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Magnetic characteristics of sediments from a radial sand ridge field in the South Yellow Sea, eastern China, and environmental implications during the mid- to late-Holocene

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ABSTRACT

Proxy records from radial sand ridge fields are essential for understanding sedimentary environmental changes forced by climate-driven coast and sea level variations that affect large river inlets. We conducted a systematic environmental magnetic study on sediments from a radial sand ridge field in the South Yellow Sea, eastern China. From 41.6 to 0 m, the sediments of core YZ07 derive from river mouth, littoral and modern tidal flat environments. Magnetic measurements indicate that magnetite and hematite dominate the studied magnetic mineral assemblages. Magnetic mineral contents are highest in the river mouth environment and lowest in the modern tidal flat environment. The magnetic minerals in the core YZ07 sediments can be attributed primarily to detrital inputs rather than biogenic sources. The highest χ and SIRM values and lowest χ_{ARM}/SIRM and χ_{ARM}/χ values reflect relatively warm and humid climate conditions respectively during the period ~7000 to 2900 a B.P. (41.6–24.73 m). Compared with the period ~7000 to 2900 a B.P. (41.6–24.73 m), the period between ~2900 and 870 a B.P. (24.73–5.14 m) is characterized by lower χ, χ_{ARM} and SIRM values and higher χ_{ARM}/SIRM and χ_{ARM}/χ values, which indicate cool and dry climatic conditions. Our results reconfirm known regional climatic events that demonstrate Holocene climatic instability. Gradual decreases in χ and SIRM and increases in χ_{ARM}/SIRM, χ_{ARM}/χ and χ_{fd} characterize the sediments after 870 a B.P. (5.14–0 m). As indicated in previous studies, these changes were influenced by diversion of the Yellow River. Additionally, spectral analysis of the χ and χ_{ARM}/SIRM records reveals rapid climatic fluctuations on millennial and centennial scales that coincide with those recorded in marine sedimentary records from adjacent regional seas. These results are important for investigations into the interactions between regional systems and global change in monsoonal climatic regions, thus providing an example of the evolution of a large scale geomorphic feature resulting from river-sea interaction.

1. Introduction

A large radial sand ridge field is located on the eastern coast of China between the Yangtze River Delta to the south and the abandoned Yellow River Delta to the north (Fig. 1). The radial sand ridge field is elongated steeply oblique the present shoreline and covers an area of 22,470 km^2, spanning 200 km in latitude and more than 140 km in longitude. It contains approximately 70 sand ridges and associated tidal channels with a water depth of approximately 30 m below the mean sea level (Wang, 2014). Global paleoenvironmental reconstructions for the Holocene have been developed from studies of oxygen isotopes of deep-sea foraminifera, ice cores and reef core records (Chappell and Shackleton, 1986; Chappell, 2002; Siddall et al., 2008; Grant et al., 2012) and are used widely to interpret the depositional evolution of river systems on continental margins (Wellner and Bartek, 2003; Anderson et al., 2004; Busschers et al., 2007; Liu et al., 2009). Additionally, continental shelf sediments primarily originate from fluvial transport, and thus, sedimentary sequences on continental shelves are sensitive recorders of changes in sediment flux and sea level. Furthermore, continental shelf sediments are characterized by high magnetic

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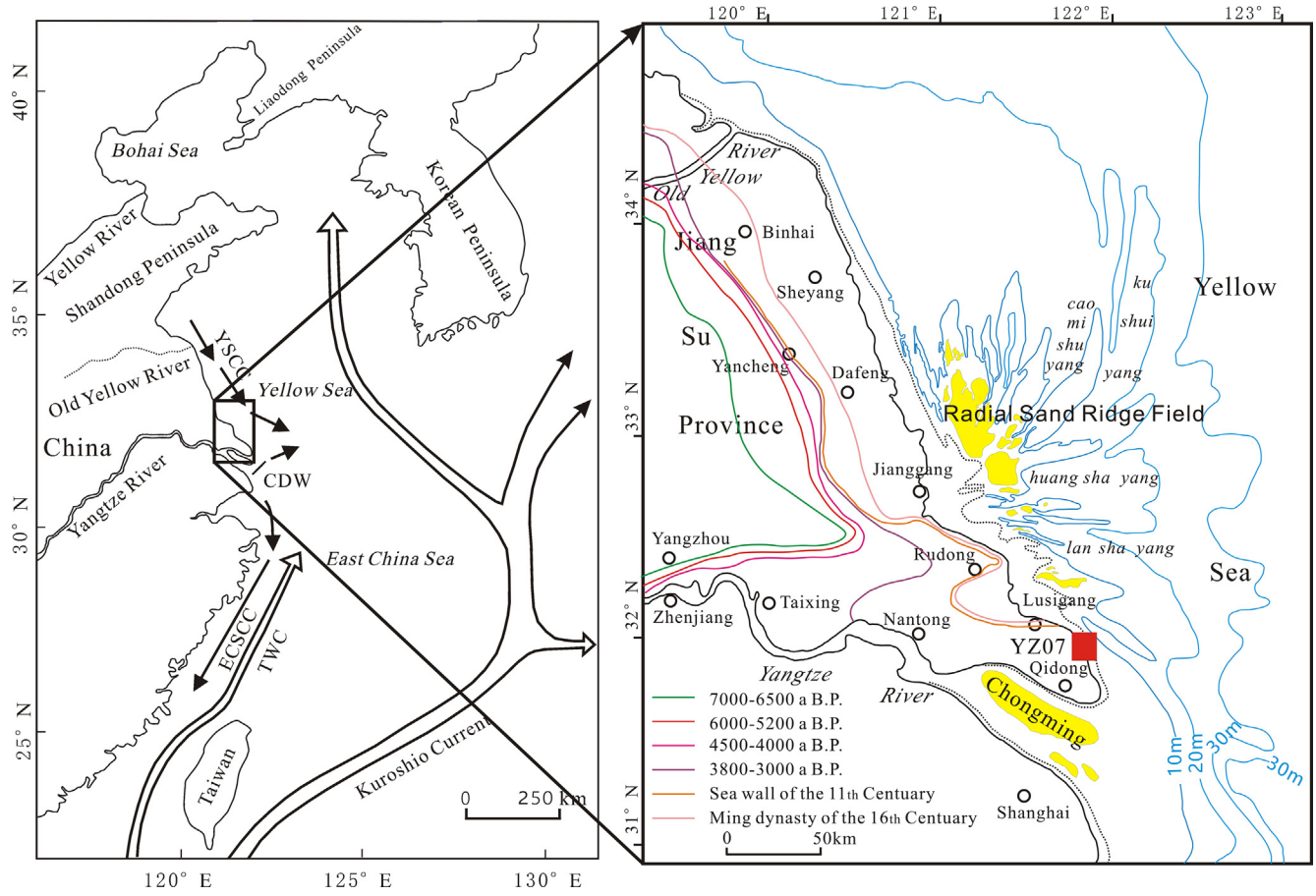

Fig. 1. Site map of the study region in China (left) and the radial sand ridge field in the southwestern Yellow Sea (right). Study site YZ07 is marked with a red square. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

mineral accumulations due to terrigenous inputs (Kwon et al., 2011; Liu et al., 2013; Chen et al., 2013, 2015; Wang et al., 2015). The study of sediments from radial sand ridges is critical for understanding the Quaternary evolution of the East China Sea, not only because it blocked the entry of sea water into the Yellow Sea and changed the flow direction of the Yangtze River, but also because it prevented the sediment from East Asia from traveling farther into the northwestern Pacific Ocean and was a major sediment source for East Asia and the Pacific Ocean.

A range of magnetic and non-magnetic proxies can be used to reconstruct paleoenvironmental conditions (Chen et al., 2013; Li et al., 2014; Hu et al., 2015; Wang et al., 2015). Among these methods, magnetic measurements provide a rapid, cheap and non-destructive way to characterize high-resolution mineralogical variations, which are widely used in sequence correlation, paleoclimate and provenance studies of marine, lacustrine and aeolian sediments (Maher and Thompson, 1999; Rosenbaum et al., 1996; Liu et al., 2003; Ao et al., 2010; Liu et al., 2012; Su et al., 2013; Zhang et al., 2012a; Ge et al., 2015; Hu et al., 2015; Tamuntuan et al., 2015; Wang et al., 2015). Magnetic methods enable the investigation of the mineralogy, concentration and grain size distributions of iron-bearing minerals that are sensitive to paleoenvironmental changes (Thompson and Oldfield, 1986). With developments in rock magnetic techniques, rapid progress in environmental magnetic studies of marine sediments was achieved during the 1960–1980s (Kent, 1982; Robinson, 1986; Bloemendal et al., 1988, Bloemendal and Demenocal, 1989; Karlin, 1990), which provide an additional approach to understand paleoenvironments. The deposits of the radial sand ridge in the South Yellow Sea contain rich information on terrestrial sediment supplies (Gao, 2009), coastal morphodynamics (Wang et al., 2007, 2012a, 2012b) and paleoenvironmental changes (Yin and Zhang, 2010; Sun et al., 2015; Wang et al., 2015) and thus have received considerable attention. However, Little information is available from Holocene magnetic studies of marine sediments on radial sand ridge fields, generally due to the high elevation and difficulty of access. The sampling intervals are too large. In this paper, we investigated systematically the sediments magnetic properties from the south of the radial sand ridge field in the South Yellow Sea. First, variations in the magnetic mineral assemblages with depth are reported. Then, the response of sediment magnetic properties to local paleoenvironmental processes is discussed, with the goal of providing fundamental knowledge for further environmental magnetic studies of marine sediments in this region.

2. Geographical settings

The South Yellow Sea is a shallow, semi-closed epicontinental sea between the Korea peninsula and China, with water depths that are primarily less than 100 m (Fig. 1). The radial sand ridge field is located seaward of the large deltaic alluvial plain built by the Yangtze River and the Yellow River into the South Yellow Sea. The radial sand ridge field sediments are mostly derived from the former Yellow and Yangtze Rivers when they debouched from the north and south sides of the system, respectively. Sediments from the two rivers have contrasting mineralogical characteristics. The Yellow River drains the Loess Plateau of NW China, and the Yangtze River includes intermediate and acidic igneous rocks and metamorphic rocks. Partial mixtures of the two sediment sources in the radial sand ridge field occurred during post-glacial transgression through longshore currents that transported materials eroded from the abandoned Yellow River Delta to the study area. There are distinctive contrasts in magnetic properties between sediments from