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Sediment provenance and paleoenvironmental change in the Ulleung Basin of the East (Japan) Sea during the last 21 kyr

Zhaokai Xu [a,b,c,*], Dhongil Lim [c,*], Jinyong Choi [b], Tiegang Li [a], Shiming Wan [a], Kyoungchan Rho [d]

[a] Key Laboratory of Marine Geology and Environment, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China
[b] Department of Oceanography, Kunsan National University, Kunsan 573-701, Republic of Korea
[c] Library of Marine Sample, South Sea Research Institute, Korea Institute of Ocean Science and Technology, Geoje 656-830, Republic of Korea
[d] EEZ Geo-Resources Research Unit, Korea Institute of Ocean Science and Technology, Ansan 426-744, Republic of Korea

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ABSTRACT

Despite the well-reconstructed paleoceanography of the late Quaternary deposits in the East (Japan) Sea (ES), provenances of terrigenous sediments and a comprehensive interpretation of their variations since the Last Glacial Maximum remain unclear, especially in regard to the mainland China- and Taiwan-derived matter. Grain size, conservative trace elements, rare earth elements (REEs), Nd isotope, and clay mineralogy of core sediments from the Ulleung Basin of the ES were investigated for better understanding of detrital sediment provenance and transport process and then their forcing mechanisms over the last 21 kyr. Geochemical–mineralogical multi-indices in this study showed notable three-phase changes in sediment provenance, which can be closely related to sea-level fluctuation, development of the Tsushima Warm Current as well as intermittent influence from the East Asian summer monsoon climate evolution. During Unit 1 (21.1–8.4 kyr BP) when the Tsushima Warm Current was absent in the ES, the paleo-Changjiang and the paleo-Huanghe mouth might be situated close to the study area and thus mainland China could have played major role in the southwestern Ulleung Basin sedimentation. In particular, the formation of rhythmic dark-colored alternation in Unit 1 is possibly attributable to the pulse of paleo-Huanghe discharge associated with centurial- to millennial-scale variability in the East Asian summer monsoon. In Unit 2 (8.4–7.2 kyr BP), these river mouths gradually retreated to their present positions with global sea-level rise, leading to decreasing terrigenous sediment supply from mainland China to the study area. Since 7.2 kyr BP (Unit 3), sedimentation in the Ulleung Basin should still be mainly derived from mainland China. Meanwhile, increasing chlorite/kaolinite ratio but decreasing ε_{Nd} value revealed that terrigenous matter from Taiwan might have been limitedly transported northward to the study area by the fully evolved Tsushima Warm Current. A prominent decline in chlorite/kaolinite ratio, together with contrast change on ε_{Nd} value, centered at around 2.9 kyr BP (3.3–2.4 kyr BP) may have been caused by the Tsushima Warm Current suppression, possibly related to the *Pulleniatina* minimum event popularly found in the study area and nearby seas.

1. Introduction

The East (Japan) Sea (ES) is a semi-enclosed, deep marginal sea (maximum water depth of about 3700 m) in the northwestern Pacific (Fig. 1). Continuous sedimentation in the ES during the late Quaternary has been regulated by the changes in terrigenous sediment supply, sea-level fluctuation, East Asian monsoon, and oceanic circulation (Tada et al., 1999, 2013; Gorbarenko and Southon, 2000; Bahk et al., 2004; Lim et al., 2006, 2011; Lee, 2007; Zou et al., 2012; Um et al., 2013). In particular, the well-silled configuration of the ES renders its oceanic mode extremely sensitive to sea-level change and to variation in the current regime resulted from sill emergence (Nakajima and Itaki, 2007). Therefore, the ES is an ideal natural laboratory in the northwestern Pacific marginal seas for discussion of land–sea interaction and paleoenvironmental change during the geologic past (Tada et al., 2013).

Over the last two decades, the late Quaternary paleoceanographic history of the ES has been well documented by many studies based mainly on paleontological (i.e., foraminifer and diatom), biogeochemical (e.g., oxygen isotope, alkenone, organic carbon, and calcium carbonate), and lithologic (i.e., dark laminated

* Corresponding authors. Address: Library of Marine Sample, South Sea Research Institute, Korea Institute of Ocean Science and Technology, Geoje 656-830, Republic of Korea (Z. Xu, D. Lim). Tel.: +82 55 639 8580; fax: +82 55 639 8509.
E-mail addresses: zhaokaixu@qdio.ac.cn (Z. Xu), oceanlim@kiost.ac (D. Lim).

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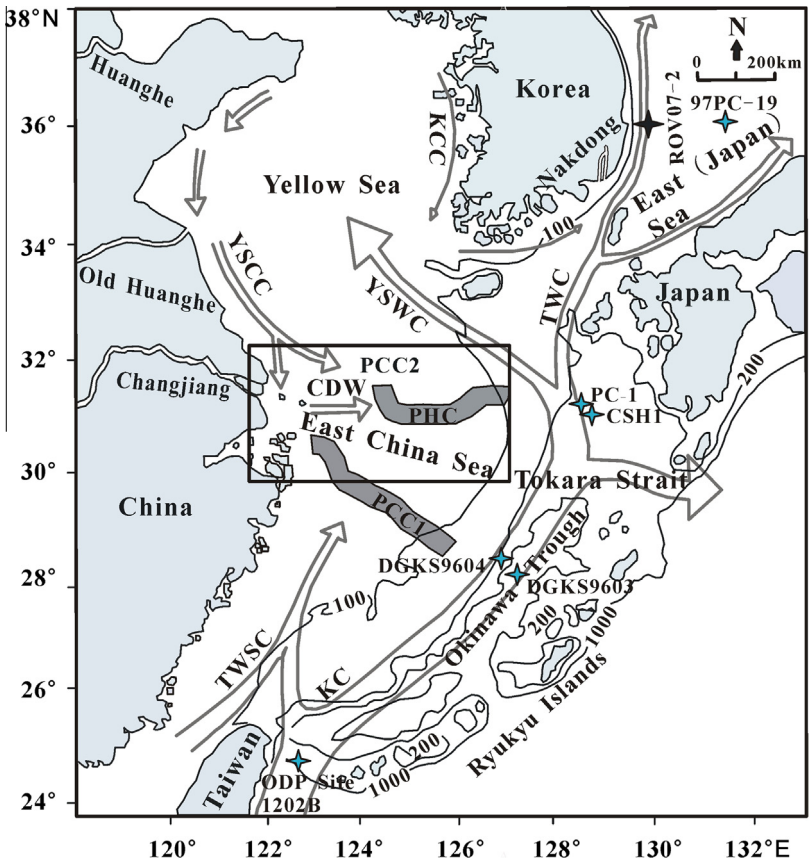

Fig. 1. Schematic map showing the locations of core ROV07-2 and other typical reference cores (97PC-19, Bahk et al., 2004; PC-1, Xu et al., 2012a, 2014; CSH1 and DGKS9603, Li et al., 2009; Xu et al., 2012b; DGKS9604, Dou et al., 2010a; ODP Site 1202B, Diekmann et al., 2008) in the southwestern ES and adjacent areas. The regional circulation paths (arrows) are sourced from Khim et al. (2008) and Yu et al. (2008). Different paleo-river channels in the East China Sea during the late last glaciation are indicated by black polygon (Ujiié and Ujiié, 1999) and black rectangle (Li et al., 2005), respectively. YSCC = Yellow Sea Coastal Current; CDW = Changjiang Diluted Water; TWSC = Taiwan Warm and Saline Current; KC = Kuroshio Current; TWC = Tsushima Warm Current; YSWC = Yellow Sea Warm Current; KCC = Korea Coastal Current; PHC = paleo-Huanghe channel; PCC = paleo-Changjiang channel.

sediment and tephra) properties of core sediments (e.g., Gorbarenko and Southon, 2000; Itaki et al., 2004; Domitsu and Oda, 2006; Koizumi et al., 2006; Khim et al., 2007, 2008; Lee, 2007; Lim et al., 2013; Khim et al., 2014). Recently, several research efforts with focus on elemental indices have been conducted to preliminarily discuss terrigenous sedimentation in the southwestern ES (Bahk et al., 2004; Cha et al., 2007; Zou et al., 2010; Lim et al., 2011; Zou et al., 2012; Um et al., 2013). These studies preliminarily identified Chinese rivers (the Changjiang and the Huanghe) as main potential provenance end-members of terrigenous sedimentation therein since the last deglaciation, although the detailed contribution changes of them over time have remained unresolved (Tada et al., 1999; Zou et al., 2010, 2012; Um et al., 2013). However, nearby Nakdong and volcanic islands (e.g., Ulleungdo and Dokdo) might have much less contributions to the late Quaternary deposition in the southwestern slope of ES (Um et al., 2013). Although the recent IODP 346 expedition began to focus on this key research gap, such as the linkage between orbital- and millennial-scale changes of the East Asian monsoon, discharge of the Changjiang and the Huanghe, and paleoceanography in the ES over the last several million years (Tada et al., 2013), yet its generally low time resolution calls for further high-resolution work.

To better understand sediment transport patterns in the southwestern slope of ES in detail, reliable provenance tracers of terrigenous sediments from different end-members are needed. Among the various indices, conservative trace elements (e.g., Zr, Th, Hf, and Nb), rare earth elements (REEs), and Nd isotopic compositions are well accepted as reliable provenance tracers for they are largely terrigenous components reflecting their provenance in sediment (e.g., Taylor and McLennan, 1985; Yang et al., 2003; Wu et al., 2009; Dou et al., 2010a, 2012; Hu et al., 2012a; Xu et al., 2012a; Um et al., 2013), although other factors such as sediment grain size, heavy minerals, and diagenesis after deposition are all possibly responsible for REEs in sediment (Taylor and McLennan, 1985; Yang et al., 2002; Xu et al., 2008, 2012a; Dou et al., 2010a). Clay minerals, TOC/TN ratio, and Ti/Ca ratio can also provide some valuable information on sediment transport and deposition processes (Xu et al., 2009a; Hu et al., 2012a), especially in regard to the Kuroshio Current/Tsushima Warm Current evolution (Diekmann et al., 2008; Dou et al., 2010b; Lim et al., 2011; Xu et al., 2012b) and the Huanghe-derived matter input (Liu et al., 2010a; Xu et al., 2014). However, a comprehensive provenance discrimination based on these indices with relatively high resolution time-frequency has not been conducted for core sediments in the southwestern ES.

Here, we present a comprehensive data set including AMS ^{14}C, grain size, conservative trace elements, REEs, Nd isotope, TOC/TN ratio, and clay minerals for core sediments taken from the southwestern ES. The study objective was to reconstruct relatively high-resolution sediment provenance change and the competing roles of sea-level fluctuation, Tsushima Warm Current strength, and East Asian monsoon climate variability in regulating terrigenous sediment input into the study area over the last 21 kyr. This multi-proxy data set should allow us to circumvent the potential