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Evolution of the Lian River coastal basin in response to Quaternary marine transgressions in Southeast China

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ABSTRACT

The coastal basin deposit in the Lian River plain is among the thickest Quaternary sequences along the southeastern coast of China. The clastic sediment accumulated in a variety of environmental settings including fluvial, channel, estuary/coastal and marine conditions. Detailed investigation of lithofacies, grain-size distributions, magnetic susceptibility, microfossils and chronology of marine core CN01, compared with regional cores, and combined with offshore seismic reflection profiles, has allowed us to correlate the spatial stratigraphy in the inner and outer plain and the seismic units. Grain size distribution analysis of core CN-01 through compositional data analysis and multivariate statistics were applied to clastic sedimentary facies and sedimentary cycles. Results show that these methods are able to derive a robust proxy information for the depositional environment of the Lian River plain. We have also been able to reconstruct deltaic evolution in response to marine transgressions. On the basis of dating results and chronostratigraphy, the estimated age of the onset of deposition in the Lian River coastal plain was more than 260 kyr BP. Three transgressive sedimentary cycles revealed in many regional cores support this age model. Detailed lithological and microfossil studies confirm that three marine (M3, M2 and M1) and three terrestrial (T3, T2 and T1) units can be distinguished. Spatial correlation between the inner plain, outer plain (typical cores characterized by marine transgression cycles) and offshore seismic reflectors reveals coherent sedimentary sequences. Two major boundaries (unconformity and erosion surfaces) can be recognized in the seismic profiles, and these correspond to weathered reddish and/or variegated clay in the study core, suggesting that Quaternary sediment changes on the Lian River plain were largely controlled by sea-level variations and coastline shift during glacial/interglacial cycles.

1. Introduction

The interaction between marine transgression and riverine sediment supply during the Quaternary is key to interpreting the evolution of river-mouth basin and sedimentary environments during glacial-interglacial cycles in coastal regions, especially on delta plains (Boyd et al., 1992; Marsset et al., 1996; Zhao et al., 2008; Hughes and Kennedy, 2009; Andrés et al., 2011; Zhou et al., 2014a). Traditionally, reconstructing the paleoenvironments associated with Quaternary depositional sequences is considered a major tool for understanding deltaic evolution and its relationship to marine transgressions, as documented in a number of studies (Hanebuth et al., 2006; J. Liu et al., 2009; Chen et al., 2010; Wang et al., 2014; Bogemans et al., 2016). The study of changes in coastal systems during recent glacial-interglacial cycles may provide a reference to predict how these delicate and highly populated environments might transform in the future in response to sea-level changes.

The Chinese coastal area can be divided into two regions, the great plain region in the north (e.g., from the Liaohe River delta to the Yangtze River delta plain) and the coastal plain region in the south, which is characterized by a long and narrow seaboard plain (Lin et al., 2012). There are at least five to eight marine transgression strata in the great plain region of north China (Lin et al., 2012). However, on the bedrock coast of the southern areas of China (northern coast of South China Sea), a great number of studies have revealed that the Quaternary record is characterized by two major marine transgression units, as recorded in the Pearl River delta (e.g., Huang et al., 1982; Li et al., 1991; Yim, 1994; Owen et al., 1998; Fyfe et al., 1999; Zong et al., 2009b, 2016), the Han River delta (e.g., Li et al., 1987; Zong, 1992), the Changle plain (e.g., Chen et al., 2016; Li et al., 2016) and Hainan island (e.g., Wang et al., 2016). In general, the evidence for each sedimentary cycle mainly consists of fluvial coarse deposits at the bottom, followed by littoral/marine deposits that are characterized by a fining upward trend. Weathered reddish or variegated clay and erosional surfaces are usually found between the Holocene and late Pleistocene sedimentary units. Although there is no major disagreement concerning the existing marine deposits along the southeast coast of China, the chronology of the late Pleistocene around the adjacent deltaic area still remains

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controversial due to the lack of precise dating older than the limits of ^{14}C analysis (Yim et al., 1990). The main issue of controversy is the age of the lower marine beds, which are either MIS 3 (59 kyr to 24 kyr BP) or MIS 5 (125 kyr to 73 kyr BP). Recently, more discussion has focused on optically stimulated luminescence (OSL) dating of the lower marine deposits. For example, the age of this marine unit are reported as 117.32 kyr BP from Hainan island of core TLG01, 135.6 kyr BP from Pearl river delta of core ZK3 and 124.65 kyr BP from Fujian coast of core PT01, respectively, i.e., equivalent to the last interglacial highstand (MIS 5e) (Yim, 1999, Yim et al., 2008; Zong et al., 2009a; Guo et al., 2013; Chen et al., 2016; Wang et al., 2016). Previous geomorphological studies along the northern coast of the South China Sea showed possible terraces of interglacial sea-level highstands during both MIS 5 and MIS 7 (Pedoja et al., 2008). However, there are a limited number of results relating specifically to the sedimentology and chronology in the coastal areas of southeast China concerning marine strata older than MIS 5. The Lian River plain in Guangdong Province, southeastern China, has very thick Quaternary deposits (~140 m maximum) (W. Chen, 1984; Song et al., 2012) throughout the south China coast area, which provide valuable materials for high-resolution studies of, possibly, the oldest deltaic stratigraphy and marine transgression events. For the first time, an estimated age as old as >300 kyr and at least three sedimentary cycles in this coastal basin have been reported (Song et al., 2012), and these were correlated with established global sea-level fluctuations and marine isotopic stages (MIS) (Martinson et al., 1987; Rohling et al., 2009; Grant et al., 2012). So far, however, few studies of the sedimentary facies and related environmental proxies have been undertaken for this coastal plain. There has been no systematic and detailed stratigraphic study of this plain until recently, previous work being restricted mostly to the adjacent area, especially the Han River delta and Pearl River delta. In this study, a core (CN-01) onshore of the Lian River coastal plain was drilled for detailed investigation. Lithofacies, combined with grain-size distributions (GSDs), loss-on-ignition (LOI), magnetic susceptibility (MS), foraminifera and ostracods were studied. Herein, we examine and correlate the regional stratigraphy and sedimentary environments based on our results and data published previously by Song et al. (2012). We also delimit the chronology of the late Pleistocene strata in the study area, and examine past environmental changes and deltaic evolution in response to marine transgressions.

2. Geological setting

The Lian River plain lies on the southeast coast of China and borders the South China Sea; it extends about 50 km inland (Fig. 1), with the Han River and the Rong River delta plain to the north and the Pearl River delta plain to the south. The Quaternary section preserved within the drainage basin of the Lian River mouth is unusually thick, with a sedimentary sequence of up to 141 m (W. Chen, 1984). The drainage area (838.5 km^2) of the Lian River is large and discharge amounts to about 587 million m^3/yr, which makes it one of the major fluvial suppliers in the east coastal plains. The climate of the study area is dominated by the East Asian monsoon system, with a warm and wet summer monsoon from the south and cold and dry winter conditions from the north. The annual mean temperature is 22.3 °C, with annual precipitation varying from 1800 to 2100 mm (Guangdong Meteorological Service, 2017).

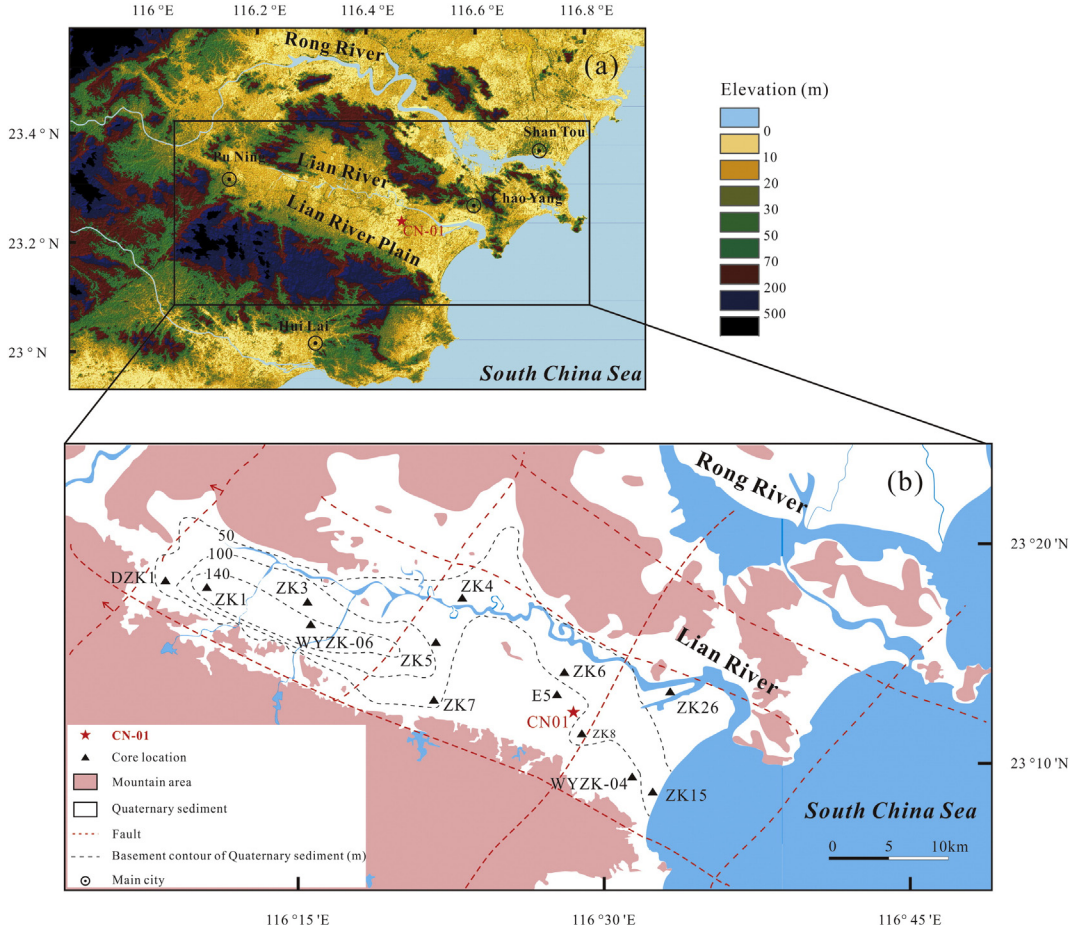

Fig. 1. (a) Topographic map of the Lian River plain and the southern part of the Rong River delta based on ASTER GDEM data. (b) Location map of the cores in the study area (modified from Song et al., 2012). Core locations on the delta plain are indicated by black triangles; core CN01 used in the detailed study is indicated by a red star. The white areas are Quaternary deposits, and the red dashed line represents both the weak normal faults and postulated faults according to Zhong and Zhan (1993).