Paleo-fluvial sedimentation on the outer shelf of the East China Sea during the last glacial maximum*

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Abstract Evidence from lithology, foraminiferal assemblages, and high-resolution X-ray fluorescence scanning data of core SFK-1 indicates tidally influenced paleo-fluvial sedimentation during the last glacial maximum (LGM) on the outer shelf of the East China Sea. The paleo-fluvial deposits consist of river channel facies and estuarine incised-valley-filling facies. Different reflections on the seismic profile across core SFK-1 suggest that the river channels shifted and overlapped. River channel deposition formed early in the LGM when sea level fell and the estuary extended to the outer shelf. Channel sediments are yellowish-brown in color and rich in foraminifera and shell fragments owing to the strong tidal influence. Following the LGM, the paleo-river mouth retreated and regressive deposition of estuarine and incised-valley-filling facies with an erosion base occurred. The river channel facies and estuarine incised-valley-filling facies have clearly different sedimentary characteristics and provenances. The depositional environment of the paleo-river system on the wide shelf was reconstructed from the foraminiferal assemblages, CaCO3 content and Ca/Ti ratio. The main results of this study provide further substantial constraints on the recognition of late Quaternary stratigraphy and land-sea interactions on the ECS shelf.

Keyword: outer shelf; East China Sea; LGM (last glacial maximum); paleo-river channel; fluvial deposition; paleoenvironment

1 INTRODUCTION The East China Sea (ECS) is a typical marginal sea of the west Pacific Ocean and has one of the widest shelves in the world. A large volume of detrital sediment accumulates on the shelf, mainly derived from large rivers, such as the Changjiang (Yangtze) River and Huanghe (Yellow) River, forming important terrigenous sinks and unique depositional systems of the East Asian continental margin. During the last glacial and interglacial periods, monsoon circulation, sea-level fluctuation and ocean circulation largely controlled the flux and fate of detrital sediments in the sea. During the last glacial maximum (LGM), the coastline of the ECS retreated to its furthest position; about 120 to 160 m below the present sea level (Emery et al., 1971; Zhu et al., 1979; Feng, 1983; Qin et al., 1987; Saito et al., 1998; Liu and Milliman, 2004), closer to the Okinawa Trough. A major part of the ECS shelf was exposed and the detrital sediments from the paleo-Changjiang, paleo-Huanghe, and/or other surrounding rivers were transported more directly to the outer shelf, the shelf break, and the Okinawa Trough.

During the past two decades, many studies have investigated paleo-fluvial sedimentation on the ECS shelf using geological and geophysical methods (Zhu et al., 1979; Yang, 1989; Nio and Yang, 1991; Yuan, 1992; Li and Zhang, 1995; Tang, 1996; Berné et al., 2002; Wellner and Bartek, 2003; Li et al., 2005; Liu et

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The earlier investigations studied the formation of sand ridges on the outer shelf using high-resolution single-channel seismic technology in combination with microfossil and pollen assemblages in borehole YQ1 sediments (Yang, 1989). It was suggested that during the LGM, the paleo-Changjiang estuary had extended seaward to the mid-outer shelf, and there had formed a river channel and delta complex as the sea level fell to its lowest position. With the onset of the deglacial transgression, the river channel and estuarine sediments were eroded and reworked to form tidal sand ridges under strong tidal currents. Tang (1996) described some fluvial deposition of MIS2 (MIS: marine isotopic stage) based on lithology and microfossil assemblages in core DZQ4, but the fluvial sequence is very thin (only about 1 m thick) and not typical. Wellner and Bartek (2003) also identified the paleo-Changjiang fluvial sedimentation after MIS3 and emphasized, by synthesizing the seismic facies and core data from DZQ4 and YQ1, that fluvial processes were the key factor in forming the tidal sand ridges. Furthermore, recent work on the high-resolution seismic analysis by Li et al. (2005) and Liu et al. (2009) revealed the distribution of the paleo-Changjiang River channel and its seismic facies characteristics.

Despite these previous studies, there still exist some differences of opinion on the paleo-fluvial sedimentation on the ECS shelf during the LGM. With regard to the thin fluvial deposition in core DZQ4, Liu et al. (2000a, b) highlighted that the fluvial processes were generally weak and that the paleo-Changjiang channel and incised-valley filling were almost absent on the outer shelf during the low sea-level stands of MIS4 and MIS2. However, they did recognize some large paleo-channels from the seismic profiles across the MIS3 strata. Xia and Liu (2001) concluded that the paleo-channel deposits of the LGM, inferred by previous research, are the result of present tidal channel sedimentation and that no paleo-Changjiang fluvial sedimentation occurred on the shelf during the lowest sea level stand. In addition, the cold and dry environment during the last glacial period was considered unfavorable for the development of large river channels on the exposed shelf, and that a broad desert-like landscape might have occurred owing to the strong winter monsoon (Zhao and Yu, 1996; Zhao et al., 1997).

These previous studies on the Quaternary stratigraphy of the ECS shelf were obtained primarily by interpretation of seismic profiles with little direct evidence from geological core analysis. In this study, the lithological description, composition of sediment grain size, microfossil assemblages, and reliable ages were applied to reveal the paleo-fluvial sedimentary characteristics and changes in the depositional environment on the outer shelf of the ECS.

2 MATERIAL AND METHOD

Borehole SFK-1 was taken from the outer shelf of the ESC (29°03.1519′N, 125°15.2978′E) by rigging method at 88.30 m water depth in 2007, using the D/V Kan 407 of the First Marine Geological Investigation Party (Fig.1). The borehole is 82.90 m long and the recovery rate averages 89.30%. Based on the lithostratigraphy of the nearby DZQ4 core and the high-resolution seismic profile across both the DZQ4 and SFK-1 cores (Fig.2) obtained in 2006 by Qingdao Institute of Marine Geology, the core samples between