (1 ky = 1000 years) to less than 3 cm ky⁻¹ near the southwest coast of India (Sirocko, 1989). In the Bay of Bengal Holocene sedimentation rates decrease from 3 cm ky⁻¹ in the northern Bay of Bengal (17°N) to less than 0.5 cm ky⁻¹ near the equator (Sarin et al., 1979).

3. Methods

Six mooring systems each consisting of two time-series sediment traps (Honjo and Doherty, 1988) were deployed in the Arabian Sea and Bay of Bengal (Fig. 1). The sediment traps were pre-programmed to measure the flux of sinking particles at intervals ranging between 9.5 to 28 days. Details of mooring configuration and sampling intervals are given in table 1. Prior to deployment the collecting cups were poisoned with mercuric chloride to inhibit microbial degradation of the samples.

The samples recovered were immediately wet sieved using a 1 mm plastic sieve and split on board using a precision rotary splitter. One quarter of the < 1 mm fraction was filtered through a polycarbonate filter (0.4 μm), dried and analysed for total flux. First order components like carbonates, organic matter, opal and lithogenics were determined using methods described elsewhere (Honjo, 1980; Honjo et al., 1987).

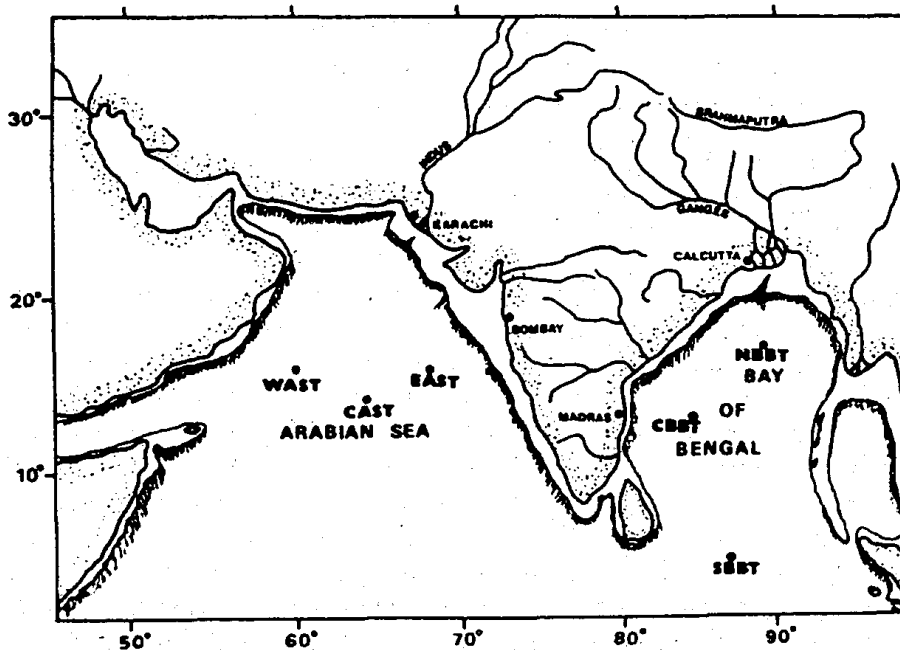


Fig. 1: Sediment trap locations in the Arabian Sea and in the Bay of Bengal

Table 1: Mooring locations and sampling intervals in the Arabian Sea and Bay of Bengal

Mooring	Position	Deployment No.	Sampling period		Sampling interval days	Depth in meters		
			from	to		shallow	middle	deep
EAST	Lat 15°30'	01	10.05.86	26.10.86	13.0	1395	—	2787
		02	20.11.86	02.02.87	12.6	1205	—	2764
	Long 68°45'	03	12.05.87	21.10.87	12.5	1705	—	2773
		04	22.11.87	31.10.88	26.0	1310	—	2778
CAST	Lat 14°30'	01	10.05.86	26.10.86	13.0	732	—	2914
		02	20.11.86	02.02.87	12.6	834	—	2894
	Long 64°45'	03	12.05.87	21.10.87	12.5	1375	—	2913
		04	22.11.87	31.10.88	26.0	1395	—	2933
WAST	Lat 16°20'	01	10.05.86	26.10.86	13.0	1023	—	3024
		02	20.11.86	02.02.87	12.6	1051	—	3021
	Long 60°30'	03	12.05.87	21.10.87	12.5	1085	—	3033
		04	22.11.87	31.10.88	26.0	1091	—	3039
NBBT	Lat 17°26'	01	28.10.87	28.02.88	9.5	809	—	1727
		02	18.03.88	06.10.88	14.5	754	—	1790
	Long 89°85'	03	02.11.88	19.10.89	26.0	968	1498	2029
CBBT	Lat 13°09'	01	28.10.87	28.02.88	9.5	906	—	2282
		02	18.03.88	06.10.88	14.5	950	—	2227
	Long 84°21'	03	02.11.88	19.10.89	26.0	955	—	2291
SBBT	Lat 04°26'	01	28.10.87	28.02.88	9.5	1040	—	3006
		Long 87°19'	02	18.03.88	06.10.88	14.5	1036	—

4. Results and Discussion

4.1. Sediment trap data

4.1.1. Total and lithogenic fluxes in the Arabian Sea

Total particulate and lithogenic fluxes to the deep traps in the eastern, central and western Arabian Sea for the period May 1986 to November 1988 are presented in figure 2. Data from shallow traps are not presented due to malfunction of some of the shallow traps. Both total and lithogenic fluxes to the deep Arabian Sea exhibit prominent increases during the monsoon seasons. During the intermonsoon period fluxes are generally very low. Fluxes of lithogenic particles vary by several orders of magnitude and range from less than $0.01 \text{ mg m}^{-2} \text{ d}^{-1}$ to over $120 \text{ mg m}^{-2} \text{ d}^{-1}$. The peak fluxes of biogenic matter during the SW monsoon period (July-August) have been shown to be due to advection of nutrient rich waters from upwelling centres and injection of nutrients into the euphotic zone from subsurface layers due to wind-stress (Nair et al., 1989). Lithogenic fluxes here also show a similar pattern as their vertical transport is mainly in association with biogenic aggregates (Ramaswamy et al., 1991). During the northeast monsoon period, strong stratification because of the inflow of low salinity waters from the tropical Indian Ocean leads to low productivity in the eastern Arabian Sea. As a result total as well as lithogenic fluxes during this period are extremely low (Fig. 2a).

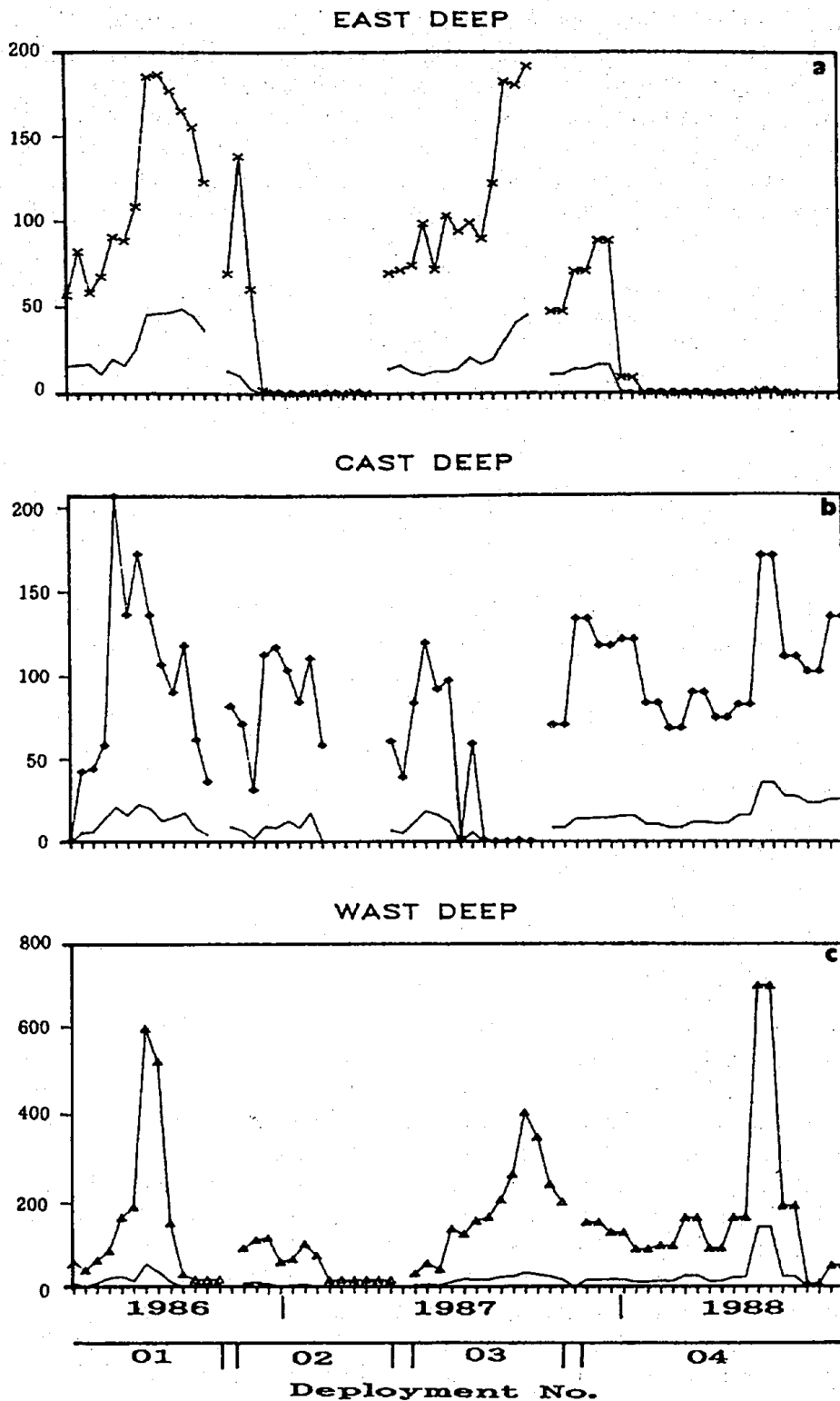


Fig. 2: Total particulate ($< 1 \text{ mm}$) and lithogenic fluxes (in $\text{mg m}^{-2} \text{d}^{-1}$) in the the period May 1986 to November 1988 in the a) eastern, b) central and c) western Arabian Sea. For deployment and sampling periods see table 1.

Annual fluxes of lithogenic matter during the first year of deployment (Tab. 2) varied from 5.4 g m⁻² in the eastern Arabian Sea to 1.8 g m⁻² in the western Arabian Sea (Nair et al., 1989). During the second year of study, annual lithogenic fluxes in the western Arabian Sea increased to 5.4 g m⁻² while the variation at the other two sites were marginal. High eolian fluxes are also seen in the central and western Arabian Sea during the SW monsoon period of 1988 (Fig. 2c). Annual fluxes of eolian matter show a high degree of variability due to the variable nature of the intensity and direction of winds.

Table 2: Seasonal and annual fluxes of total particulate and lithogenic matter (in g m⁻²) for the first year of deployment in the Arabian Sea (1986-87) and in the Bay of Bengal (1987-88)

	NE-SW	SW monsoon	SW-NE	NE monsoon	Total
<i>Eastern Arabian Sea</i>					
Total flux	1.85	14.68	6.25	0.80	23.58
Lithogenic flux	0.42	3.60	1.35	0.03	5.40
<i>Central Arabian Sea</i>					
Total flux	0.85	14.02	3.22	8.36	26.45
Lithogenic flux	0.07	1.84	0.35	0.79	3.05
<i>Western Arabian Sea</i>					
Total flux	2.16	23.56	2.91	5.29	33.95
Lithogenic flux	0.11	2.10	0.28	0.15	2.64
<i>Northern Bay of Bengal</i>					
Total flux	9.06	26.68	6.00	9.85	51.59
Lithogenic flux	4.06	15.65	3.32	4.93	27.96
<i>Central Bay of Bengal</i>					
Total flux	8.46	16.30	5.85	14.18	44.79
Lithogenic flux	2.66	6.54	2.04	3.46	14.70
<i>Southern Bay of Bengal</i>					
Total flux	8.98	15.58	5.42	8.10	38.08
Lithogenic flux	2.62	2.56	1.25	2.13	8.56

Clay mineralogy of the trap samples shows that the western Arabian Sea receives mainly illite derived from the Somali-Arab deserts while the eastern part of the sea receives fluvial material derived from the Indus and other rivers draining the Indian peninsula (Ramaswamy et al., 1991). Smectite derived from the Deccan traps are generally less than 10 % of the total lithogenic fluxes in the eastern and central Arabian Sea but reach upto 25 % during the SW monsoon period due to higher rainfall in the western part of the Indian Peninsula. Eolian dust from the Arabian deserts may even reach the Indian Peninsula as evident from the fact that upto 8 % palygorskite is found in the eastern traps during the SW monsoon period (Ramaswamy et al., 1991).

4.1.2. Total and lithogenic fluxes in the Bay of Bengal

Total particulate and lithogenic fluxes at two sites in the northern and central Bay of Bengal for the period November 1988 to November 1989 are presented in figure 3

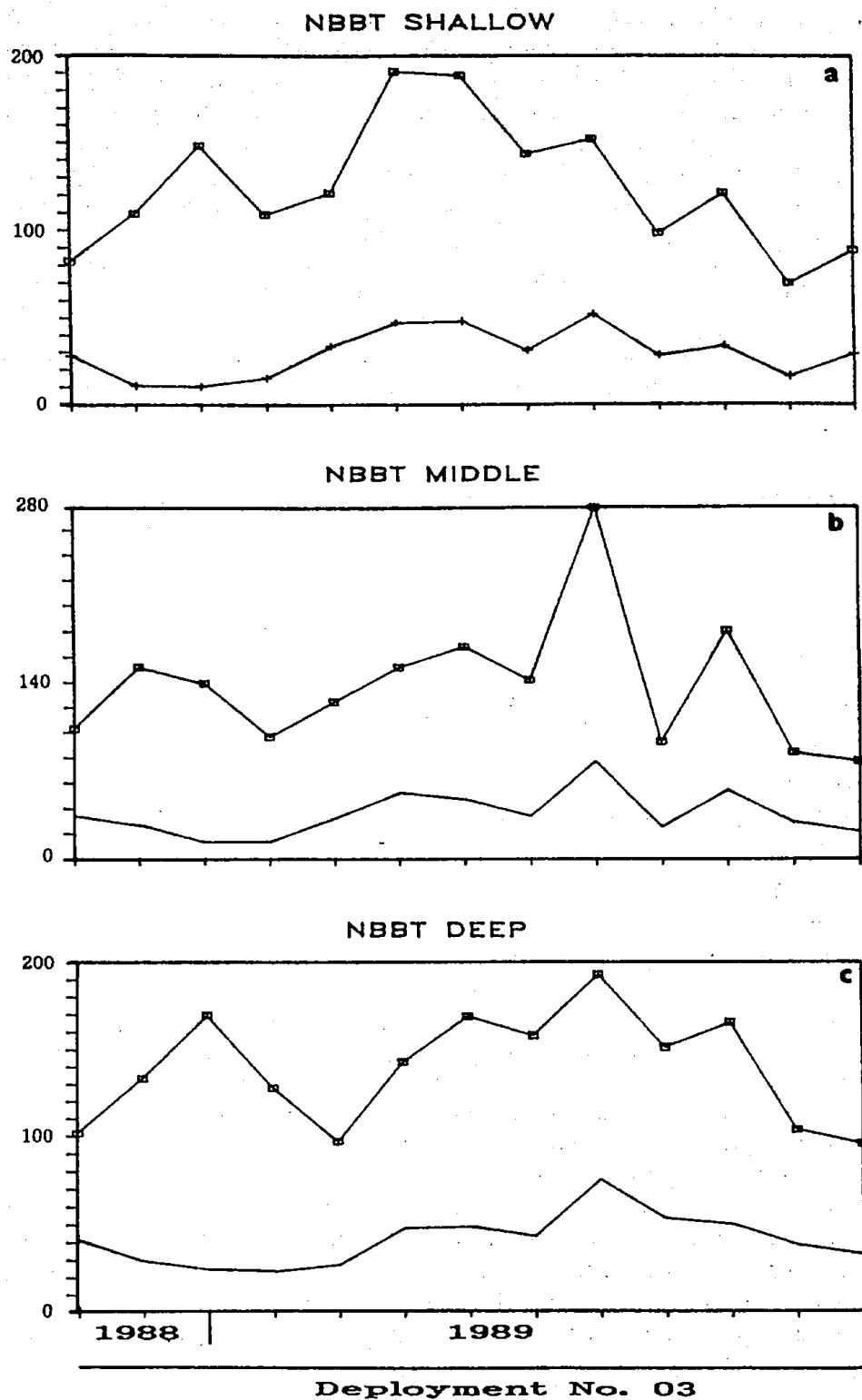


Fig. 3: Total particulate ($< 1 \text{ mm}$) and lithogenic fluxes (in $\text{mg m}^{-2} \text{d}^{-1}$) for the period November 1988 to November 1989 in the northern Bay of Bengal, a) shallow trap b) middle trap and c) deep trap. For deployment and sampling periods see table 1.

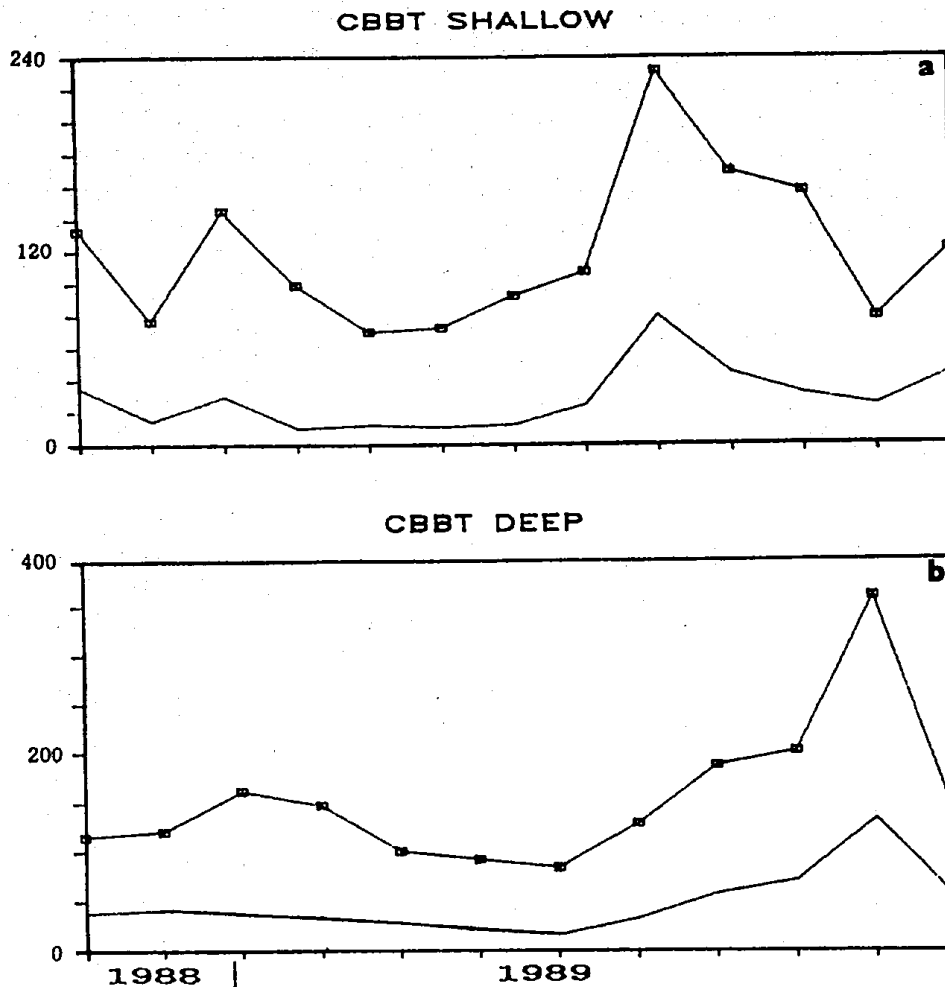


Fig. 4: Total particulate ($< 1 \text{ mm}$) and lithogenic fluxes (in $\text{mg m}^{-2} \text{ d}^{-1}$) for the period November 1988 to November 1989 in the central Bay of Bengal, a) shallow trap b) deep trap. For deployment and sampling periods see table 1.

and 4. Similar data for the period November 1987 to November 1988 (Tab. 2) are taken from Ittekkot et al. (1991). As in the Arabian Sea, total particulate as well as lithogenic fluxes in the Bay of Bengal are higher during the SW monsoon period. Lithogenic fluxes range between $200 \text{ mg m}^{-2} \text{ d}^{-1}$ in the northern Bay of Bengal to less than $5 \text{ mg m}^{-2} \text{ d}^{-1}$ in the southern Bay of Bengal. Peak fluxes of lithogenic matter is during July but unlike the Arabian Sea lithogenic fluxes during the intermonsoon period continue to be high resulting in some of the highest annual fluxes ever recorded in the open ocean. The interannual variability of lithogenic particles fluxes is higher in the northern Bay of Bengal with the annual lithogenic flux to the deep trap dropping from 28.0 g m^{-2} during 1987-88 to 14.4 g m^{-2} in 1988-89. In the central Bay of Bengal annual lithogenic fluxes increased only marginally during the second year from 14.7 g m^{-2} to 16.6 g m^{-2} .

Clay mineralogy of the Bay of Bengal trap samples (manuscript in preparation) are similar to that of the Arabian Sea in that here also illite is the dominant mineral throughout the year and smectites percentage are higher during the SW monsoon

period. Highest concentrations of smectites are found in the central Bay of Bengal traps which are located about 500 km from the river mouths of the Godavari and Krishna. The main catchment areas of these rivers are also in the Deccan Trap. Smectites percentages in the central and southern traps during the SW monsoon period is greater than 20%. This shows clearly the influence of the peninsular rivers as the suspended matter of these rivers contain more than 60 % smectites (Naidu et al., 1985). Palygorskite however, is negligible in the Bay of Bengal samples. The mineralogy of the northern Bay of Bengal samples is similar to that of the Ganges-Brahmaputra river (Konta, 1985) except for a higher percentage of smectites. The suspended sediments of the Ganges-Brahmaputra river contains less than 2% smectites whereas the northern Bay of Bengal traps show more than 10% smectites. There is a clockwise circulation of surface waters during the SW monsoon period (Wyrski, 1973) which probably transports suspended sediments from the peninsular rivers towards the north.

Though total and lithogenic fluxes in the Arabian Sea and Bay of Bengal showed a lot of similarity in seasonal patterns and mineralogy there are also important differences. Total annual fluxes (Tab. 2) to the Bay of Bengal is higher than that of the Arabian Sea by a factor of about 2 but lithogenic fluxes are higher by a factor of about 5. Lithogenic particles constitute between 9 to 25% of the total fluxes in the Arabian Sea, but, in the Bay of Bengal their percentage is much higher and range between 22 to 54%. A strong seasonality in the lithogenic fluxes is seen in the Arabian Sea as 60 to 80 % of the total annual lithogenic fluxes are during the SW monsoon period. In the Bay of Bengal this seasonality is not so pronounced as only 30 to 56 % of the lithogenic fluxes are during the SW monsoon period.

4.2. Lithogenic/organic carbon ratios

Clay minerals, because of their extremely small settling velocities should take more than a hundred years to settle through the water column on their own (McCave, 1975). During the last decade sediment trap experiments have shown that lithogenic particles settle mostly in association with organic aggregates (Honjo, 1982; Deuser, 1983; Haake and Ittekkot, 1990). One measure of the amount of organic aggregates in the traps are the organic carbon fluxes. The importance of organic matter in transport of lithogenic particles can be seen from the lith/Corg ratios (Ramaswamy et al., 1991). Variation in lith/Corg ratios in the Arabian Sea (Tab. 3) is comparatively smaller and decreases from about 4 in the eastern Arabian Sea to less than 0.5 in the western Arabian Sea. In the Bay of Bengal these ratios are much higher and decrease from about

Table 3: Seasonal and annual lithogenic/organic carbon ratios in the northern Indian Ocean

	NE-SW	SW	SW-NE	NE	Annual
WAST	0.69	1.78	2.00	0.47	1.47
CAST	1.17	2.49	1.75	1.49	1.99
EAST	2.33	3.60	4.09	0.60	3.46
NBBT	7.66	12.04	11.45	9.30	10.55
CBBT	5.02	7.19	7.03	3.93	5.63
SBBT	4.85	2.94	5.21	5.46	4.20

12 during the SW monsoon period in the northern Bay of Bengal to about 2.5 in the southern Bay of Bengal. The higher lith/Corg ratios in the Bay of Bengal shows greater availability of lithogenic matter in the water column which can be scavenged by organic aggregates.

In the Bay of Bengal surface suspended matter concentrations are high only near the river mouths of the major rivers and decrease rapidly towards the open ocean. Rao (1985) reports less than 0.2 mg l⁻¹ of total suspended matter at the surface during August-September at a distance of less than 300 km from the mouths of the Ganges-Brahmaputra rivers. The percentage of combustible matter in these samples is between 60 to 80 % showing that most of the suspended matter is derived from biological activity. This together with the fact that the northern and central Bay of Bengal samples have very high lith/Corg ratios and high increase of lithogenic matter with depth (Tab. 4) shows that lithogenic matter is rapidly scavenged and removed from the water column.

Table 4: Gradient of increase of lithogenic matter fluxes with depth in the Bay of Bengal (R values in $\mu\text{g m}^{-3}$)

	NE-SW	SW	SW-NE	NE	Annual
NBBT	12.16	28.05	13.07	13.89	18.12
CBBT	8.24	11.93	4.25	11.93	10.61
SBBT	9.07	-4.70	1.10	-0.13	0.10

The southern Bay of Bengal shows higher annual lithogenic fluxes compared to the Arabian Sea traps located much more nearer the coast. It is surprising that the southern Bay of Bengal traps show higher lithogenic fluxes compared to the western Arabian Sea traps which are located downwind of the deserts regions of Somalia and Arabia. Lateral transport of lithogenic matter has been shown in sediment trap experiments in the Panama Basin (Honjo et al., 1982b) and a similar process probably plays a very important role here. Even the shallow traps in the Bay of Bengal show higher lithogenic fluxes compared to the Arabian Sea. From this we can assume that advection of lithogenic matter takes place even in the upper part of the water column. The huge freshwater influx from the Ganges-Brahmaputra river systems leads to the formation of a low saline layer between 30 to 125 m thick which flows towards the equator against the local winds during the SW monsoon (Murty et al., 1990; Shetye et al., submitted). This southward flowing low saline layer must carry considerable amounts of lithogenic matter to the southern Bay of Bengal. But, as stated above surface waters of the Bay of Bengal show low lithogenic suspended matter (Rao, 1985) due to rapid removal by biological activity. However, concentrations of total suspended matter as well as non-combustible material in the intermediate and bottom waters is higher (Rao, 1985). Advection of lithogenic matter is probably throughout the water column except the euphotic zone where lithogenic matter is quickly removed due to biological process of aggregation and coagulation with marine snow (Alldredge and McGillivray, 1991).

4.3. Increase of lithogenic flux with depth

Due to malfunction of some of the shallow traps in the Arabian Sea, the increase of fluxes with depth could not be calculated. Data from the SW monsoon period of 1987

showed an increase of lithogenic flux with depth in the eastern Arabian Sea while there is a decrease of lithogenic flux with depth in the western Arabian Sea.

The gradient of increase of lithogenic flux, R , can be calculated from the formula as $R = (F_1 - F_2)/D$ where F_1 and F_2 are the lithogenic flux ($\text{mg m}^{-2} \text{d}^{-1}$) at the shallow and deep traps and D is the distance (depth, m) between the two traps (Honjo et al., 1982a). At the eastern Arabian Sea R , calculated between the shallow and deep trap is $2.17 \mu\text{g m}^{-3} \text{d}^{-1}$ while in the western Arabian Sea it is $-0.16 \mu\text{g m}^{-3} \text{d}^{-1}$. R values in the Bay of Bengal are much higher than those of the Arabian Sea except in the southern Bay of Bengal. R values are as high as $28 \mu\text{g m}^{-3}$ in the northern Bay of Bengal during the SW monsoon period shows greater availability of standing stock of suspended lithogenic matter in the water column. Higher gradients are found in the Bay of Bengal as fluvial input is more here. Though lithogenic fluxes are high in the western Arabian Sea, R values are low because lithogenic matter is introduced at the sea surface as eolian dust. The low R values in the southern Bay of Bengal is not easily explained. The intermediate water masses of the southern Bay of Bengal which are different from that of the central and northern Bay of Bengal probably do not contain high amounts of suspended lithogenic matter (Sastri et al., 1985).

4.4. Sedimentation rates

Sediment accumulation rates as measured by sediment traps and Holocene sedimentation rates from sediment cores are presented in table 5. Such comparisons can be best made only for the refractory components as there are significant losses of organic matter and opaline silica due to dissolution (Cole et al., 1987). Here, I have compared trap fluxes of carbonates and lithogenics with sediment accumulation rates as the sea floor in the northern Indian Ocean is above the CCD and not much dissolution of carbonates is expected.

In the Arabian Sea trap fluxes are comparable to the sedimentation rates and the offset between the two is less than a factor of two. The eastern Arabian Sea is influenced strongly by suspended sediment discharge from the Indus due to clockwise circulation of the surface waters during the monsoons (Ramaswamy and Nair, 1989). As the suspended sediment discharge of the Indus has reduced by a factor of 10 due to construction of dams and barrages the present day trap fluxes are lesser than Holocene sedimentation rates. The central and western Arabian Sea traps also show slightly lower lithogenic accumulation rates. The traps are located 1000 m above the sea floor and it is possible that considerable amount of lithogenic matter is additionally being scavenged in the bottom nepheloid layer.

In the Bay of Bengal not much data is available on sedimentation rates. Based on ^{230}Th and ^{210}Pb isotopes Sarin et al. (1979) have reported sedimentation rates between 2 to 40 mm per thousand years during the Holocene. Trap fluxes are comparable to sediment accumulation rates only in the northern Bay of Bengal (Tab. 5). In the central and southern Bay of Bengal sedimentation rates are less by a factor of 5. The reasons for this is not very clear. As already mentioned this cannot be explained by dissolution of carbonates as the sea floor lies well above the CCD (Kolla, 1982). Furthermore, even the flux rates of lithogenic material alone is more than the total Holocene sedimentation rates. Another possibility is that sediments are getting resuspended and eroded. Though there are indication of strong bottom current activity in the Bay of Bengal (Kolla, 1976b) these currents are restricted only to the western part of the Bay. A more likely

Table 5: Present day sedimentation rates in the northern Indian Ocean compared to Holocene sedimentation rates

Station No.	Lat	Long	Depth in m	Carbonate percentage	Sedimentation rates in mm/1000y	
					Total	Lithogenic
<i>Northern Bay of Bengal</i>						
NBBT	17.20	89.35	1727	20.7	35.0	24.3
30P	17	93	2403	<5.0	30.0	28.5
<i>Central Bay of Bengal</i>						
CBBT	13.10	84.20	2282	37.8	27.5	12.8
38G	13	87	3076	22.2	2.0	1.6
22PG	11	84	3456	28.2	5.6	4.0
<i>Southern Bay of Bengal</i>						
SBBT	06.40	87.35	3006	48.6	25.9	7.4
42G	07	89	3714	65.0	7.2	2.5
44G	04	89	4057	60.2	5.1	2.0
<i>Eastern Arabian Sea</i>						
EAST	15.28	68.45	2770	50.4	15.0	4.7
KL-26				58.1	18.7	7.7
<i>Central Arabian Sea</i>						
CAST	14.29	64.46	2900	66.2	17.9	2.6
KL-15				67.4	16.3	4.7
<i>Western Arabian Sea</i>						
WAST	16.15	60.28	3020	56.0	21.3	2.3
KL-71				55.9	26.0	7.2

Present day sedimentation rates calculated from trap fluxes assuming packing density of 1.15 g cm^{-3} , Holocene sedimentation rates from Sarin et al. (1979) and Sirocko (1989)

explanation is that the sedimentation rates reported by Sarin et al. (1979) are an underestimation. Sedimentation rates as low as 2 mm per thousand years are generally reported only in areas far removed from continental influence (Lisitzin, 1975).

From the sediment trap fluxes it is estimated that out of more than 2500 million tonnes of lithogenic matter discharged into the northern Indian Ocean, between 30 to 40 million tonnes of lithogenic matter is being deposited in the deeper part of the ocean as hemi-pelagic sediments. In the Arabian Sea cross shelf transport is negligible and hemi-pelagic sediments are dominated by eolian sediments in the western and central Arabian Sea. In the Bay of Bengal cross shelf transport of fluvial sediments is considerable and the high fluxes observed in the Bay of Bengal traps is due to scavenging of this advected material by biogenic aggregates. Hemi-pelagic sedimentation accounts for less than 5 % of the total lithogenic matter discharged into the northern Indian Ocean. Other transport processes of lithogenic material like high density lutite flows, turbidity currents, transport through submarine channels is not yet well understood and needs to be further investigated.

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