Marine Chemistry 162 (2014) 60–70

Contents lists available at ScienceDirect

Marine Chemistry

journal homepage: www.elsevier.com/locate/marchem

Late Holocene elemental and isotopic carbon and nitrogen records from the East China Sea inner shelf: Implications for monsoon and upwelling

Bangqi Hu [a,b,c], Jun Li [a,*], Jingtao Zhao [a,b,c], Helong Wei [a], Xijie Yin [d], Guogang Li [e], Yin Liu [a], Zhilei Sun [a], Liang Zou [a], Fenglong Bai [a], Yanguang Dou [a], Libo Wang [a], Rongtao Sun [f]

[a] Key Laboratory of Marine Hydrocarbon Resources and Environmental Geology, Ministry of Land and Resources, Qingdao Institute of Marine Geology, Qingdao 266071, China
[b] State Key Laboratory of Loess and Quaternary Geology, Institute of Earth Environment, Chinese Academy of Sciences, Xi'an 710075, China
[c] Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China
[d] Third Institute of Oceanography State Oceanic Administration, Xiamen 361005, China
[e] North China Sea Branch of The State Oceanic Administration, Qingdao 266033, China
[f] School of Resources & Environment Engineering, Shandong University of Technology, Zibo 255049, China

ARTICLE INFO

Article history:
Received 29 April 2013
Received in revised form 25 February 2014
Accepted 17 March 2014
Available online 26 March 2014

Keywords:
East China Sea
Stable isotopes
East Asian monsoon
Upwelling
Late Holocene

ABSTRACT

The East China Sea (ECS) is characterized by a relatively high riverine martial input that is associated with East Asian monsoon systems. In this study, we investigated a 272 cm-long sediment core (THB-2) from the ECS inner shelf for the AMS ^{14}C dating, grain size, total organic carbon (TOC), total nitrogen (TN), and stable carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$) isotopes to provide insights into previous changes in the monsoon-climate and the intensity of the coastal upwelling. A three end-member (riverine, deltaic, and marine) mixing model was applied to determine the temporal variations in sedimentary organic matter sources. The transport and burial of the Changjiang riverine organic carbon in the ECS inner shelf is strongly controlled by the combined effects of the monsoon-climate and human activities during the late Holocene. The sedimentary $\delta^{15}N$ records of the THB-2 core are more complex and may be best explained by changes in the nutrient utilization in the coastal zone surface waters. The downcore variations of the marine organic matter-$\delta^{15}N$ are closely related to the intensity of East Asian summer monsoon during the last 3.6 ka. The stronger East Asian summer monsoon likely favored the intensive coastal upwelling and additional Changjiang discharge during the 3.6–2.7 ka and 0.4–0 ka periods, which triggered the greater relative nitrate utilization in the coastal surface water.

1. Introduction

Over 90% of the global organic carbon burial occurs in the shallow continental margins, especially in the large river-dominated estuarine–coastal regions (Bianchi and Allison, 2009; de Haas et al., 2002; Hedges and Keil, 1995; Schlünz and Schneider, 2000). The transport and dispersal of terrestrial organic matter (TOM) in the continental shelf is complicated by the different geological, hydrological and climatological settings (de Haas et al., 2002; Gordon and Goñi, 2003; Hu et al., 2009, 2012a, 2012c, 2013; Ogrinc et al., 2005; Ramaswamy et al., 2008; Tesi et al., 2007; Usui et al., 2006). Understanding the origins, distribution, and fate of the TOM in these shallow marine systems is critical for global carbon cycle and earth surface evolution (Blair and Aller, 2012). Sedimentary organic matter (SOM) in coastal marine sediments is a complex mixture of organic compounds originating from various sources. A better identification of SOM sources is essential when elucidating the stored environmental signals relative to the sediment dispersal transport mechanisms and global climate changes (Hu et al., 2006; Jia et al., 2013; Lamb et al., 2006; Meyers, 1997, 2003; Yang et al., 2011; Yu et al., 2010, 2012; Zhan et al., 2012). The elemental and stable isotopes of carbon and nitrogen (C/N ratios, $\delta^{13}C$ and $\delta^{15}N$) have frequently been used as effective proxies for decoding biogeochemical processes and evaluating the SOM sources in estuarine and coastal marine environments.

The East China Sea (ECS) is one of the largest river-dominated marginal seas in the world and is primarily influenced by the Changjiang (Yangtze River) (Fig. 1). It ranks fifth in terms of water discharge (920 cubic kilometers per year, km^3/a) and is historically fourth in sediment load (480 million tons per year, Mt/a) (Milliman and Meade, 1983; Milliman and Syvitski, 1992). The supply and transport of the Changjiang materials is strongly influenced by the East Asian monsoon climate system, which is composed of summer and winter monsoons. The East Asian summer monsoon intensified during the early and mid-Holocene before weakening dramatically from the mid- to late Holocene onward (e.g., Cheng et al., 2012; Dykoski et al., 2005; Jiang et al., 2013; Wang et al., 2005). In contrast, past changes of the East Asian

* Corresponding author at: Key Laboratory of Marine Hydrocarbon Resources and Environmental Geology, Ministry of Land and Resources, Qingdao Institute of Marine Geology, Fuzhou South Road 62#, Qingdao, Shandong 266071, China. Tel.: +86 532 85776342; fax: +86 532 85720553.
E-mail address: junli741001@gmail.com (J. Li).

http://dx.doi.org/10.1016/j.marchem.2014.03.008
0304-4203/

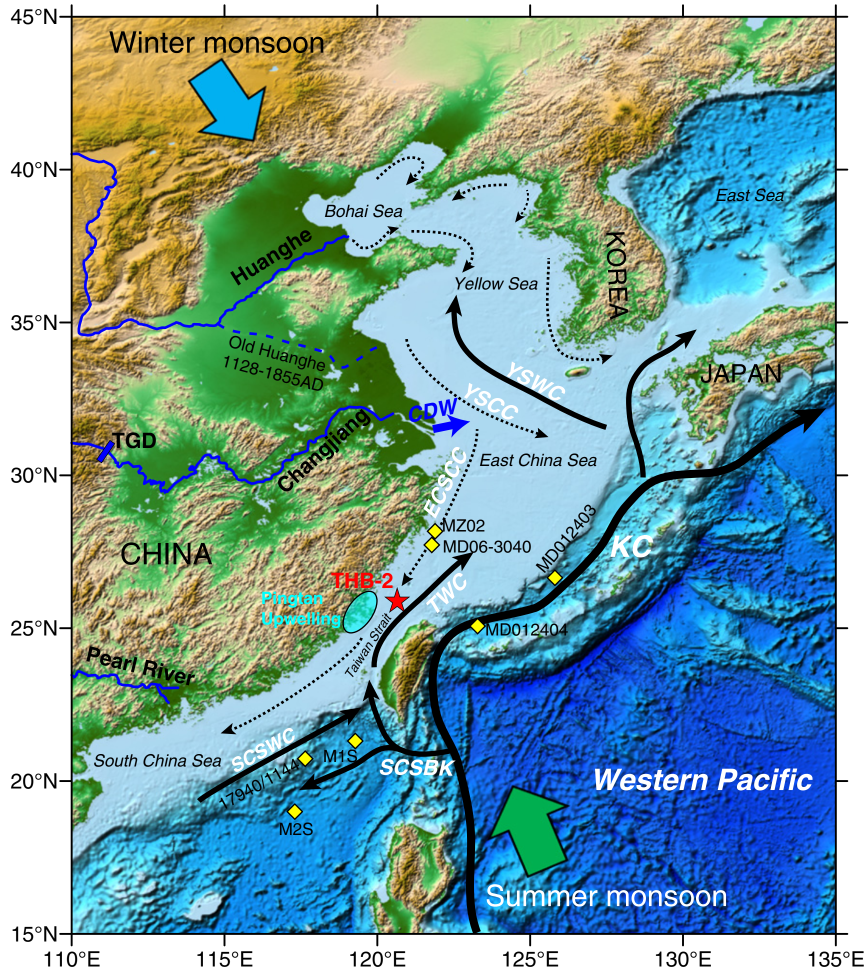

Fig. 1. Schematic bathymetry and oceanic circulation (winter) of the East China Sea. The black lines with arrows denote the Kuroshio Current (KC), the Yellow Sea Warm Current (YSWC), the Taiwan Warm Current (TWC), the South China Sea Warm Current (SCSWC), and the South China Sea Branch of Kuroshio (SCSBK). The dashed lines with arrows denote the Yellow Sea Coastal Current (YSCC) and the East China Sea Coastal Current (ECSCC). The Changjiang Diluted Water (CDW) is also shown. TGD is the Three-Gorges Dam. The locations for the THB-2 core and the other cores in previous studies: MZ02 (Li et al., 2012d) and MD06-3040 (Zhao et al., 2009) in the ECS inner shelf; MD012403 and MD012404 (Kao et al., 2008) in the Okinawa Tough; 17940/1144 (Higginson et al., 2003; Kienast, 2000) in the northern continental slope of South China Sea. M1S and M2S are two time series sediment traps in the South China Sea (Kao et al., 2012).

winter monsoon have not been well reconstructed and are also under debate (e.g., Hu et al., 2012b; Wang et al., 2012; Xiao et al., 2006; Yancheva et al., 2007).

The seasonal hydrodynamics of ECS play an important role in the redistribution, transport and fate of the resuspended sediments from the Changjiang Estuary to the southern ECS inner shelf (Liu et al., 2007; Xu et al., 2012). Under this unique sedimentary process, an elongated (~1000 km) distal subaqueous mud wedge in the inner shelf of ECS was formed during the Holocene (Xu et al., 2012). These continuous and rapidly accumulated mud deposits provide natural “recorders” of high-resolution paleoenvironmental change (Liu et al., 2013; Zheng et al., 2010). Recent studies have highlighted that the estuarine-inner shelf of the ECS is a major sink for the fine-grained Changjiang sediments (Li et al., 2012a; Xu et al., 2009, 2011, 2012) and the associated organic materials (Deng et al., 2006; Hu et al., 2012c; Kao et al., 2003; Xing et al., 2011; Zhu et al., 2011b). However, the limited work has focused on the temporal variation of organic carbon burial in the ECS inner shelf and the controlling factors during the late Holocene.

In this study, a 272 cm-long sediment core (THB-2) from the inner shelf of the ECS was investigated regarding the AMS ^{14}C dating, grain size, total organic carbon (TOC), total nitrogen (TN), and stable carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$) isotopes. The main objectives of this study were (1) to characterize the source of SOM in the ECS inner shelf, (2) to discuss the potential influences on the sedimentary $\delta^{15}N$, and (3) to illustrate the implications for monsoon and upwelling in this dynamic continental shelf during the late Holocene.

2. Regional setting

The East China Sea (ECS) is strongly affected by seasonal monsoon wind fields, as well as the seasonal riverine freshwater plumes. The winds over the ECS are dominated by the East Asian monsoon: southwesterly in summer and northeasterly in winter. During the winter, the Chinese coastal cold waters (Yellow Sea and East China Sea Coastal Currents, i.e., YSCC and ECSCC) flow southward due to the strong northerly winds. In contrast, the Yellow Sea Warm Current (YSWC) is influenced by the warm Kuroshio Current (KC), and it flows northward more effectively (Fig. 1). During the summer, mild southerly winds carrying warm and moist air prevailed; the coastal currents tend to flow northward except for the currents off the western coast of Korea, which flow southward, and the Changjiang Diluted Water (CDW), which mainly flows northeastward (Fig. 1). The Taiwan Warm Current (TWC) flows northeasterly to the ECS in summer. The flow of the TWC increases in early spring as the northeast monsoon weakens, peaking during the summer when the southwest monsoon prevails (Fig. 1).

The Changjiang originates in the Qinghai–Tibetan Plateau and flows eastward across central and eastern China, totaling 6300 km in length and 1.94×10^6 km^2 in drainage area, before debouching into the ECS.