Geomorphology 283 (2017) 173–188

Contents lists available at ScienceDirect

Geomorphology

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

Structure, distribution, and evolution history of the Early Holocene erosional mud ridge system on the inner East China Sea shelf near the Yangtze River estuary

Zhibing Feng [a,b], Baohua Liu [b,*], Yuexia Zhao [b], Xishuang Li [c], Olusegun A. Dada [d], Li Jiang [a], Shaokun Si [b]

[a] College of Marine Geoscience, Ocean University of China, Qingdao, China
[b] National Deep Sea Center, State Oceanic Administration, Qingdao, China
[c] The First Institute of Oceanography, State Oceanic Administration, Qingdao, China
[d] Department of Marine Science and Technology, Federal University of Technology, Akure, Nigeria

ARTICLE INFO

Article history:
Received 23 May 2016
Received in revised form 4 January 2017
Accepted 8 January 2017
Available online 14 January 2017

Keywords:
Inner East China Sea shelf
Mud ridge
Early Holocene
Topography

ABSTRACT

Utilizing the collected high-resolution seismic dataset and accompanying borehole and bathymetric data, we systematically evaluated the morphology, architecture, sedimentology, and evolution of erosional mud ridges within the inner East China Sea (ECS) shelf. We identified 20 mud ridges, i.e., seismic reflection profile crossings of exposed or buried mud ridges, which are 3.0–30.1 km in width and 2.5–17.3 m in height. The mud ridges are composed predominantly of gray clayey silt, and on seismic profiles contain parallel to subparallel reflectors. They formed around ~10–12 ka BP within an estuarine environment. Scouring features of some mud ridges on the eastern part of the study area can be recognized. Consideration of the relative positions of mud ridges, together with the topographical features, enables us to map four linear mud ridges (LMRs). The SE-NW oriented LMRs are >50 km in length, 3.0–9.5 km in width and running parallel to each other. They also display asymmetric shapes, with steeper slopes to the SW. The eastern segments of some LMRs are exposed on the present seafloor whereas other segments are mainly overlain by the mid- and late Holocene strata. Since the LMRs share similarities with the modern tidal sand ridges in shape and orientation, we hypothesize that they are formed under a uniform tidal current. Seismic data highlight that the internal reflectors of sand ridges consist of dipping clinoforms and are significantly different from LMRs, a feature which is largely due to the difference in grain-size composition of sediments between the inner and mid-outer ECS shelf. The mid- to outer ECS shelf is capped by coarser-grained sediments (i.e., medium to fine-grained), which were reworked and deposited at locations near the erosional areas under a polycyclic tidal current, thus forming multiphase sand ridges. However, fine-grained sediments (i.e., silty clay and clayey silt) overlain on the inner ECS shelf with light mass were carried far away from the erosional areas by the tidal currents, and the relict mud ridges were built. Evidence shows that the LMRs were formed by the early Holocene strata being scoured by a persistent southeasterly flowing current during ~8–10 ka BP. The evolution of the LMRs occurred in three stages: (a) formation of the transgressional strata at ~10–12 ka BP, (b) strong trough erosion at ~8–10 ka BP, and (c) local adjustment (i.e., local erosion slightly and preservation) after ~8 ka BP.

1. Introduction

Large rivers transport voluminous particulate and dissolved materials into coastal areas and marginal seas, where the interaction between sea-level oscillations and tidal currents is thought to control the landforms, deltas, and coastal-plain sequence formation (Milliman and Syvitski, 1992; Wang et al., 2014). Studies of the complex deposition processes provide abundant geological archives on the response of river–sea interactions and paleo-environmental changes (Dalrymple and Choi, 2007; Counts et al., 2015; Sun et al., 2015; Winsemann et al., 2015).

The Yangtze River is one of the largest rivers in the world in terms of sediment load and water discharge (Huang et al., 2001; Yi and Saito, 2004; Dai and Lu, 2014). Over the last 7 ka BP, more than half of the Yangtze-derived sediments have been delivered to the Yangtze estuary and inner East China Sea (ECS) shelf, thus forming a mega-delta near the present Yangtze River mouth and three muddy areas in the ECS (Xu et al., 2009; Wang et al., 2010; Liu et al., 2013; Xu et al., 2015). Numerous geological and geophysical investigations have been conducted near the Yangtze estuary to document various geological issues, including the delta initiation and evolution (Chen et al., 2000; Hori et al., 2001a; Hori et al., 2002; Yi et al., 2003; Wang, 2011; Wang et al., 2012; Song et al., 2013; Wang et al., 2013; Xu et al., 2013), the sequence stratigraphy near the Yangtze estuary (Li et al., 2000; Hori et al., 2001b; Xu,

* Corresponding author.
E-mail address: bhliu@ndsc.org.cn (B. Liu).

http://dx.doi.org/10.1016/j.geomorph.2017.01.011
0169-555X/

2013; Xu et al., 2016b), and the modern sediment dispersal and distribution characteristics (Xu and Milliman, 2009; Dong et al., 2014; Dai et al., 2015; Liu et al., 2015; Luan et al., 2016). Most of these studies focused on the sedimentary history associated with the Yangtze estuary (Chen et al., 2000; Hori et al., 2001a; Hori et al., 2002; Yi et al., 2003; Wang, 2011; Wang et al., 2012; Song et al., 2013; Wang et al., 2013; Xu et al., 2013). However, studies addressing landforms and sediments within the inner shelf near the Yangtze estuary during the Early Holocene are scarce.

Chen et al. (2003) reported that there is a mud ridge system in the inner ECS shelf near the Yangtze estuary and discussed its internal architecture, geometry and formation mechanism, i.e., tidal-controlled estuarine conditions. Subsequently, Xu et al. (2012) also mentioned the mud ridge system in the inner ECS shelf near the Yangtze estuary but did not study its formation. Additionally, the mid- to outer ECS shelf is capped by sandy sediments in the form of sand ridges or sand sheets (Berné et al., 2002; Liu et al., 2007b). Liu et al. (2007b) suggested that the ridge-shaped acoustic units revealed in seismic profiles in the inner ECS shelf near the Yangtze estuary were a small portion of the tidal sand ridge systems. However, owing to the limitations of previous study conditions, there is as yet insufficient information and debate continues on the genesis of the mud ridge system within the inner ECS shelf near the Yangtze estuary.

Here the topographic features within the study area are elucidated by compiling the available seismic and bathymetric data (Fig. 1). In terms of the seismic-borehole correlation, we decipher the compositions and sediment textures of the erosional mud ridges. We then identify some mud ridges and map the distribution of the linear mud ridges (LMRs) in space, and further analyze their geometric characteristics via high-resolution seismic data. Given that the geometry and orientation of the LMRs coincide well with those of tidal sand ridges on the mid-

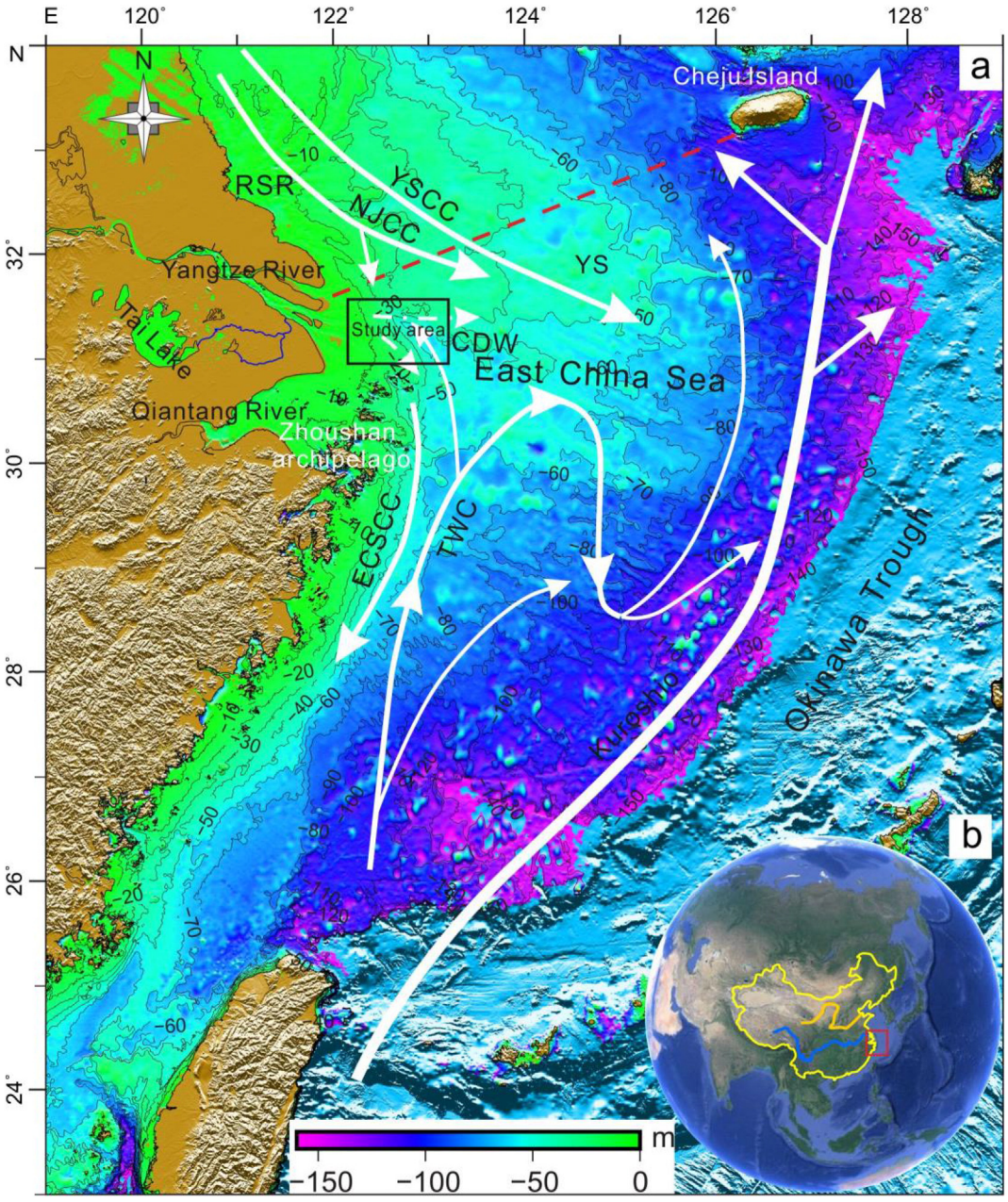

Fig. 1. (a) Schematic map of the bathymetry in the ECS and its adjacent areas, showing the regional circulation pattern (Guan, 1983; Liu et al., 2006). YS: Yangtze Shoal. The dotted line indicates the northern border of the ECS (Xu et al., 2009). The arrows indicate Yellow Sea Coastal Current (YSCC), North Jiangsu Coastal Current (NJCC), Changjiang (Yangtze River) Diluted Water (CDW), East China Sea Coastal Current (ECSCC), and Taiwan Warm Current (TWC) in the map. Contour unit is meters. RSR: radial sand ridges along the Jiangsu Coast. (b) The location of the study area (rectangle). Two lines represent the Yangtze and Yellow rivers, respectively.