Quaternary International xxx (2018) 1–13

Contents lists available at ScienceDirect

Quaternary International

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

Optical dating of Holocene sediments from the Yangtze River (Changjiang) Delta, China

Xiaomei Nian*, Weiguo Zhang, Zhanghua Wang, Qianli Sun, Jing Chen, Zhongyuan Chen

State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China

A R T I C L E I N F O

Article history:
Received 20 July 2017
Received in revised form
21 December 2017
Accepted 7 January 2018
Available online xxx

Keywords:
Optically stimulated luminescence (OSL)
Coarse silt-sized quartz (45–63 μm)
Fine sand-sized quartz (90–125 μm)
Holocene
Paleo-incised valley
Yangtze River (Changjiang) Delta

A B S T R A C T

Establishing a reliable chronology is essential for understanding delta evolution, which is normally performed using radiocarbon (^{14}C) dating and the recently emerging technique of optically stimulated luminescence (OSL). The application of the latter one to the Holocene Yangtze River (Changjiang) Delta deposit is still quite limited. In this study, two 60.9-m-long cores were collected from Taizhou (TZ) and Nantong (NT) within the paleo-incised valley of the Yangtze River, and a total of seven and nine OSL samples were collected from the TZ and NT cores, respectively. In addition, ten accelerator mass spectrometry (AMS) ^{14}C ages of the TZ core were presented with eight AMS ^{14}C ages that were previously obtained from the NT core. The single-aliquot regenerative-dose (SAR) protocol was applied to coarse silt-sized (45–63 μm) and fine sand-sized (90–125 μm) quartz. The results showed that the grains in the 45–63 μm size fractions appeared to be better bleached than those in the 90–125 μm size fractions, and the detection of insufficiently bleached sediments is required in order to obtain accurate age estimates. The ages adopted for the samples range from 3 ka to 9 ka for the TZ core, and from 1 ka to 14 ka for the NT core, which were in general internally coherent within the limits of experimental errors and with respect to their stratigraphic order. The AMS ^{14}C age of the TZ core were significantly older than their OSL ages, while those from the NT core generally showed good agreement with their OSL ages. One should be cautious when using AMS ^{14}C to date deltatic deposits. Based on the OSL ages, two periods of rapid accumulation rates can be found in both cores, which are linked to the rapid sea level rise in early Holocene and migration of delta front facies in late Holocene. These investigations indicate that OSL technique is an effective method with which to date Holocene deltaic deposits, especially in coarse sedimentary layers where organic carbon material is sparse.

1. Introduction

The Yangtze River (Changjiang) Delta is one of the most densely populated mega-deltas in the world. Its Holocene deposits, which can reach thicknesses of up to 80 m in its incised paleo-river valley (Fig. 1), can be used to obtain high-resolution records of land-sea interaction history (Delta Research Group, 1978; Wang et al., 1981). Obtaining reliable geochronologic data is of paramount importance in investigations of deltaic palaeoenvironmental changes. To date, the dating of the Yangtze River Delta deposits has mainly been based on ^{14}C dating (e.g. Hori et al., 2001; Wang et al., 2012, 2013a; Xu et al., 2012; Feng et al., 2016). Based on a large number of ^{14}C age analyses, a general framework of sediment accumulation history in the incised-river valley and its implications for Holocene delta evolution have been well-established (e.g. Delta Research Group, 1978; Wang et al., 1981; Hori et al., 2001; Song et al., 2013). However, reworking of carbon material and carbon reservoir effect can yield inaccurate ages. It is common to observe age reversals in the delta stratigraphy (Stanley and Chen, 2000). In the study area, the Holocene stratigraphy in the incised-valley typically comprises a lower estuarine-marine facies and an upper delta facies (e.g. Li et al., 2000). The delta front facies often occurs in the upper 20 m of the stratigraphy, where sands represent the major sediment type and materials that are suitable for radiocarbon dating occur only sporadically. As a result, ^{14}C age analyses of the sandy delta front facies are very limited (e.g. cores of HQ98, JS98 and CM97 from Hori et al., 2001, 2002; JD01 from Song et al., 2013), leaving age 'blanks' in the studied cores, which impede the generation of high-resolution environmental records.

Optically stimulated luminescence (OSL) dating represents an

* Corresponding author.
E-mail address: xmnian@sklec.ecnu.edu.cn (X. Nian).

https://doi.org/10.1016/j.quaint.2018.01.011
1040-6182/© 2018 Published by Elsevier Ltd.

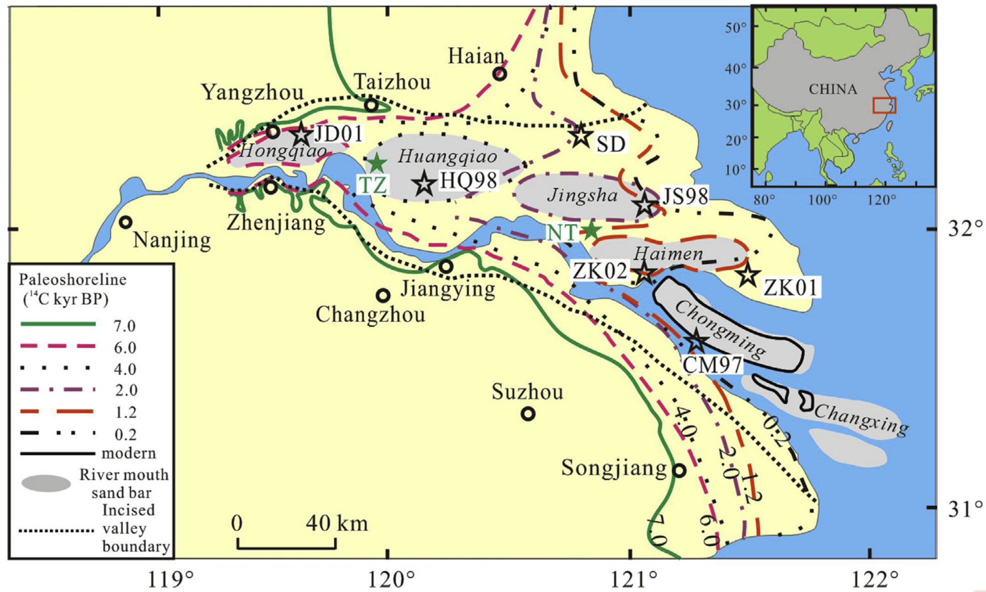

Fig. 1. Location map of the study area (modified from Song et al. (2013)), showing the geographic locations of the TZ and NT cores in this study. Also shows are published cores HQ98, JS98, CM97 (Hori et al., 2001, 2002), JD01 (Song et al., 2013), ZK01, ZK02 (Zhang et al., 2017), SD (Nian et al., 2018).

invaluable alternative technique that can be used to date coastal sediments (e.g. Roberts and Plater, 2007; Jacobs, 2008; Bateman, 2015; Oliver et al., 2015; Lamothe, 2016), and the precision and age ranges of these measurements have been improved recently. For example, this technique has been used to successfully date Holocene deposits in the Mississippi Delta (Shen and Mauz, 2012; Shen et al., 2015), the Mekong River Delta (Tamura et al., 2012), the Ganges-Brahmaputra-Meghna Delta (Chamberlain et al., 2017) and the Nakdong Delta (Kim et al., 2015). In recent years, the results of OSL chronologic analyses have also been reported for cores collected from the subaqueous Yangtze River Delta (Wang et al., 2013b; Sugisaki et al., 2015), the neighboring South Yellow Sea and East China Sea (Yi et al., 2014; Wang et al., 2015; Gao et al., 2016, 2017), and paleo-incised Yangtze River valley (Nian et al., 2018).

In this study, two 60.9-m-long cores were collected from Taizhou (TZ, 32°23.8317′N, 119°54.845′E, 4.72 m above sea level (asl)) and Nantong (NT, 32°3.9417′N, 120°51.4′E, 3.99 m asl) in the Yangtze River Delta in 2013. The OSL dating technique was applied to both the 45–63 μm and 90–125 μm quartz size fractions. Although it is difficult to perform ^{14}C dating in the study area, this method can still be used to produce a valuable chronological framework for the Holocene deposits. The OSL results were systematically compared with the obtained ^{14}C dating results in order to refine the chronology of the cores. The purpose of this study is to investigate the feasibility of using the OSL dating technique to determine the ages of Holocene deposits that exhibit significant variations in their particle size distributions. Suitable grain-size fractions and techniques for OSL dating are recommended, which may be applied to other studies performed in similar environmental settings.

1.1. Study area and samples

During the Last Glacial Maximum (LGM) of the Late Pleistocene, when the sea level was ca. 120 m below its present level, the present-day Yangtze River Delta region was incised, forming a river valley that was 70–80 m deep (Li et al., 2000). When postglacial transgression occurred, the Yangtze Estuary shifted landward in response to sea-level rise, and the apex of the delta retreated to the Zhenjiang and Yangzhou areas at approximately 8 ka (e.g. Song et al., 2013) (Fig. 1). Since then, the coastline has shifted seaward and the modern Yangtze River Delta was initiated when sea-level rise slowed down and huge amounts of sediment supply were deposited. It has been suggested that the Yangtze River Delta was formed through six subdelta stages, with each subdelta stage characterized by the formation of a river-mouth sand bar deposit in the upper 20 m of its stratigraphic sequence (Fig. 1; Wang et al., 1981; Li et al., 2000; Hori et al., 2001, 2002; Song et al., 2013). Based on the results of ^{14}C dating and archaeological evidence, the six stages of delta formation are defined as follows: the Hongqiao phase (7.5–6.0 ka or recently revised as 6.0–5.5 ka by Song et al., 2013), the Huangqiao phase (6.5–4.0 ka), the Jinsha phase (4.5–2.0 ka), the Haimen phase (2.5–1.2 ka), the Chongming phase (1.7–0.2 ka), and the Changxing phase (0.7 ka-present) (Delta Research Group, 1978; Song et al., 2013).

Cores TZ and NT (Fig. 1) are located in the sand bar deposits that were formed during the Huangqiao phase and between the Jinsha and the Haimen phases, respectively. Seven samples (TZ-1 to TZ-7) were collected from the TZ core and nine samples (NT-1 to NT-9) were collected from the NT core for OSL dating. Ten samples were collected from the TZ core for ^{14}C dating (Fig. 2). The lithology of the NT core and the results of its AMS ^{14}C age analyses were reported by Bai et al. (2016). According to lithology and the stratigraphic correlation with the well-established sedimentary facies of cores JD01 (Song et al., 2013), HQ98, JS98 (Hori et al., 2001, 2002), ZK01 and ZK02 (Zhang et al., 2017) from adjacent area (Fig. 1), five sedimentary units in ascending order were identified in the TZ core: estuary (TZ-U1), prodelta (TZ-U2), distributary channel (TZ-U3), delta front (TZ-U4), and delta plain (TZ-U5). Six sedimentary units were distinguished in the NT core: tidal river (NT-U1), estuary (NT-U2), tidal sand ridge (NT-U3), prodelta (NT-U4), delta front (NT-U5), and delta plain (NT-U6) (Fig. 2; Bai et al., 2016).

3. Methods

To select suitable grain-size intervals for OSL dating, the grain-size distributions of the sediments were measured using a

Please cite this article in press as: Nian, X., et al., Optical dating of Holocene sediments from the Yangtze River (Changjiang) Delta, China, Quaternary International (2018), https://doi.org/10.1016/j.quaint.2018.01.011