D-1.1.3 Study on methodology of the estimate of paleo-sediment discharge using marine sediments

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Abstract

The purpose of this study is to develop methods for estimating paleo-sediment discharge and anthropogenic impact of river-load change on coastal environments on time scales of 10 to 10^3 years based on analyses of marine sediment cores. Detailed sediment core analyses using borehole samples taken from the Huanghe (Yellow River) and Changjiang (Yangtze) deltas showed the increase of sediment discharge for the last 1000-2000 years due to human activities in their drainage areas. Sediment cores taken from sea bottom offshore Changjiang also showed anthropogenic changes in coastal environment. Some cysts of red-tides causative dinoflagellates such as *Lingulodinium polyedrum, Scrippsiella trochoidea* and *Polykrikos kofoidii/schwartzii* complex occurred in the upper part of the gravity core G-1, which dates to after about 1970.

Key Words human impact, sediment load, Bohai Sea, East China Sea, Huanghe, Changjiang,

Introduction

The Changjiang (Yangtze) and Huanghe (Yellow) Rivers are two major rivers in the world in terms of sediment and water discharge. At the present time, the river is forming a large delta at its mouth. Since the Holocene maximum inundation of about 6000 to 7000 years ago, both rivers have prograded seaward and huge delta plains surrounding the western part of the Bohai Sea and East China Sea have formed by riverine sediments during the late Holocene. The purpose of this study is to develop methods for estimating paleo-sediment discharge and anthropogenic impact of river-load change on coastal environments on time scales of 10 to 10^3 years based on analyses of marine sediment cores.

Materials and Methods

Two kinds of sediment cores were collected from the Huanghe and Changjiang Deltas: core samples from the sea bottom offshore Changjiang (Table 1) and borehole samples from the both delta plains (Table 2). The core samples were taken from the present delta front-prodelta area to the inner-shelf area using a simple multicore sampler (three simultaneous cores, each 60 cm long) and a gravity corer. These cores were split, described, and photographed. X-ray photographs were taken using slab samples from all split cores. Sand and mud content, water content, and magnetic susceptibility were measured every about 2cm. Mineralogical analyses were done by X-ray diffraction method (XRD). Accumulation rates were measured by the Pb-210 and Cs-137 methods. Marine palynomorph analysis was conducted under the light microscope and SEM. Heavy-metal contents (Zn, Cu, Pb, Ni, Co, Cr, Mn, Fe) was measured by atomic absorption every one cm. Two borehole samples (H9601 and H9602) from the Huanghe Delta and three borehole samples (CM-97, JS-98, and HQ-98) from the Changjiang Delta were taken for 103 time-scale analysis. These cores were also split, described, and photographed. X-ray photographs were taken using slab samples from the split core. Sand and mud content was measured from 5-cm thick samples taken every 20 cm. Wet bulk density was measured every 2.2 cm. More than 100 radiocarbon dates were obtained from mollusc shells and organic matter using Accelerator Mass Spectrometry.

Results and Discussion

Millennial scale changes:

Huanghe

Downcore changes of accumulation rate and sediment facies show that delta progradation has occurred at least two times during 2.6-1.2 yrBP and 1855-present at the two borehole sites, and that the boundary of these prograding sediments is sharp and erosional. This erosional surface correlates with cheniers between borehole sites on the delta plain. Its diastem period almost coincides with the periods when the river mouth was located at other lobe areas: northwestern part of the Bohai Sea (1048-1128 AD), and Jiangsu region facing the Yellow Sea (1128-1855). This means that chenier formation and delta progradation are linked to each other and controlled by the river course of the lower reaches of the Huanghe. Chenier formation is not caused by sea-level changes, but rather due to changes of sediment supply due to river course shifts in the Huanghe delta.

Paleo-sediment discharge of the Huanghe to the sea before 2000 years ago was estimated to be about one-tenth of the present level based on sediment volume in the Bohai and Yellow seas by Milliman et al. (1987)[1]. Our study also shows abrupt increase up to ten times at about 1000 years ago (Figure 1). As more than half of sediments passing Sanmenxia is deposited on the North China Plain, paleo-sediment discharge of the Huanghe at Sanmenxia has been estimated based on Holocene sediment volume in the North China Plain. The result shows it is 2.7×10^8 tons/yr, which is 15-20 % of the present level (1.6×10^9 tons/yr). The possible cause of this recent rapid increase is soil erosion from the Loess Plateau caused by human activities. The river name and its meaning also have been changed from large river to yellow river through turbid river for the last 2000 years.

Changjiang

Lithologically, the CM-97 borehole samples exhibited an upward-fining succession from 70 m to ca. 25 m, an upward-coarsening succession from 25 m to 11 m, and an upward-fining succession from 11 m to the ground surface. Based on sediment facies and foraminifera/mollusc analyses, these successions were interpreted as fluvial, through estuary, to neritic environments for the lower succession, prodelta to delta-front environments for the middle succession, and tidal flat to delta plain for the upper succession, in ascending order. Radiocarbon ages of these successions were from 12 000 to 6000 years BP for the lower succession and 6000 to 1000 years BP for the middle to upper successions. The high accumulation rate from 2000 to 1000 years BP and the sediment facies from this time period indicate that the paleo-delta front of the Changjiang Delta passed the CM-97 site at this time. Since the present delta front is located about 100 km east of this site, the average progradation rate of the delta front for the last 1000 to 2000 years was 60 to 70 m/yr. This is a slightly higher than the average migration rate of 40 to 50 m/yr for river-mouth bars during the last 6000 years. Considering the funnel-shape of the Holocene delat plain and prodelta depth, the annual sediment volume deposited in the delta-front and prodelta areas must have been increasing over the last 1000 to 2000 years. A similar result has been reported for the shoreline migration rate in the southern delta plain of the Changjiang by Chen and Zong (1998)[2). They report an abrupt increase in the shoreline migration rate 2000 years ago, from ca. 2 m/yr to between 6 and 35 m/yr. This increase is thought to have been caused by a depocenter change from the fluvial plain to the delta area of the Changjiang (Chen, 1996)[3).

Decadal scale changes:

Surface sediments were taken from the lower part of the delta front, prodelta, and inner-shelf areas. These sediments consisted of alternating sand and mud in the delta-front area, silty clay in the prodelta area, and muddy sand in the inner-shelf area. Downcore variation in grain size was large in the delta-front area. The grain-size distribution in surface sediment samples did not show large differences compared with that of samples collected 20 to 25 years before (Department of Marine Geology, 1975)[4). Downcore variations in heavy-metal content is not large in any core. In muddy sediments taken from the prodelta area, a slight upward increase of about 10 to 20% is recognized for Zn, Cu, Pb, Ni, and Cr. This change occurred over the last 10 to 20 years. Though sediments from the delta-front area indicate some downcore changes, they are thought to be due to variations in grain size. The maximum concentrations of heavy metals were 115 ppm (Zn), 43 ppm (Cu), 34 ppm (Pb), 49 ppm (Ni), 19 ppm (Co), 145 ppm (Cr), 1.4% (Mn), and 4.7% (Fe). Assemblages of identified dinoflagellate cysts are similar to those found around the Japanese islands. Autotrophs dominate heterotrophs in the gravity core G-1 and increase upward from about 50% to 70%. The G-1 core is 88 cm long and records about the last 30-years according to the Pb-210 and Cs-137 chronologies. Causative organisms for paralytic shellfish poisoning, thought to be Alexandrium catenella or A. tamarense, are found in the upper part of the gravity core G-1, which dates to after about 1970.

References

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Table 1. Sampling location of surface sediments taken from the East China Sea, offshore of the Changjiang.

Site	Latitude	Longitude	water depth	core length
Meso-1	30-50.5N	122-36.6E	20.5 m	31 cm
A-1	31-59.8N	122-30.3E	25.5 m	24 cm
A-3	31-59.5N	123-14.8E	42.0 m	8 cm
A-5	32-00.1N	123.59.9E	39.8 m	20 cm
B-1	31-45.4N	122-30.4E	27.2 m	26 cm
B-3	31-35.6N	123-14.9E	42.0 m	14 cm
B-5	31-29.8N	123-59.8E	41.5 m	12 cm
C-1	31-25.5N	122-34.7E	35.3 m	28 cm
C-3	31-10.5N	123-14.7E	58.7 m	31 cm
C-5	30-59.8N	124-00.0E	39.0 m	no sample
G-1 Core	31-27.1N	122-23.4E	16.0 m	88 cm
B-1 Core	31-45.2N	122-31.1E	28.5 m	160 cm

Table 2. Sampling location of borehole sediments taken from the Huanghe and Changjiang deltas.

Site	Hole	Latitude	Longitude	Altitude	Depth
Huanghe					
H9601	I	37-40.6N	118-28.7E	5.50 m	22.7 m
H9601	III	37-40.6N	118-28.7E	5.50 m	23.9 m
H9602	II	37-47.8N	118-54.3E	4.84 m	28.5 m
Changjiang					
CM97	A,B,C	31-37.5N	121-23.6E	2.48 m	70.50 m
JS98	A,B,C	32-05.0N	121-05.0E	4.20 m	61.50 m
HQ98	A,B	32-15.0N	120-14.0E	5.91 m	60.55 m

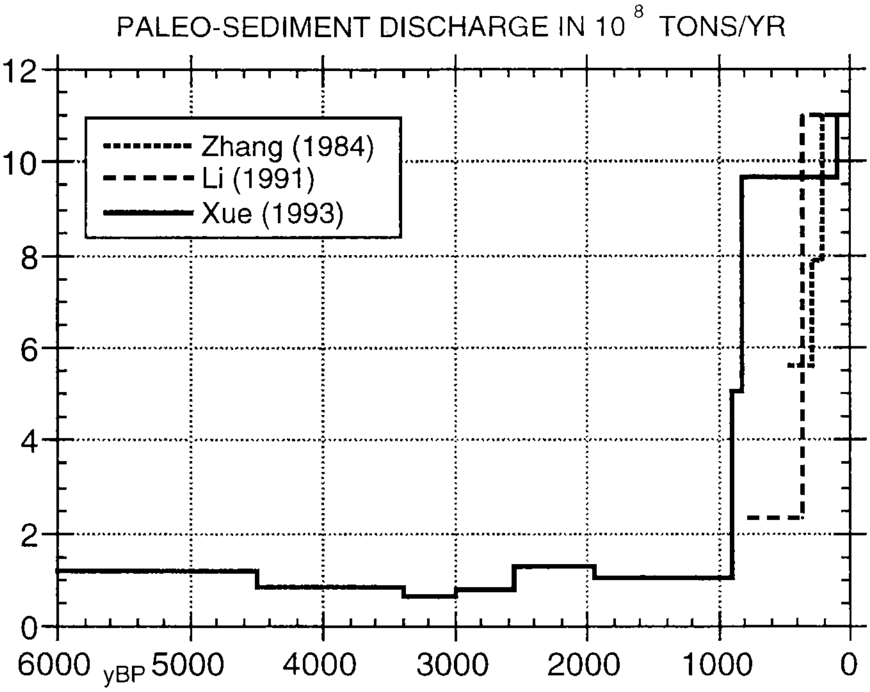

Figure 1. Paleo-sediment discharge of the Huanghe (Yellow River).

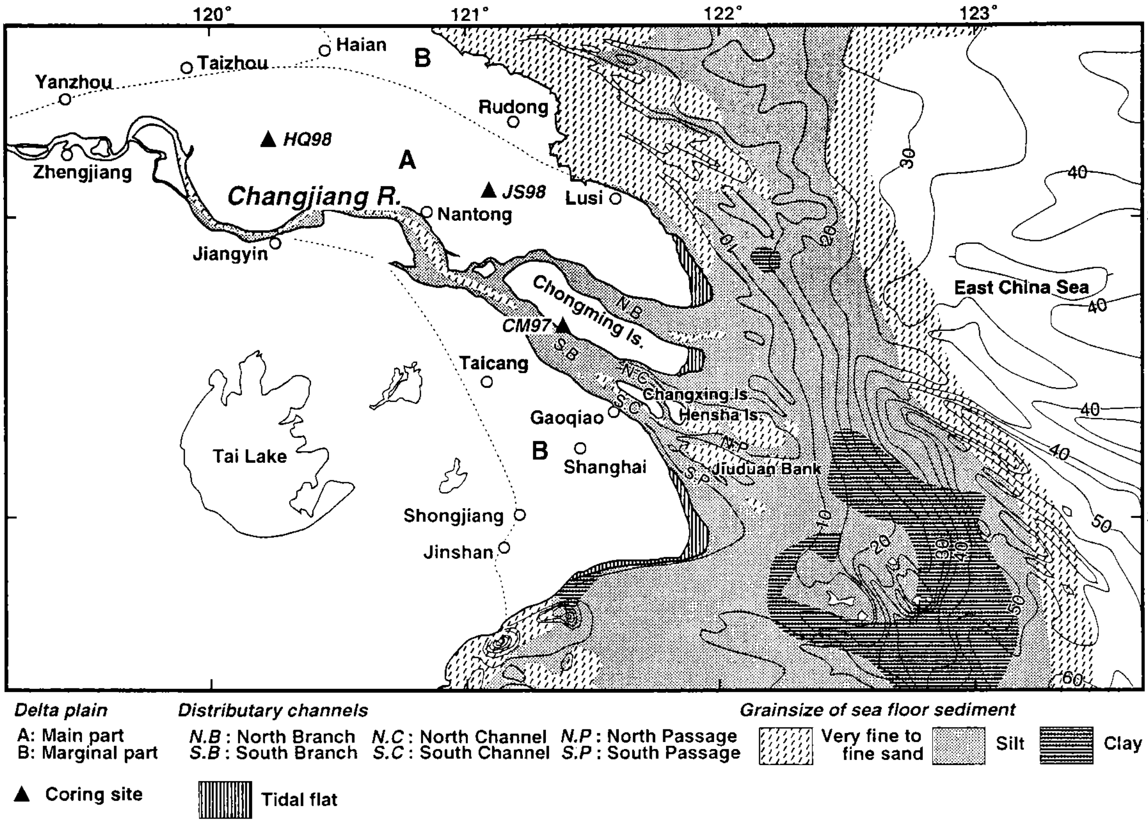

Figure 2. Borehole sites and grain-size distribution of the Changjiang Delta.