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Radioactive isotope geochronology of mud deposit in the central area of the south Yellow Sea

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남황해 중앙부해역 니질퇴적물의 동위원소에 의한 지질연대연구

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남황해 중앙부해역에 분포하는 니토대의 퇴적속도과 공급지를 파악할 목적으로 이곳 니질퇴적물에서 채취한 13개의 표층퇴적물과 3개의 코아시료를 분석하였다.

연구지역 표층퇴적상의 분포는 사질퇴적상이 분포하는 동쪽지역, 니토대가 분포하는 서쪽지역, 중앙부지역에 남북방향의 대상분포를 보이는 혼합퇴적상으로 구분된다. 퇴적물내 탄산염 함량은 2.8~10.5%의 범위를 보이고 사질퇴적물이 분포하는 동쪽보다 니질퇴적물이 분포하는 서쪽으로 갈수록 점차 증가하는 경향을 보인다. Pb-210 동위원소를 이용한 연구지역 니질퇴적물의 퇴적속도는 0.21~0.68 cm/yr 혹은 0.176~0.714 g/cm^2 · yr의 범위를 보였다. 황하강과 가까운 산동반도 동쪽 정점 CY96010에서 퇴적속도는 0.68 cm/yr 혹은 0.714 g/cm^2 · yr의 높은 값을 보이고, 남황해 중앙부해역 정점 CY96008과 CY96002에서 퇴적속도는 0.21~0.23 cm/yr 혹은 0.176~0.220 g/cm^2 · yr로 낮은 값을 보여 황하강기원 퇴적물이 연안류에 의해 황해 중앙부해역까지 이동되어 퇴적되고 있음을 의미한다. 또한 남황해 중앙부에서 남쪽지역(0.23 cm/yr)이 북쪽지역(0.21 cm/yr)보다 높은 퇴적속도를 보이는 것은 남쪽으로부터 퇴적물공급이 있음을 의미한다.

A total of 13 surface sediments and 3 gravity core samples collected from the central area of the south Yellow Sea have been investigated the sedimentation rate and provenence.

The mud facies exists in the western area of the south Yellow Sea and the sandy sediment facies is distributed in the eastern part. The sandy mud and clay facies extend north to south zonal distribution in the central region. The content of calcium carbonate ranges from 2.8 to 10.5%, and its distributional trends to be more concentrated on the western muddy sediments near toward the China side rather than on the eastern sandy sediments. The accumulation rates obtained using Pb-210 geochronologies for the muddy sediments in the south Yellow Sea showed ranges from 0.21 to 0.68 cm/yr or 0.176 to 0.714 g/cm^2 · yr. The sedimentation rate from core CY96010 located in the east near side off Shandong Peninsula shows 0.68 cm/yr or 0.714 g/cm^2 · yr. The sediment cores CY96008 and CY96002 in the central area of the south Yellow Sea, the estimated of sediment accumulation rates shows 0.21~0.23 cm/yr or 0.176~0.220 g/cm^2 · yr respectively, and a large quantity of materials from the Huanghe and old Huanghe River was carried into the central Yellow Sea by the coastal current. The sedimentation rates in station of the south part(CY96002: 0.23cm/yr) are higher than that in the north(CY96008: 0.21cm/yr)area, its may have received influence of materials from the south part.

Key words : mud deposit, Pb-210 geochronology, south Yellow Sea

1. Introduction

The Yellow Sea is a broad and long basin between China and Korea, steeper in the east, gentler in the west and more than 50 m deep in the middle. Surrounded land, and sedimentation in the sea are subject to the great effect of river input. The major sediment sources to the Yellow Sea are the Huanghe and Changjiang rivers, which annually discharge about 1.1×10^9 and 4.9×10^8 tons of suspended sediments, respectively (Schubel et al., 1984). A number of small rivers draining the Korea Peninsular contribute less than 5×10^6 tons of suspended sediments to the Yellow Sea annually (Schubel et al., 1984).

Marine sediments around the Korean Peninsula are a complex mixture of various components originating from both China and Korea. They are characterized by the complexity of their constituents along with great areal variation. Many scientists have tried to identify different origins of the sediments in the Yellow and East China Sea using geochemical and mineralogical characteristics (Yang and Milliman, 1983; Alexander et al., 1991; Park and Khim, 1992; Zhang et al., 1990).

The present study examines the surface distribution of grain size, organic materials in combination with the Pb-210 dating for the surface and core sediments in the central area of the south Yellow Sea and to discuss sediment accumulation rate and sources.

2. Sample collection and methods

Sediment samples were obtained in the south Yellow Sea in August 1996 using the Ara A/V of Cheju National University. A total 13 surficial sediments and 3 sediment gravity core samples were collected from the central area of the south Yellow Sea (Fig. 1).

Grain-size analyses were performed by standard procedures (Krumbein and Pettijohn, 1938), the sand fraction was analyzed by sieve method and the silt and clay fractions by pipette techniques. Organic carbon in the sediments was analyzed using CHN Analyzer following the method of Byers et al.(1978).

Calcium carbonate in the sediments was determined

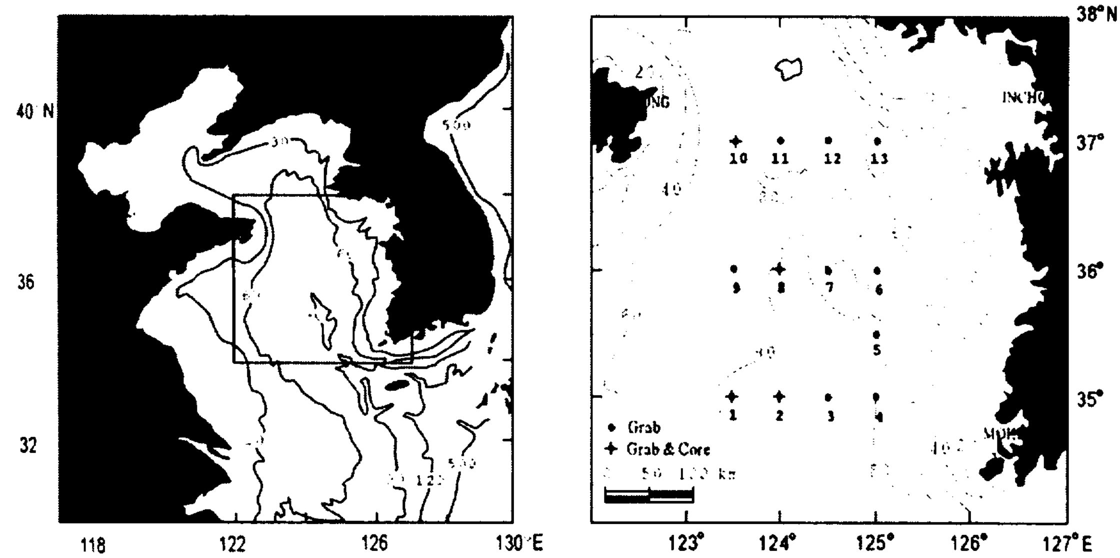

Fig. 1. Map showing the study area, bathymetry, and sites of the surface sediment samples and cores. Depth contours are given in meter.

using a Bernard calcimeter. To estimate the flux of Pb-210 into sediment and determine the sedimentation rates, core samples was analyzed by the radiochemical techiques. Cores were sectioned into 1 cm and each sub-core samples was used for Pb-210 analysis. Various methods are available for Pb-210 analysis. The one employed in this study is similar to that described by Nittrouer et al.(1979) and depends upon its secular equilibrium with Po-210. Approximately 3.0g of dried sub-sediments, which has been passed through a one phi sieve to remove coarse particles, was spiked with a known amount of Po-208 tracer. The sample was dissolved totally with HNO_3, $HClO_4$, HCl and HF acids and then taken to dryness. The Po isotopes were picked up in 1N HCl and plated onto 1 cm^2 silver planchets. The Po activities were determined by alpha spectrometry.

3. Results and discussions

3.1 Sedimentary facies and distribution of organic matter

The surface sediment types in the central area of the south Yellow Sea were divided into three zones (Fig. 2 and 3). The western part of the central Yellow Sea is covered with mud and clay. The composition of mud deposit consists of 1.83% sand, 32.92% silt and 65.27% clay, and has mean size of 8.5ø. The deposit is characterized by abundant clay, and has higher organic carbon(av. 1.2%) and calcium carbonate (av. 9.43%)(Table. 1). The sand facies exists in the northeastern part, and is composed of 90.36% sand, 5.42% silt and 4.22% clay, and moderately sorted sands of 1.73ø in mean grain-size. Lee et al.(1988) suggest that the sand deposit represents a transgressive basal layer formed during the Holocene sea-level rise. The muddy and clayey sands are distributed in the eastern part of the Yellow Sea, which is composed of 75.28% sand, 11.19% silt and 13.53% clay and mean size of 3.68ø, and has a lower organic carbon (av. 0.42%) and $CaCO_3$ contents(av. 4.3%). The sandy mud and clay facies are dominated in the central region. These sediments consist of 23.5% sand, 32.65% silt and 43.86% clay, and is 6.70ø in mean grain size.

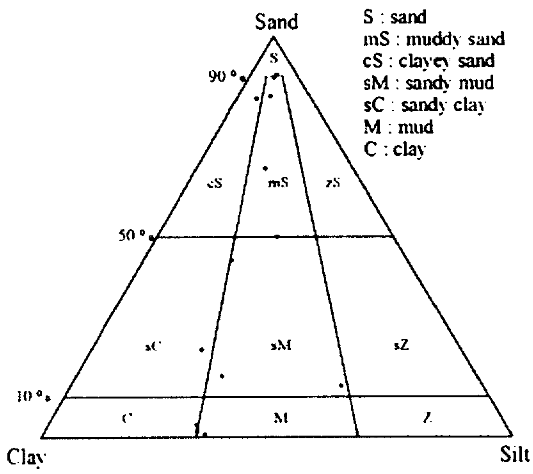

Fig. 2. Surface sediment type on the central Yellow Sea.

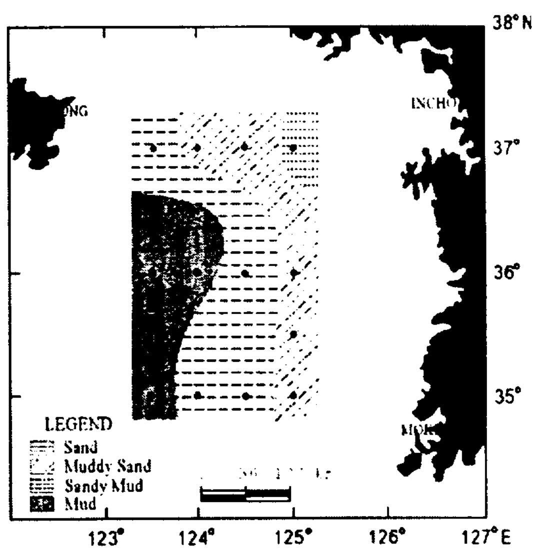

Fig. 3. Distribution of sedimentary facies.

The central Yellow Sea surface sediments were composed of sediments originating from different epochs, and include modern as well as the late Pleistocene

Table 1. Sediment type, textural parameters and organic material content

Station	Sediment composition			Classification	Textural parameters				Organic matter	
	sand (%)	silt (%)	clay (%)		Mean (ø)	Sorting (ø)	Skewness (ø)	Kurtosis (ø)	Org. C (%)	$CaCO_3$ (%)
1	3.12	31.65	65.23	C	7.97	2.01	-0.48	0.55	1.05	8.70
2	21.76	23.47	54.77	sC	7.19	2.93	-0.47	0.64	0.82	6.80
3	44.26	18.75	36.99	sC	6.07	2.88	0.39	0.54	0.67	5.60
4	67.08	14.56	18.36	mS	4.33	2.85	0.75	0.90	0.45	3.70
5	84.39	4.13	11.48	cS	2.85	1.72	0.62	3.60	0.44	3.70
6	85.08	6.78	8.14	mS	2.98	1.57	0.55	3.64	0.41	3.40
7	15.21	31.07	53.72	sM	7.30	2.53	-0.43	0.65	1.06	8.80
8	0.73	34.58	64.70	M	8.28	1.87	-0.41	0.74	1.26	9.10
9	1.63	32.54	65.89	M	9.25	1.89	0.19	0.85	1.30	10.50
10	12.75	57.29	29.96	sM	6.25	2.29	0.36	0.56	0.81	9.40
11	50.12	25.34	24.54	mS	5.37	2.88	0.67	0.71	0.47	6.70
12	89.71	5.15	5.14	mS	2.87	1.25	-0.46	3.44	0.34	3.90
13	90.36	5.42	4.22	S	2.67	1.73	1.84	1.85	0.30	2.80
Average	43.55	22.36	34.09		5.65	2.19	0.24	1.44	0.73	6.39

Note: mS: muddy sand, cS: clayey sand, sM: sandy mud, sC: sandy clay, M: mud, C: clay, Org. C: organic carbon.

relict sediments(Niini and Emery, 1961). The modern sediments were usually characterized by a high water content, a fine grain, and a great chage in thickness. According to the Zhao et al.(1990), the main areas of distribution were located in the area at the southeast of the Shandong Peninsula, and the central area of the south Yellow Sea and the Haizhou Bay. In the central part of the south Yellow Sea, the ranges of the sediment types are limited to the finest types, fine silt and clay dominated in this region(Fig. 2).

The calcium carbonate contents in the sediments vary from 2.80 to 10.5%(Table 1). The highest contents of calcium carbonate are found in the sediments of the western part of the central Yellow Sea where fine-grained mud dominated(Fig. 4).

The lowest contents of calcium carbonate are observed in the eastern part where they are dominated sandy sediment. The calcium carbonate contents in the muddy sediments of the western part are two times higher than the sandy sediment of the eastern part of the south Yellow Sea, suggesting that the

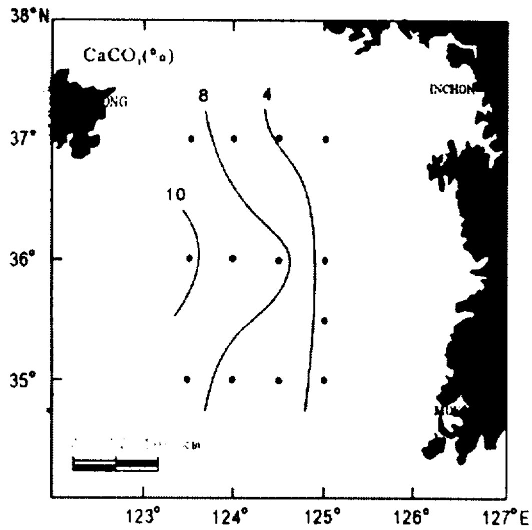

Fig. 4. Areal distribution of $CaCO_3$ in the surface sediments on the central Yellow sea.

major sediments of the former region were probably transported by Huanghe River from the China side.

According to Qin and Li(1983), the sediment loads discharged from the Huanghe River mainly come from Loess Huanghe Plateau in the northwestern China.

which is characterized by high content of calcium carbonate. The contents of organic carbon in the sediments vary from 0.3 to 1.3%(Table 1). The minimum contents of organic carbon (av. 0.40%) are found in the sandy sediments of the eastern area and the maximum (av. 1.20%) in the mud deposit of the central Yellow Sea(Fig. 5). The concentration of organic carbon shows increasing in the muddy sediments than those of the sandy sediments. The organic matters are generally absorbed and precipitated in the fine-grained sediments(Bordovskiy, 1965). According to Niino and Emery(1961), the organic matters are originated from the organism such as foraminifera and mollusks that are abundantly found in the Kuroshio Current. Therefore the biological productivity and sedimentation intensity are the most important factors controlling the variation of organic carbon cotents in the central Yellow Sea.

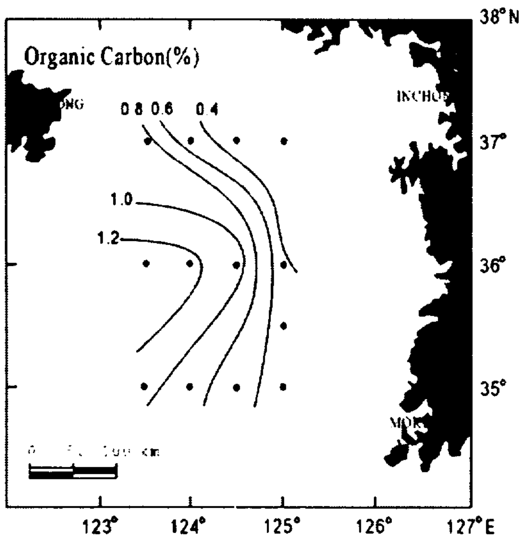

Fig. 5. Areal distribution of organic carbon in the surface sediments on the central Yellow sea.

3.2 Sedimentation rates deduced from profiles of Pb-210

The Pb-210 profile has been determined for three sediment cores collected from the muddy sediments in the south Yellow Sea was used for the measurement of Pb-210 activits. The profiles of Pb-210 are useful in characterizing sedimentary processes over a one hundred year time scale(DeMaster et al., 1985). To determine the sedimentation rate, the excess Pb-210 in the sediments must be decided rather than the total amount. The amount of parent supported Pb-210 is determined by measuring the activity of depths large enough to assure the atmospheric component to be negligible. The amount of excess Pb-210 represent in any particular sample is therefore the difference in activities between the sample in question and that of the parent supported sample (Nittroner et al., 1979). The Pb-210 supported activity was determined in a few section core samples using the Rn-222 emanation method (Lucas, 1975). The Pb-210 profiles from the muddy sediments in the central Yellow Sea are shown in Fig. 6. The open circles represent the total Pb-210 activity and the closed circles indicate the excess Pb-210 activity which with the same point after background is subtracted. The sediment accumulation rate is determined from the slope of the least squares fit to the log excess Pb-210 activity versus total accumulation profiles below the surface mixed layer(Fig. 6). The excess Pb-210 activity was used to compute sediment accumulation rates following the simplified equation of Nittroner et al.,(1979) and Demaster et al., (1985). The equation is given by

$$S = \lambda z(\ln A_0/Az)$$

where S is sediment accumulation rates(cm/yr), λ the decas constant of Pb-210 ($0.031/yr^{-1}$), Z is depth in the profile, and A_0 and Az are the unsupported excess Pb-210 activity at the sediment surface(dpm/g) and the unsupported excess Pb-210 activity at depth Z, respectively. Profiles of Pb-210 activity for the coring station of muddy sedimentary region in the central Yellow Sea and in the eastern side off Shandong Peninsular are shown in Fig. 6.

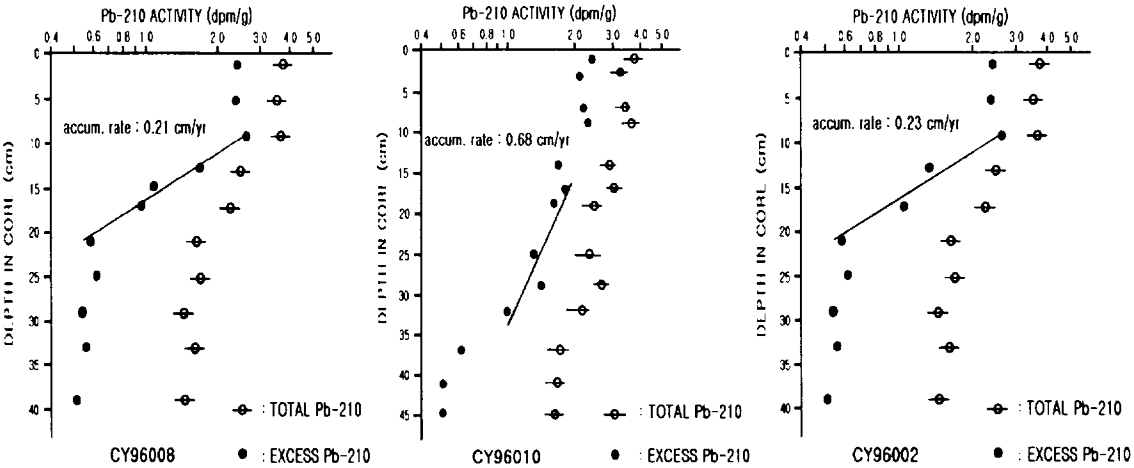

Fig. 6. A profile of Pb-210 activity from cores CY96010, CY96008 and CY96002 in the Central Yellow Sea.

Table 2. Pb-210 dating results from the core samples in the central Yellow Sea

Sample Station	Linear Range (cm)	Water Content (% dry wt.)	Bulk Density (g/cm^3)	Initial Specific Activity of Excess Pb-210 (dpm/g)	Intercept	Sediment Rate (cm/yr)	Sediment Material Flux ($g/cm^2 \cdot yr$)	Pb-210 Sedimentation Flux ($dpm/cm^2 \cdot yr$)
CY 96002	34	39.05	1.57	2.257	2.407	0.23	0.220	0.497
CY 96008	40	44.37	1.51	2.380	2.270	0.21	0.176	0.419
CY 96010	46	35.16	1.62	2.418	2.460	0.68	0.714	1.727

Table 2 shows the Pb-210 dating results for the coring station.

Using the Pb-210 radioactive decay formular, the sedimentation rate, sediment material flux and input of Pb-210 based on the decreasing Pb-210 activity exponentially with depths profile at the station CY96010 located in eastern side off Shandong Peninsular which is affected by the Huanghe River shows 0.68 cm/yr, 0.714 cm/yr and 1.727 $dpm/cm^2 \cdot yr$ respectively(Table 2). Its may cause that sediments from the Huanghe River are carried by the coastal currents, reaching station of CY96010. In sediment cores CY96008 and CY96002 in the central area of the south Yellow Sea, the estimated sediment accumulation rates, sediment material flux and input of Pb-210 range from 0.21 to 0.23 cm/yr, 0.176 to 0.220 $g/cm^2 \cdot yr$ and 0.419 to 0.497 $dpm/cm^2 \cdot yr$, resceptively (Table 2), which are relatively low over the eastern side off the Shandong Peninsular. Its also indicate that the mud in the central area of the south Yellow Sea may have received influence of the sediment discharge from the Huanghe River. As shown in Fig. 6, the excess Pb-210 distribution decreases exponentially with depth in all the cores from the muddy sedimentary region, indicating that the sedimentation in this region is stable and suitable for Pb-210 dating.

The Pb-210 profile from the mud deposit of the south Yellow Sea is shown in Figure 6. The Pb-210 accumulation rate predicts that in the absence of mixing. The mixing layer can be found in the upper 15 cm at core CY96010 station, that is much deeper than in the central Yellow Sea mud area(9 cm). This date indicate that sediment are accumulating very rapidly in the eastern side off Shandong Penibsular rather than that in the mud of central area of the south Yellow Sea. The sedimentation rates of the station CY96002(0.23 cm/yr) in the south part of the region are higher than those of the station CY96008(0.21 cm/yr) in the north part(Fig. 6). The sedimentation rate in the mud of central area of the south Yellow Sea decrease gradually from south to north, which suggests a southly sediment supply. The supply is likely related to the Yellow Sea Warm Current, which carries fine-grained materials of the northern East China Sea on it way to the enter the Yellow Sea.

4. Conclusions

Results of analysis of sediment component, variations in content of the organic matter and the Pb-210 dating for the muddy sediments in the central Yellow Sea are as follows:

The surface sediment types in the study area are divided into three zones. The part of the western Yellow Sea is covered with muds and clays, and the sediment are characterized by higher organic carbon and $CaCO_3$. The sediments in the eastern area were a variety of coarse sediment types of which sand and muddy sand prevailed and formed during the Holocene sea-level rise. In the central zone, the ranges of sediment types are limited to the finest types, silt and clay dominated in this region.

The $CaCO_3$ contents in the muddy sediments of the western and the central zone are two times higher than the sandy sediments dominated in the eastern region, and it may be transported by the Huanghe River. The contents of organic carbon range from 0.3 to 1.3%. The concentration of organic carbon shows increasing in the mud deposit than those of the sandy sediments. The sedimentation rate of the muddy sediment in the eastern nearshore of the Shandong Peninsular is 0.68 cm/yr. The sediment accumulation rate in the mud of the central area of the south Yellow Sea shows 0.21～0.23 cm/yr, which are much lower than the eastern nearshore of Shandong Peninsular. The sedimentation rates are relatively low over the central part of the Yellow Sea than those of the southern part, which indicate that the northward Yellow Sea Warm Current transporting some materials into the Yellow Sea.

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