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Biogenic Particulate Matter Accumulation in Peter the Great Bay, East Sea (Japan Sea)

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Sediment cores were collected from one site each in Amursky and Ussuriysky Bays in the Peter the Great Bay for ^{210}Pb, org C, N, biogenic Si, δ^{13}C and δ^{15}N analysis to elucidate the processes of biogenic particulate matter accumulation and early diagenetic change in the upper sediment column. Biogeochemistry at the core sites of both bays shows differences in sedimentation rate, sediment mixing, and diagenetic processes of particulate biogenic matter. Sedimentary organic matter at the core sites in both bays appeared to be largely derived from marine origin. Sedimentation rates are 173 and 118 mg cm^{-2} yr^{-1} (0.13 and 0.11 cm yr^{-1}) in Amursky and Ussuriysky Bays, respectively. The surface mixed layer in the core top was present in Amursky Bay but not in Ussuriysky Bay. At the core site in Amursky Bay, incorporation of biogenic particulate matter into the sediment from the overlying waters is 236, 19, 142 mmol cm^{-2} yr^{-1} for organic C, N, and biogenic Si, respectively. Of which about 70% of organic C and biogenic Si are degraded within the upper 25 cm sediment and the rest are buried at 25 cm sediment horizon. At the core site in Ussuriysky Bay, incorporation of biogenic particulate matter into the sediment from overlying waters is 164, 18, 76 mmol cm^{-2} yr^{-1} for organic C, N, and biogenic Si, respectively. Of which less than 50% of organic C and biogenic Si are degraded within the upper 25 cm sediment and the remainder are buried at 25 cm sediment horizon. This large difference of degradation of biogenic matter in the upper 25 cm sediment column appears to be resulted from the difference in sediment mixing rates between the two cores.

INTRODUCTION

Coastal waters throughout the world are the sites of intense biological, chemical and geological processing of materials arriving from both terrestrial and offshore zones. The interface between the land and the ocean is highly dynamic. The character of these waters, from their capacity to assimilate anthropogenic inputs, to their ability to sustain viable and healthy fisheries, or their influence on regional climate is dictated by a complex set of oceanographic processes and forcing function that is often unique to coastal environments. The fluxes of material through this region and transformations have not been well studied, and consequently, the ability to forecast the impact of both natural and anthropogenically-induced phenomena remains poor (Klump *et al.* 1995).

The continental shelf of the East Sea (Japan Sea) is relatively narrow (Chough, 1983; Lee 1987). In particular, the western coastline is relatively straight and has a few embayments of Peter the Great Bay near Vladivostok (ca. 90 km wide) , Wonsan Bay near Wonsan (60 km wide) and Yeongil Bay near Pohang (45 km wide). Large harbors and heavy industry are developed and draw large population (ca. one million each) in these bays. Therefore, coastal embayments are subject to the man's impingement. However, sediment biogeochemistry in Peter the Great Bay has received very little attention. Tkalin *et al.* (1993) has reviewed coastal water contamination in Amursky Bay. Deep water sediment biogeochemistry in the East Sea has been studied largely in the Ulleung and Yamato Basins

(Masuzawa and Kitano, 1983; Masuzawa, 1987) and settling particulate matter in the Japan Basin (Masuzawa *et al.* 1989; Hong *et al.* in preparation). In this paper, we report a preliminary findings on the fluxes and processes controlling biogenic particulate matter in Peter the Great Bay, East Sea (Japan Sea).

MATERIALS AND METHODS

Two sediment cores were collected at the center of Amursky (43°01.6'N 131°45.6'E) and Ussuriysky Bays (43°07.4'N 132°11.2'E) using a gravity corer in September 1994. Sediment cores were sliced by 2 cm intervals and kept frozen until the analysis. The core sediments consisted of a uniform gray clayey mud. Surface sediment samples were collected using a grab sampler. Organic carbon and nitrogen were determined using a CNS elemental analyzer (Carlo-Erba) after acidification in order to remove carbonates with precision of less than 1%. Biogenic silica contents were determined by Na_2CO_3 dissolution (DeMaster, 1981) with precision of 2%. ^{210}Pb was determined by alpha spectrometry of its grand daughter, ^{210}Po. ^{210}Po was released from dried, homogenized sediments by successive digestion with concentrated acids, and then spontaneously deposited on silver discs. ^{209}Po yield tracer was added to each sample prior to acid digestion (Carpenter *et al.* 1981). For determination of stable isotopic ratios of sedimentary organic carbon and nitrogen, the carbonate-free sediment sample was washed with deionized distilled water to remove the excess acid and salts that tend to interfere in carbon isotope analysis. V.G. Micromass Model 602E mass spectrometers were used for the analysis with the precision for δ^{13}C and δ^{15}N within 0.2% (Naidu *et al.* 1994).

ENVIRONMENTAL SETTINGS

Climate in Peter the Great Bay is relatively arid. Average annual precipitation in the region is 884 mm. 85% of the precipitation occurs during the period of April to October. Especially, 40% of the precipitation concentrates during the wet summer monsoon period, August and September (Climate in Vladivostok, 1983). Seaward boundary is the southward-flowing North Korea Cold Current (Seung, 1992; Halloway *et al.* 1995). Surface water freezes during winter, although the interannual variability of the ice cover is great (Gloersen *et al.*, 1992). Seasonal changes of phytoplankton biomass are pronounced as other boreal climate regions. Phytoplankton biomass is very low during winter. However, phytoplankton develops rapidly in spring and continues to its peak during the fall in Peter the Great Bay (Menshutkin *et al.* 1974; Rassashko, 1974).

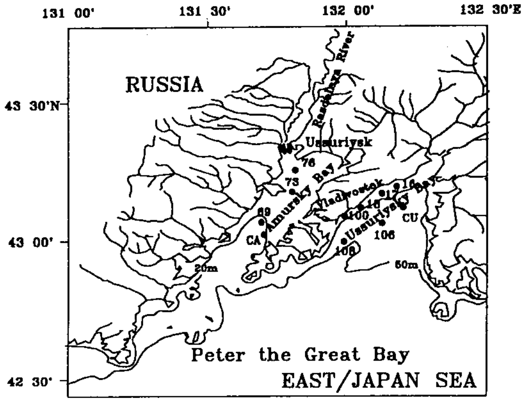

Fig. 1. Sampling stations in Peter the Great Bay, East Sea (Japan Sea). Numbers stand for the surface sediment sampling sites. CA and CU are the core sites in Amursky and Ussuriysky Bays, respectively.

Peter the Great Bay has two inlets of Amursky and Ussuriysky Bays separated by Muravyov-Amursky Peninsula. The characteristics of the drainage basins of the two bays are different. The average annual surface runoffs from the adjacent land mass to Amursky and Ussurisky Bay are 92 and 25 m^3 s^{-1}, respectively, for the last few decades (FEHRI unpublished data). Razdolnaya River has been regulated for agricultural purpose since 1980s. Large cities, Vladivostok and Ussurijsk, and heavy industries are more concentrated in the drainage basin of the Amursky Bay. There is no major industry other than the naval shipyard of Bolshoi Kamen in Ussurisky Bay. Major discharges of municipal and industrial waste water are into Amursky Bay (Tkalin *et al.* 1993). Primary productivity are much higher in Amursky Bay than Ussuriysky Bay. Also, primary productivity in Amursky Bay is reported to have increased by a factor of two over the last decades. According to Rassashko (1974), more than 8g C m^{-2} day^{-1} is fixed through phytoplankton photosynthesis assuming the 10 m of eupohotic zone as ususally observed in the coastal bays (e.g. Hong *et al.* 1991). Heavy metals of anthropogenic origin of Zn, Cr, Cu, Pb, Ni, Co, Cd, Ag and Hg concentrations in the bottom sediments are about two times higher in Amursky Bay than in Ussuriysky Bay (Tkalin *et al.* 1995).

RESULTS

Recent sediment accumulation and mixing

^{210}Pb-derived sediment accumulation rates and sediment parameters in Peter the Great Bay (Table 1) are different greatly at the core sites in two bays. Sediment accumulation rate is higher in Amursky Bay (173 mg cm^{-2} yr^{-1}) than in Ussuriysky Bay (118 mg cm^{-2} yr^{-1}). ^{210}Pb concentration is low in Amursky Bay than in Ussuriysky Bay (Fig. 2). Sediment accumulation rates in Peter the Great Bay is similar to the southwestern shelf of the East Sea (Hong *et al.* 1995). Mixing of surface sediments based on the downcore excess ^{210}Pb activity distribution is appeared only for Amursky Bay. Downcore distribution of Fe-normalized Mn concentrations also indicated the mixing of top 6 cm of sediment (Tkalin *et al.* 1996). ^{210}Pb-derived mixing coefficient is estimated to be at least 6 cm^2 yr^{-1}.

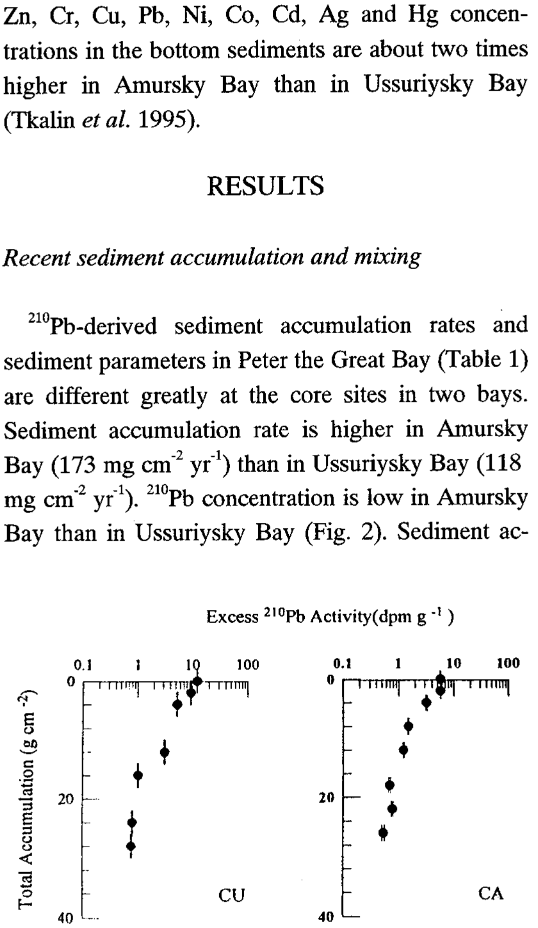

Fig. 2. Down core profiles of excess ^{210}Pb (dpm g^{-1}) in Ussuriysky (Stn. CU) and Amursky Bays (Stn. CA), East/Japan Sea.

Concentration of biogenic matter in sediments

In surface sediments, organic carbon contents are 790 to 1910 and 100 to 1950 μmol C g^{-1} in Amursky and Ussuriysky bays, respectively. In Amursky Bay, organic carbon contents in the surface sediments are high in the inner part and low in the outer part. In Ussuriysky Bay, organic carbon contents are higher in the outer part than in the inner part of the bay (Table 2).

Downcore biogenic matter distribution patterns are shown in Fig. 3. In Amursky Bay, organic carbon, nitrogen, and biogenic silica contents are 740, 76, and 403 μmol g^{-1}, respectively, in the surface sediment, and decrease to 359, 39, and 185 μmol g^{-1}, respectively, at 25 cm depth. In Ussuriysky Bay, organic carbon, nitrogen, and biogenic silica are 1390, 155, and 640 μmol g^{-1}, respectively, in the surface sediment and decreases to 753, 80, and 409 μmol g^{-1}, respectively, at 25 cm depths. Organic carbon contents in the continental shelf of Primorye and North Korea are less than 2% in the fine grained sediment area (Bezrukov *et al.* 1977). Organic carbon, nitrogen and biogenic silica concentrations in the surface sediments of Amursky Bay are about a half of those of Ussuriysky Bay (Table 2). All three biogenic component

Table 1. ^{210}Pb derived sediment accumulation rates and sediment parameters in Peter the Great Bay, East Sea

Latitude	Longitude	Region	Depth	Accumulation Rate		SML Depth	Mixing Cpef.	SML Residence Time	^{210}Pb Flux	Surficial ^{210}Pb
			m	mg m^{-2}yr^{-1}	cm yr^{-1}	cm	cm^2 yr^{-1}	yr^{-1}	dpm cm^{-2} yr^{-1}	dpm g^{-1}
43°07.4'N	132°11.2'E	Ussurisky Bay	25	118	0.11	-	-	-	1.6	10.4
43°01.6'N	131°45.6'E	Amursky Bat	25	173	0.13	3	>6.2	15	1.1	5.5

Table 2. Depth distribution of sediment organic carbon, nitrogen and biogenic silica in Peter the Great Bay, East Sea

Amursky Bay					Ussurisky Bay				
Stn.	Depth (cm)	Org. C	Org. N (μmol g-1)	Bio. Si	Stn.	Depth (cm)	Org. C	Org. N (μmol g-1)	Bio. Si
69	surface	784	86	104	16	surface	104	9	118
73	surface	1918	211	123	17	surface	193	23	142
76	surface	1591	172	105	18	surface	617	59	124
CA	0~2	740	76	403	100	surface	518	61	108
	2~4	705	72	356	106	surface	77	4	134
	4~6	606	49	329	108	surface	1953	75	86
	6~8	595	60	272	CU	0~2	1390	155	640
	8~10	450	34	280		2~4	1271	114	540
	10~12	433	40	202		4~6	1291	112	594
	12~14	568	51	261		6~8	1214	97	549
	14~16	561				8~10	1102	91	513
	16~18	458		233		10~12	926	98	487
	18~20	397				12~14	1086	120	494
	20~22	458		255		14~16	948	107	
	22~24	368	23			16~18	948	135	460
	24~26	359	39	185		18~20	1061	178	
						20~22	953	100	506
						22~24	1030	146	
						24~26	753	80	409

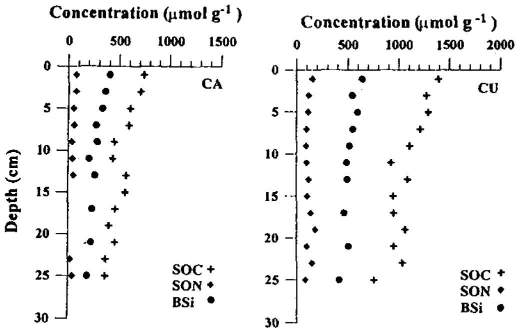

Fig. 3. Down core profiles of sediment organic carbon (SOC), nitrogen (SON) and biogenic silica (BSi) contents (μmol g-1) in Ussuriysky (Stn. CU) and Amursky Bays (Stn. CA).

concentrations decrease with depth significantly from the surface to 25 cm depth.

Stable carbon isotopes and elemental concentration ratios among organic carbon, nitrogen and biogenic silica in sediments

Average mole ratio of organic carbon to nitrogen in the surface sediments varies from 9 to 14 in Amursky Bay and Ussuriysky Bay, respectively (Table 2). Average mole ratios of organic carbon to biogenic Si is 1.8 and 2.2 in surface sediment of Amursky and Ussuriysky Bays, respectively. Similar values are found in Chinhae Bay on southern coast of Korean Peninsula (KORDI, 1992). The $\delta^{13}C$ values are -22.29 and -22.63 ‰ in the surface sediment of Amursky and Ussurisky Bays, respectively. The $\delta^{15}N$ values are 5.43 and 5.25 ‰ in the surface sediment of Amursky and Ussuriysky Bays, respectively. Sediment $\delta^{15}N$ values suggest that nutrient utilization is higher in Amursky Bay than Ussuriysky Bay (Altabet *et al.*, 1991; Francois *et al.* 1992).

DISCUSSION

Sources of organic matter

Mole ratios of organic carbon to nitrogen and stable isotopic ratios of organic carbon and nitrogen suggest that most organic matter is derived from primary producers in the water column. Mean $\delta^{13}C$ values of phytoplankton are -21.2±1 ‰ in Bering Sea phytoplankton (Naidu *et al.* 1994).

The fate of biogenic particulate matter in the benthic regime

Fluxes of particulate organic carbon and other biogenic particulate matter in the benthic regime can be divided into 4 components: Js, Jpb, Jd and Jb (Reimers and Suess, 1983). Js is the biogenic matter input rate into the sediment. Jpb is the rate of organic carbon consumed or degraded at the sediment-water interface, and Jd is the rate of biogenic matter consumed within the sediment. Both are mediated by respiration of the macro-benthos and micro organisms. Jb is the carbon accumulation rate below the reaction zone. Thus the flux of particulate biogenic matter to the sediment-water interface (Jf) is:

$$Jf = Jpb + Jd + Jb \tag{1}$$

In this scheme the total benthic utilization (Ju) is

$$Ju = Jpb + Jd$$

Also, the incorporation rate of particulate biogenic matter into the sediment (Js) can be described as

$$Js = Jd + Jb \tag{2}$$

Particulate biogenic matter arriving at the sediment-water interface is one of the major deriving forces determining benthic metabolism and hence the fluxes of metabolite species from or to the sediments. However, the composition of biogenic matter raining to the sea floor is not well known. The refractory particulate organic matter is believed to originate from phytoplankton materials, and to form very rapidly (Cronin and Morris, 1983). Westrich and Berner (1984) proposed that the pool of decomposable sedimentary organic carbon (phytoplankton detritus) actually consists of various groups of compounds that are metabolized at different rates. Reeburgh (1983) and Henrichs (1992) reviewed progresses made in the study on the decomposition rates of various organic substances and the preservation of organic matter in sediments.

There has been some controversy over whether the majority of biogenic matter raining to the sediment-water interface is predominantly oxidized at or near the sediment-water interface (oxidation rate Jpb) or within the sediments (oxidation rate Jd). Reimers and Suess (1983) argued that resuspension near the sediment-water interface tends to increase Jpb and subsequently reduces Jd, because the resuspension increases the residence time of biogenic matter in the water column. Emerson *et al.* (1985) show that Jd is dominant in the deep Pacific Ocean. Zeitzchel (1979) argued that Jpb is significantly larger than Jd in shallow waters (<200 m deep). Jpb has been measured using benthic chambers, and Jd has been estimated using diagenetic models of sediment organic carbon profiles and from pore water profiles (summarized by Reimers and Suess, 1983). Interstitial water concentration profiles have been used to examine sediment-water exchange, because relatively small changes in solid phase chemical compositions cause large changes in pore water solute concentrations (e.g. Grundmanis and Murray, 1977).

The contemporaneous combination of direct measurements of the flux of biogenic material to the sea floor and studies on their subsequent diagenesis in sediments is very rare, as noted by Reeburgh (1983), especially in the Peter the Great Bay in the northern part of the East Sea. This work is only based on the two cores collected from the vast area of Peter the Great shelf, therefore, this study must be regarded as a preliminary one. Since each sediment core section represents several years of deposition (Table 1), each core section must be regarded as the combined results of processes occurring in sediments integrated over a time span of years.

Input of particulate biogenic matter to the sediment (Js)

The rate of particulate biogenic matter incorporation into the sediment (Js) can be obtained using Eqs. 3 and 4, which describe sediments without (J_{s1}) and with sediment mixing (J_{s2}), respectively (Walsh *et al.*, 1985).

$$J_{s1} = \omega_{\pi} G_0 (1 - \phi) \tag{3}$$

$$J_{s2} = \omega_{\rho} G_0 (1 - \phi) + K_{\rho} (dG/dz) z = 0 (1 - \phi) \tag{4}$$

Where ω is the sediment accumulation rate, ρ is the porosity, G_0 the superficial biogenic concentration

Table 3. The relative importance of sediment mixing to the incorporation rate of biogenic matter into the sediment. w is sedimentation rate, ρ is sediment density, and ϕ is porosity taken as 0.8 and 0.5 at the surface and 25 cm depth horizon, respectively. K is sediment mixing coefficient. Advection = $\omega\rho G_0(1\text{-}\phi)$, Diffusion = $K\rho(dG/dz)_{z\text{-}0}(1\text{-}\phi)$, and $J_b = \omega\rho G_{25cm}(1\text{-}\phi)$

Stn.		$(dG/dz)_{z=0}$	Incorporation Rate (s)			Burial Rate(J_b) at 25 cm horizon
		μmol g^{-1} cm^{-1}	Advection	Diffusion μmol cm^{-2} yr^{-1}	Total	μmol cm^{-2} yr^{-1}
CA	Organic C	35	128	108	236	62
	Sediment N	2	13	6	19	7
	Biogenic Si	24	70	72	142	32
CU	Organic C	60	164		164	89
	Sediment N	21	18		18	9
	Biogenic Si	50	76		76	48

taken from the top section of sediment core, K a sediment mixing coefficient, and $(dG/dz)z = 0$ is the concentration gradient at the sediment-water interface. For the purpose of this discussion, sediment particle mixing is assumed to be a Fickian type diffusive process. On the basis of the data in Figs. 2 and 3, each parameter was calculated using sediment mixing coefficient (K) estimated from ^{210}Pb depth distribution (Table 1). The results are tabulated in Table 3. As seen in Table 3, the contribution of sediment mixing to Js is almost equal to the advective input in Amursky Bay. It is also noticeable that Js in the two bays of Amursky and Ussurisky in the Peter the Great Bay is similar to each other for organic carbon and nitrogen despite the large difference in their concentration in the sediment columns.

Burial of organic carbon in the sediment (Jb)

The carbon accumulation rate below the reaction zone was estimated using Eq. 5, assuming no mixing below the 25 cm depth horizon (which is the deepest part of the cores), although the biogenic matter appears to decrease in deeper depths of the sediment.

$$Jb = \omega_p Gnm(1 - \phi) \qquad (5)$$

Burial flux of biogenic matter is much higher in Ussurisky Bay than in Amursky Bay due to their higher concentration in the sediment column.

Decomposition rate of biogenic particulate matter in the sediment (Jd)

Since the surface sediment is mixed in Amursky Bay but not in Ussurisky Bay, decomposition and dissolution rates of biogenic matter were estimated separately. In Ussuriysky Bay, an estimate of the degradation of biogenic matter within the sediment was attempted here without taking into account sediment mixing. The total amount of biogenic matter remineralized, Gr, over a depth interval down to 25 cm depth would be:

$$\%Gr = (G_0\text{-}Gb)/G_0 \times 100 \qquad (6)$$

and the decomposition rate of biogenic matter, Jd, is

$$Jd = \omega_p(G_0 - Gb)(1 - \phi) \qquad (7)$$

Where G_0 and G_b are the biogenic matter concentrations at the surface and core bottom, respectively (Martens and Klump, 1984). Applying Eq. 6 to biogenic matter depth distribution yields Gr values of 36-48% in Ussuriysky Bay. The Jd values obtained using Eq. 7 is about 76, 9, and 27 μmol cm^{-2} yr^{-1} for organic carbon, nitrogen and biogenic Si, respectively, in Ussuriysky Bay.

In Amursky Bay where surface sediment appears to be mixed, the decomposition rate is determined by subtracting Jb from Js. Decomposition and dissolution rates of organic carbon, nitrogen and biogenic silica are 174, 12, 110×10^{-6} mol cm^{-2} yr^{-1}, respectively, and are about twice higher in Amursky Bay than in Ussurisky Bay. Stirring of surface sediment significantly contributes to the biogenic matter degradation rate in the sediment column.

Reaction rate constants for organic carbon, nitrogen, and biogenic silica

A first-order reaction rate constant for the oxidation or dissolution of biogenic matter in the sediment was estimated using the steady-state diagenetic model of Berner (1980).

$$K\,(d^2G/dz^2) - \omega(dG/dz) - kcG = 0 \qquad (8)$$

where K is the sediment mixing coefficient, z the depth in sediments (positive downward), w the sedimentation rate, and kc is a first order rate constant for the oxidation or degradation of biogenic matter, G. The analytical solution of Eq. 8 for the boundary conditions of $G = G_0$ at $z = 0$ and G approaches 0 as z approaches to infinite is

$$Gz = G_0\exp\,(Bcz) \qquad (9)$$

$$\text{where } Bc = (\omega - (\omega^2 + 4kcK)^{1/2})/2K \qquad (10)$$

and G_0 is the biogenic matter concentration at the sediment-water interface. In general, biogenic matter concentrations rather decrease to an "equilibrium concentration" than becoming zero. This background concentration is generally regarded as non-metabolizable or non-mineralizable biogenic matter. It should be noted that the term "metabolizable" and "non-metabolizable" are strictly operationally defined, based on biogenic matter profiles. The presence of non-metabolizable biogenic matter is included in Eq. 8.

$$Gz = Gnm + Gm{,}0\exp(Bcz) \qquad (11)$$

$$\text{where } Gz = Gnm + Gm{,}z \text{ at } z \qquad (12)$$

Gnm is non-metabolizable biogenic matter, and Gm, 0 and Gm,z are the metabolizable biogenic matter concentration at the sediment-water interface and at depth z, respectively. If sediment mixing can be ignored, Eq. 8 becomes:

$$-\omega(dG/dz) - kcG = 0 \qquad (13)$$

Solving Eq. 13 for the boundary conditions of $G = Gm{,}0$ at $z = 0$ and Gm,z approaches 0 as z approaches to infinite gives

$$Gz = Gnm + Gm{,}0\exp\,(Bcz) \qquad (14)$$

$$\text{where } Bc = -kc/\omega \qquad (15)$$

Values for Bc were obtained by a least squares fit to the biogenic matter concentration data shown in Fig. 2. The biogenic matter degradation rates (kc) were subsequently computed using Eqs. 10 and 15 for Amursky and Ussurisky Bays according to the presence and absence of surface mixed layer in the sediment columns, respectively. The residence time (τ) of the biogenic matter is taken as the inverse of kc (Table 4).

Annual biogenic matter budget in the benthic regime

Since the actual settling flux of particulate biogenic matter at the sediment-water interface was not measured and respiration and remineralization of biogenic matter at the sediment surface, we do not know these fluxes of Jf and Jpb. In shallow waters, Jf is usually at least twice of Js, and Jpb is equal to or larger than Js (Zeitzschel 1979). Therefore, Jf may be about 300 to 400 μmol C cm^{-2} yr^{-1} in Peter

Table 4. Parameters for the fit of Eq. 10 to the biogenic matter down core profiles. Bc is taken as Eq. 10 in the surface layer of sediment which exponential decrease of biogenic matter concentration with depth. Sediment accumulation and mixing rate is derived from ^{210}Pb depth distribution (Table 1). R is the correlation coefficient

Stn.		Gmn (μmol g^{-1})	Gm, O (μmol g^{-1})	Bc (cm^{-1})	Kc (yr^{-1})	τ (yr)	R
CA	359	381	-0.116	0.10	10	-0.79	
	39	37	-0.144	0.14	7	-0.63	
	185	218	-0.215	0.25	4	-0.88	
CU	753	637	-0.047	0.01	100	-0.76	
	80	75	-0.227	0.02	50	-0.98	
	409	231	-0.091	0.01	100	-0.88	

Table 5. Annual budget of sedimentary biogenic matter in Peter the Great Bay

Stn.		J_s	J_d (μmol cm^{-2} yr^{-1})	J_b
CA	Organic .C	236	174	62
	Sediment N	19	12	7
	Biogenic Si	142	110	32
CU	Organic C	164	78	89
	Sediment N	18	9	9
	Biogenic Si	76	27	48

the Great Bay, and it is reasonable assumption sin ce world average mature coastal waters fix 12 mol C m^{-2} yr^{-1} of carbon dioxide annually.

The factors that affect the relative importance of Jd and Jb have been discussed by many scientists. Muller and Suess (1979) proposed that sedimentary organic carbon content can be related to the bulk sedimentation rate and primary productivity in the overlying waters. Toth and Lerman (1977) showed empirically that average reactivity of organic matter is proportional to a power of the sedimentation rate. Aller and Mackin (1984) demonstrated theoretically that sedimentation and reactive organic burial rates are not necessarily coupled. Preservation of organic matter in sediments depends on the relative importance of electron acceptor concentration, advection due to sedimentation, solute diffusion, and the supply and reaction rate of metabolizable organic matter. Hedges and Keil (1995) proposed the importance of mineral surface area coatings in the organic matter preservation in sediment.

At the core site in Amursky Bay, respiration within the sediment (Jd) accounts 60-70% of total incorporated flux (Js). And Jd is larger than burial rate (Jb). However, Jd accounts only 35-50% and Jd is much less than Jb in the Ussuriysky Bay sediment. Sediment mixing probably results in significant difference in sediment biogenic matter degradation in the two core sites in the neighboring inlets of Peter the Great Bay.

CONCLUSION

The fate of biogenic particulate matter in the benthic regime was studied in Peter The Great Bay of the East Sea (Japan Sea). Two 26 cm long sediment cores were collected at Amursky and Ussuriysky Bays in September 1994. Major findings of this preliminary study on the early diagenesis of biogenic matter are:

1. Sedimentary biogenic matter appears to be largely derived from marine source.

2. Sedimentation rates are 118 and 173 mg cm^{-2} yr^{-1} in the Ussuriysky and Amursky Bays. Downcore excess ^{210}Pb distribution patterns suggest that top few centimeters of the sediments appears to be mixed vertically in Amursky Bay.

3. At the core site in Amursky bay, incorporation of biogenic particulate matter into the sediment from the overlying waters are 236, 19, 142 μmol cm^{-2} yr^{-1} for organic C, N, and biogenic Si, respectively. About 70% of org C and biogenic Si are degraded within the upper 25 cm sediment and the remainder are buried at 25 m sediment horizon.

4. At the core site in Ussuriysky Bay, incorporation of biogenic particulate matter into the sediment from the overlying waters are 164, 18, 76 μmol cm^{-2} yr^{-1} for organic C, N, and biogenic Si, respectively. Less than 50% of org C and biogenic Si are degraded within the upper 25 cm sediment and the remainder are buried at 25 m sediment horizon.

5. It appears that very different benthic recycling process of biogenic matter occurs between core sites in Amursky and Ussuriysky Bays. This large difference of degradation within the sediment column appears to be resulted largely from the difference in sediment mixing.

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